Focused Video Reflections in Concert with Practice-Based Structures to Support Elementary Teacher Candidates in Learning to Teach Science

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Focused Video Reflections in Concert with Practice-Based Structures to Support Elementary Teacher Candidates in Learning to Teach Science

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Abstract

Recommendations for science education, including elementary education, highlight instructional practices such as using discussion to promote deep understandings of science. A task facing science teacher educators is to craft instruction to support teacher candidates (TCs) to develop skills that will encourage such practices in classrooms. In 2011, we developed and implemented a class activity —the Supported, Collaborative Teaching Model (SCTM)—to focus TCs' attention on key aspects of science teaching. The SCTM, which is designed around the idea that practical experience is critically important to teacher education, involves having TCs teach science to elementary students in three different grade levels three different times throughout the semester. In this study, we examine the outcomes related to two newly added components of the SCTM: focused video reflections and the use of the Charlotte Danielson Framework for Teaching (FfT; Danielson, 2013). In this study we asked: In what ways do the SCTM and focused video reflections support TCs in crafting opportunities for students to develop deep understandings of science? Interviews and reflections from eight TCs were analyzed to examine the impact of the SCTM. Our analysis indicated that the focused video reflections based on the FfT coupled with the SCTM provided tools for growth and for documenting this growth. We describe areas in which TCs indicated they had developed as teachers, as well as the structures that contributed to shifts in practice in these different areas.

Keywords: teacher education, elementary, science, reflection, video analysis

Current recommendations about science education, such as those put forth in the *Next Generation Science Standards* (NGSS; NGSS Lead States, 2013), highlight instructional practices designed to promote deep understandings of science. Thus, improving elementary science education – which builds the foundation for secondary and post-secondary science learning – necessarily involves helping teachers understand how to implement such recommendations. As Wilson, Schweingruber, and Nielson (2015) noted,

> One aspect of classroom instruction that is important for supporting the learning goals in the…NGSS is providing students with opportunities to make sense of investigations and discuss their emerging ideas. This kind of systematic sense making is supported by verbal prompts from teachers or varied opportunities for student talk. (p. 53-54)

Consequently, a significant task facing science teacher educators is to craft instruction to support teacher candidates (TCs) to develop skills so they may provide these types of opportunities and verbal prompts in their classrooms.

As science teacher educators consider ways to provide this support, one option might be to have TCs observe discussion-rich instruction and co-implement this instruction in the field. However, it has been reported that only 24% of K-5 teachers report teaching science "most days/every week" and only 54% of those teachers report having students support arguments with evidence (a key component of scientific discussions) at least once a week (Trygstad, 2013). Therefore, it is imperative to create purposefully structured opportunities for TCs to experience reform-oriented science instruction within their preparation program.

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To this end, we have developed and implemented an activity we call the Supported, Collaborative Teaching Model (SCTM). This activity is designed to focus TCs' attention on key aspects of science teaching via giving TCs opportunities to teach brief science lessons multiple times to elementary students in a small, classroom-based center format. Key components of the SCTM include having the opportunity to teach the lesson several times in one day, scaffolded support for lesson planning, and working with peers in small teaching groups (see Authors, 2013, for more detail on the SCTM). The SCTM was originally created to provide opportunities for TCs to try new pedagogical strategies in science, reflect on the efficacy of these strategies, and make appropriate modifications to these strategies in real time. In this study, we examine two new components of the SCTM: video reflections and the Charlotte Danielson Framework for Teaching (FfT; Danielson, 2013). To evaluate the effectiveness of these additions, the following question guided our inquiry: *In what ways do the SCTM and focused video reflections support TCs in crafting opportunities for students to develop deep understandings of science?*

Review of the Literature

This research is rooted in the idea that "practice must be at the core of teachers' preparation" (Ball & Forzani, 2009, p. 497). Although practical experience is critically important (Feiman-Nemser, 2001), simply spending time in classrooms is not sufficient for developing clinical expertise (Darling-Hammond et al., 2005). Science teacher educators must be deliberate about experiences that support TCs in learning about and practicing reform-oriented science instruction as described in the NGSS. Here we describe how the SCTM is intended to support TCs in this way. We frame this work with literature pertaining to elementary science education, discourse in the classroom, and reflective activities in preservice teacher education.

Elementary Science and Novice Teachers

Sandholtz and Ringstaff (2011) stated, "[T]he status of science education, particularly in elementary schools, is weak" (p. 514). Yet teaching elementary science is more complex than is typically considered. Among other knowledge and skills, elementary science teachers need

> [A] deep understanding of content, ways to accurately represent conceptual ideas to promote student understanding, approaches to engage students in scientific practices, strategies to assess and monitor students' understanding of big ideas, and methods of identifying students' resources and using them as leverage for learning… (Mikeska, Anderson, Schwarz, 2009, p. 679)

This is a tall order for novice teachers. Davis and Smithey (2009) found that beginning elementary teachers often struggle with content and appropriate pedagogy, focus solely on fun activities that have little meaning, do not know how to make connections to their students, and sometimes avoid teaching science altogether. Further, teaching science can be exceedingly difficult for teachers who are attempting to teach in ways other than how they were taught (Windschitl, 2003). Given that the NGSS explicitly acknowledge several conceptual shifts in science teaching and learning that depart from aspects of traditional science instruction, it is easy to see why elementary teachers may struggle. Finally, it has been noted that self-efficacy in science can play a large role in how elementary teachers go about teaching science. As Menon and Sadler (2016) note, "highly efficacious" science teachers are more likely to teach in reform-oriented ways; however, many elementary teachers have had negative experiences in science courses or feel they do not have the content knowledge to be successful in science.

It has been documented that teacher education – and science methods courses in particular – can have a positive impact on novice elementary teachers' understandings about and enactment of high-quality elementary science instruction (e.g. Avraamidou, 2016; Zembal-Saul, 2009). Specifically, science methods courses can employ a variety of instructional strategies (e.g. video cases, hands-on activities, group discussion, etc.) to support TCs in perceiving themselves as science teachers (Menon & Sadler, 2016), learning how to thoughtfully utilize curricular materials (Ross & Cartier, 2015), and enacting instruction that will scaffold the use of scientific practices (Ricketts, 2014). Methods courses may also provide TCs with opportunities to put theory into practice as they 'try out' what they have learned in their teacher education courses (e.g. Wilson, Bradbury, & McGlasson, 2015). Consequently, if we truly believe that what occurs at the elementary level creates the foundation for further learning, we must simultaneously acknowledge the difficulties inherent in teaching today's TCs how to teach science well and problem-solve how to move forward within our teacher education courses. Thus in our teaching and in this research, we have attempted to make thoughtful decisions about experiences that allow TCs to practice reform-oriented science instruction as described in the NGSS.

Fostering Discourse in the Classroom

A key feature of reform-oriented science instruction is the prominence of discourse to promote deep understandings of science phenomena. From Lemke's (1990) work on talking science to current efforts to integrate argumentation into classrooms (Zembal-Saul, 2009), researchers recognize the importance of fostering discourse in the classroom. Discourse is believed to support science learning in the sense that students begin to use the language of science. As articulated by Mortimer and Scott (2003),

> It is through talk that the scientific view is introduced to the classroom. Talk enables the teacher to support students in making sense of that view. Talk enables the students to engage consciously in the dialogic process of meaning making, providing the tools for them to think through the scientific view for themselves. (p. 3)

In addition to supporting learning, discourse also helps to foster learner-centered environments in which students are encouraged to share their thinking (Mortimer & Scott, 2003).

Teachers play a key role in orchestrating discussions, even in classrooms in which the curriculum provides direction concerning discourse (McNeill & Pimentel, 2010). For example, Harris, Phillips, and Penuel (2011) found that teachers varied in the ways in which they responded to students' questions even though the curriculum all three teachers used "provided explicit guidance about how to elicit questions" (p. 784). In light of the centrality of the teacher in supporting discourse in the classroom, we intended to use the SCTM to support novice teachers' use of discourse. As will be described later, we focused TCs' attention on particular kinds of discourse. Through intentional, focused reflection, we encouraged TCs to consider the impact of the incorporation of these discourse moves in their instruction.

Teacher Education and (Video) Reflection

Cochran-Smith et al. (2016) in their recent survey of the field of education noted, "…the practice of teaching is conceptualized broadly to include *reflection*, collaboration, inquiry, and decision making" (p. 480, emphasis added). It is quite clear, then, that reflection is a vital component of teaching; the challenge then becomes how to create opportunities to support TCs in reflection on their practice (Scherff & Singer, 2012).

Larrivee (2008) asserts that reflective activities should begin early in teacher education programs and that there are, indeed, productive strategies to scaffold the development of a reflective stance. For example, given that TCs are new to the world of teaching, Scherff and Singer (2016) suggest that TCs be given "frames" or lenses through which to view their practice to help them bound and focus their reflections. Hollins (2011) also encourages directed observation (TCs are instructed to focus on particular phenomena or actions) because TCs "understand classroom learning from a student perspective, but very few have examined classroom learning from a teacher perspective, and most will need guidance in learning what to attend" (p. 403). Finally, Hiebert, Morris, Berk, and Jansen (2007) note that teacher preparation programs should "prepare prospective teachers to learn from teaching when they enter the profession" (p. 48). As such, it is important to guide TCs to consider how to refine their practice based on reflections of their own teaching.

Throughout the SCTM, TCs use video recordings of their teaching as a basis for focused reflection. Reflecting on videos of teaching has become a common practice in teacher education (e.g. Hawkins & Park Rogers, 2016; Johnson & Cotterman, 2015; Rosaen, Lundeberg, Cooper, & Fritzen, 2010). Star and Strickland (2008) point out that, "Being a good observer of practice is a learned skill (e.g., Berliner et al. 1988), and the use of video in preservice teacher education presents an opportunity to focus explicitly on preservice teachers' ability to notice" (p. 108). Hawkins and Park Rogers (2016) and Rosaen et al. (2010) all note that video is a particularly useful tool because it allows TCs to stop, rewind, and slow down the teaching process so that they may focus on particular aspects of their teaching and students' responses to that instruction. Accordingly, reflecting on videos may allow TCs to shift their focus from broad perceptions of lessons to more complex analyses of classroom interactions, attend to student thinking, and self-identify opportunities for growth (Rosaen et al., 2010; Santagata & Guarino, 2011; Laparo, Maynard, Thomason, & Scott-Little, 2012).

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To be successful, video reflections must be scaffolded, similar to more general reflections (Santagata & Guarino, 2011). Baker El-Dib (2007) and Davis (2006) note that many TCs are accustomed to writing low- to low/medium-level reflections that may simply be a list or description of what transpired or expressions of satisfaction/dissatisfaction, with weak reasoning if provided at all. Consequently, studies of the use of video reflection with TCs have found that to be effective, the viewing of the videos must be paired with focusing activities or tools (Santagata & Guarino, 2011; Hawkins & Park Rogers, 2016). Santagata and Angelici (2010) found that using a particular observation framework that was rooted in the differences between novice and expert teachers allowed TCs to be much more thoughtful in their reflective activities and to create much richer analyses of their teaching.

In the SCTM, we heed these recommendations, framing reflection around particular practices that take place during teaching experiences with real elementary students. TCs are provided with clear expectations aligned with a research-based observation framework (the FfT; Danielson, 2013) for their reflections.

Methods

In this section, we describe the general structure of the SCTM as well as the Charlotte Danielson Framework for Teaching (Danielson, 2013). Following that, we describe data collection and data analysis methods.

Structure of SCTM

The SCTM involves TCs teaching science to elementary students three different times throughout the semester. Each of these times, TCs are working with a different grade level. For example, in one semester, TCs may work with 1st grade, 4th grade, and 6th grade. Below is a summary of the model (more details can be found in Authors, [2013]):

- Topics/standards are determined by classroom teachers
- Lessons are short (approximately 15 minutes)
- Lessons are structured as centers through which elementary students rotate; there are three or four centers that relate to the same topic
- The first set of lessons is planned by the course instructor, the second set is co-planned by the instructor and TCs, and the third set is planned entirely by TCs
- Elementary students are in small groups ranging in size from four to eight students
- TCs work in groups of three to plan and implement lessons
- TCs rotate roles (lead instructor, supporting instructor, observer) as students rotate through the centers
- The observer serves as the video recorder for the lead instructor, but also has time to simply observe the lesson
- Each group of TCs teaches the same lesson eight times in one day; each TC within that group has the opportunity to be the lead instructor two or three times within that day
- TCs are encouraged to make minor adjustments from lesson to lesson in order to be responsive to students. There is a 15-minute break between the fourth and fifth lessons for TCs to talk with each other and make more significant adjustments to the lesson.

Note that the actual teaching in the SCTM is not a graded assignment. TCs are graded on the quality of the second and third lesson plans and their reflections on the SCTM.

Danielson Framework for Teaching

To date, we have implemented the SCTM with 19 different cohorts at two different institutions. This research examines the addition of two new elements: video reflections and the use of the Charlotte Danielson Framework for Teaching (FfT; Danielson, 2013) to guide those reflections. The FfT is an observation instrument of general pedagogical skill, consisting of four domains (1: Planning and Preparation; 2: The Classroom Environment; 3: Instruction; 4: Professional Responsibilities). Each domain is broken into five to six components, for a total of 22 components (e.g. *1a: Demonstrating Knowledge of Content and Pedagogy*). Domains 2 and 3 are considered to be the 'observable domains', as these are the only domains evaluators attend to when conducting classroom observations (for more information on the FfT, please refer to The Danielson Group website [2017] listed in the references).

Although the FfT is a general pedagogical observation instrument, components of the FfT reinforce skills found in science instruction that is consistent with the NGSS. For example, within component *3c: Engaging Students in Learning*, the FfT examines teachers' ability to provide activities and assignments that promote high-level student thinking as well as use instructional materials that can engage students in deep learning. A teacher who scores Distinguished (4 on a scale of 1-4) on this component would teach a lesson consistent with the following description:

> Virtually all students are intellectually engaged in challenging content through well-designed learning tasks and activities that require complex thinking by students. The teacher provides suitable scaffolding and challenges students to explain their thinking. There is evidence of some student initiation of inquiry and student contributions to the exploration of important content; students may serve as resources for one another. The lesson has a clearly defined structure, and the pacing of the lesson provides students the time needed not only to intellectually engage with and reflect upon their learning but also to consolidate their understanding. (Danielson, 2013, p. 69)

This description of high quality instruction clearly aligns with several components of the NGSS (NGSS Lead States, 2013), such as the practices of asking questions, constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information.

Throughout the semester, we asked the TCs to focus on three different components from the FfT: *3a: Communicating with Students*, *3b: Using Questioning and Discussion Techniques*, and *3c: Engaging Students in Learning*. TCs were asked to consider elements of these components in terms of their actions and students' (re)actions as they watched videos of themselves teaching. The program in which this research takes places has the stance that TCs cannot score a 4/Distinguished on the FfT as they are not yet teachers; thus, TCs were asked to consider characteristics of each component up to a rating of a 3/Proficient.

Context and Participants

This study took place at a state university serving ~22,000 students. Twenty-three TCs were enrolled in an undergraduate elementary science methods course. All TCs in the course participated in the SCTM and completed the assigned reflections. However, this research focuses on a subset of nine TCs (eight females and one male) with a complete data set of all related class assignments *as well as* an interview with the first author. Note that the IRB at the study site's institution does not allow for instructors to know who has consented to course-related studies until all grades are submitted for the semester; consequently, once consenting TCs were able to be contacted in relation to the study there were many TCs who were unavailable after the semester for interviews, which led to the lower number of complete data sets. All participants were juniors or seniors seeking Elementary Education (K-8) certification. For nearly all TCs in this course (and the nine TCs who are the focus of this study), the SCTM provides the first opportunity to teach *any* lessons – let alone science lessons – in classrooms to elementary students. Throughout the methods course, emphasis was placed on strategies that would support students in developing deep understandings of science content/phenomena; these strategies were often rooted in the language of the FfT and the NGSS practices.

Data Sources and Analysis

SCTM reflections. After each of the three SCTM experiences, TCs completed reflection papers that were due one week after the SCTM. The first paper focused solely on *3b* of the FfT (discussion techniques), the second paper focused on *3b* and *3a* (discussion techniques and communicating), and the third paper focused on all three components described above (discussion techniques, communicating, and engaging students; see Appendix A in Supplemental Online Material for more detail). TCs were asked to reflect on the videos of themselves teaching (two to three 15-minute videos) and were given a guiding document for their reflection that asked them to respond to questions such as "What were the key science learning moments and how did you facilitate these?" and "What were the purposes of your conversations with students?" TCs were graded on each reflection according to a rubric that encompassed three components:

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1. Addressing the FfT: The TC discusses the selected domain(s) and makes use of the given Danielson rubric(s) and guiding questions to rate him/herself.
2. Citing Evidence from Videos: The TC provides several specific examples/pieces of evidence from the videos to support statements/rating made in the reflection.
3. Actions for the Future: The TC describes multiple, specific actions for future teaching that are clearly connected to self-discovery via the video reflection.

These three components were nearly equal in weight, with the component focusing on evidence being weighted slightly more in the rubric. Each TC turned in three of these reflections for a total of 27 reflections in our data set. Videos were *not* turned in with the assignment, nor were they watched during class time; rather, the videos were used to provide evidence in their reflections.

Interviews. After the course ended, the first author interviewed the TCs for approximately one hour each using a semi-structured (Roulston, 2010) protocol. TCs were asked questions about the overall affordances and constraints of the SCTM as a model, their experience using the videos as a reflection tool, and personal growth in terms of their questioning and discussion techniques over the course of the semester. Each interview was recorded and transcribed verbatim.

Data Analysis. We began analyzing the data through structural coding (Saldaña, 2016) by reading through all of the reflections and interview transcripts on a case-by-case basis so we could examine TCs' growth over time. During this coding phase, we individually applied "conceptual phrase[s]…to a segment of data that relates to [the]…research question" (Saldaña, 2016, p. 98); this allowed us to observe shift in practice or improvement that TCs noticed. We then met to discuss our individual analyses and worked together to pattern code (Saldaña, 2016) themes. Saldaña notes that pattern codes are "pull together a lot of material from first cycle coding into more meaningful and parsimonious units of analysis" (p. 236). Pattern codes that arose related to questioning students, how to best engage students in activities, and how to explore students' ideas. From there we repeated the structural/pattern coding process as we returned to each participant's data to investigate to what they attributed their shifts in practice. Again, this analysis was conducted individually and then we met to discuss our analyses, work out any differences in our applications of codes, and together we grouped our findings into themes surrounding the use of FfT, viewing the videos, and having time as an observer.

Findings

Our analysis indicated that the focused video reflections based on the FfT coupled with the SCTM provided tools for growth and for documenting this growth. We prompted TCs to focus on particular actions and practices associated with three components of the FfT (*3a: Communicating with Students*, *3b: Using Questioning and Discussion Techniques*, and *3c: Engaging Students in Learning*), but we argue that TCs' reflections demonstrated nuanced understandings of what constitutes 'good' questions, for example, and preliminary ideas about what intellectually engaging science can look like. TCs were able to provide concrete examples of how these FfT components applied to their science teaching, the ways in which they had improved in relation to these components, and the ways in which they wanted to improve in relation to these components.

To illustrate our findings, we will begin by presenting the areas in which TCs indicated they had developed as teachers. This section of the findings will be organized by the three elements of *3b* (quality of questions prompts; discussion techniques; and student participation), as these categories best capture the TCs' main areas of focus. After this section, we will present the structures that TCs believed contributed to shifts in practice in these different areas, with a focus on the FfT, the reflection process, and structures inherent to the SCTM.

Quality of Questions

Throughout the semester, TCs came to the understanding that not all questions are created equal. Each TC commented on how the questions they asked changed over the course of the semester. Many of them stated that they began the semester by asking questions that required one-word answers and progressed to higher quality questions that elicited student thinking:

> In the beginning, it was a…lot of, "What is this?" or "What is that?" or "How does this work?" And like one-answer questions where [at the end of the semester] we would be like, "Oh. Check this out. Look at this. Observe this. Tell us what you think is going on. What did you observe? What you think is happening and then why do you think that's happening?" It progressed into those big questions and more questions.

The TCs often stated that they came to the realization that they needed better quality questioning because they wanted conversation to "flow" or "feel natural." One TC stated that, "Natural language and questions seemed to engage the students more so than anything else" and that she aimed for this type of instruction because when she asked closed questions, she "forced a lot of terms and science gabble at them [the students]." All TCs echoed that statement that, "…when it was more discussion, I feel like they [students] got more from the lesson."

Discussion Techniques

Another pedagogical move TCs focused on in terms of 'natural' conversations was getting students to talk and listen to one another rather than just speaking directly to the TCs. The TCs found this to be a much more difficult task than they had anticipated and often attributed this (correctly or not) to the fact that they only had 15 minutes to build sense of community amongst students. However, by the end of the semester, several TCs acknowledged successes in terms of facilitating student discussion. One stated that by the end of the semester, "I would say, 'Ok, what do you girls think about that?' directing the conversation to other students' perspectives instead of going straight back to teacher talk time." This TC was forthcoming in that this type of peer discussion was not successfully carried throughout the whole lesson, but "…it is encouraging to see these third graders bounce ideas off one another, even if it was only briefly." Another TC observed her progress from the first to the third SCTM lesson, noting,

> I actually had another student who seemed to really understand already, right away he was giving a pretty great example of thermal equilibrium. This time instead of moving on I asked why he thought that, if everyone else agreed, if they could expand, why they thought differently. They were talking so much and I was so excited!

Over time, TCs realized that encouraging this type of peer discussion was not just a function of teacher moves in the moment, but also deliberately planning and designing the lesson to be conducive to peer discussion. One TC shared that when he designed his final lesson, he made sure that there was plenty of time for students to work together in pairs and share their ideas.

A second component of discussion techniques is allowing students space to explain their thoughts and reasoning. Similar to the notion that not all questions are created equal, TCs learned that not all discussions are created equal. In addition to having students talk to one another, TCs realized that those discussions should be about students' ideas rather than simply about the parts of the activity. This required TCs to "push" students to be thoughtful "on a deeper level" about the phenomena at hand and allow time for students to "think longer." The TCs found that when students were talking with each other about their ideas, students "kind-of teach each other…and [if] this one really understands and this one doesn't, you can definitely use that to your advantage." In other words, by allowing the space for students to share their ideas, TCs realized that they could facilitate students leading the instruction.

Student Participation

Throughout the SCTM lessons, TCs struggled with how to engage all students in learning – not just the most vocal students. Over time, however, TCs found ways to make sure that all students were actively involved in the lessons. Some of the TCs refined how they presented materials to students and how they prompted students to work with those materials. One TC stated that, "One thing I loved about this lesson in particular was that students were the main handlers of the materials…the students learned so much more by actually manipulating the materials on their own!" TCs found that even by simply changing the timing of when the materials were brought out students more focused on the lesson and their own ideas.

Many other TCs found that to increase student participation in the lesson, they needed to make deliberate moves to include those students in the conversation. For example, after teaching a lesson about natural hazards to a group of students and noticing that a shy student was not participating, a TC engaged the student in the following way:

> As we were cleaning up our activity, I pulled up a chair (so we were at the same basic eye level) and started cleaning beside the quietest student of the group. I casually asked him as I wiped down tables, "So [student's name], if I were to come up to you and say 'I will give you one million dollars if you can build me a house that will absolutely withstand a flood,' what kinds of materials do you think you would use on that house?" He didn't initially respond so I said, "Would you make your house out of paper?" He immediately answered no. I asked him why not and he gave me a very thoughtful answer of why not. I asked him, "What about brick?" He very quickly answered yes and was able to defend his answer. This was the same kid who when asked by the teacher, me, in the whole group setting about what materials he was using in his structure and why, he said, "I don't know." Having a conversation in a less formal and less threatening way like that, allowed me to…connect with the student.

Similarly, another TC found that he needed to deliberately include a student in an activity about circuits to have her voice heard:

> One thing I was pretty proud of doing was when there would be someone who was a little more quiet or shy or less outgoing…getting that person involved…There was a little girl who pretty much got it [the content] but just was not going to talk. I asked her idea and had her work with her working group leader at the time. And I was like, "Maybe she has an idea." And he asked her and she said they should do this and here's what they should have done. They started working together on that and got it figured out…They were all talking together and they went to her because she was the one that made it work.

As the semester progressed, there were fewer comments from TCs concerning non-participation from students, and many more stories like these. Through practice, TCs found ways to "not leave students behind" while they were teaching.

The previous sections describe shifts in practice that TCs noticed throughout the semester, which was quality of their questions, discussion techniques, and student participation. In the next section, we will describe how elements of the SCTM supported this growth. Namely we will discuss the focus on the FfT, the video reflection process, and structural components of the SCTM that supported growth.

<u>What Supported Shifts in Practice?: The Danielson Framework for Teaching</u>

One of the requirements of the SCTM reflection was that TCs were to frame their reflection in terms of the identified component(s) of the FfT. By the end of the semester, most TCs were able to easily and correctly identify pieces of the FfT components in their teaching and describe how those components positively impacted their teaching, as illustrated in the following statement: "Phrasing that question a little bit different seemed to skyrocket the students' engagement right off the bat, which is a part of Domain 3b in the Danielson Framework." As indicated by this comment, the FfT provided TCs with a target for evaluating the quality of their questions and for giving them ideas about the kinds of questions that are desirable.

For each component in the FfT, there is a general narrative of the goals and qualities of the component, as well as a bulleted list of behaviors that can be seen at each level (1/Unsatisfactory to 4/Distinguished). Therefore, TCs could identify goal behaviors or actions in addition to identifying current behaviors. For example, one TC stated,

> It was during this [lesson] that students were building off one another's ideas to share their knowledge. In the Danielson Framework, that is a significant aspect of questioning and discussion techniques: "Students extend the discussion, enriching it. Students invite comments from their classmates during a discussion and challenge one another's thinking."…[This] challenges me to pursue those outcomes even more next time.

Another TC reported that she had created note cards of what a 3/Proficient looked like for each of the components and brought them with her during her SCTM teaching so she could remind herself and her group members what they should be working on.

What TCs appreciated in particular about the FfT with the SCTM was that they were not being asked to focus on all 22 components at once. TCs called the FfT as a whole "overwhelming" and "a lot", so they found it valuable to focus on "a little bit" of the FfT to get used to it. In the same vein, with many TCs teaching actual elementary students for the first time during SCTM, they found it comforting that they could focus on being successful in just a few areas. One TC joked, "It's nice having that thought, being like, 'OK. Even if I butcher this lesson, if I have good questioning, then at least I'm making improvement.'" TCs took solace in the fact that they did not have to be perfect or even make improvement in all realms of teaching; they could place the three FfT components at the fore and appreciate the small victories.

<u>What Supported Shifts in Practice?: The Reflection Process</u>

Consistent with the literature on video reflections and reflections on teaching more generally, TCs in this study found the FfT-guided video reflections to be useful. The first element of the reflection that TCs identified as being beneficial was the scaffolded nature of the FfT reflection prompts. TCs appreciated that each iteration of the SCTM required them to build upon the previous FfT component and continue to think about the same practices in their teaching. One TC noted that as she planned for her lessons and viewed her instruction, "We didn't forget about what we had previously learned [regarding the FfT]…We kept building off of that…It was a good progression, but still repeating that practice. I think that helped." TCs also found the FfT-focused reflection prompts helped them to kick-start their thinking when it came time to process the experience and write about it:

> I think each time, I was like, "Oh. I have to do this reflection. What am I going to say?" And then as soon as I did it, I would be like [motions writing quickly]. I could just – it just all came out. I had plenty to say!

More generally, the fact that there *was* a reflection assignment to complete in conjunction with the SCTM pushed TCs to think more deeply about their practice. One TC stated that had there not been a reflection assignment, "I would not have gone back through those videos as much as I did…So the reflection part was key," while another TC commented, "Just the fact that I knew I had to reflect was the biggest part [of the SCTM]."

In addition to the FfT-guided prompts, the videos that TCs watched of themselves teaching was a second useful element of the reflection process because the video made the otherwise invisible visible. Although most TCs commented about hating watching themselves on video, all TCs found the videos to be invaluable to the improvement of their teaching because inevitably, "I definitely saw stuff that I did that I didn't think I did." Many TCs noticed students' reactions to their instructional moves, such as one TC who noted, "I would be really awkward and I would ask a question and get a one-word answer and then silence," or another TC who observed, "That doesn't go very well when I just test them. But if I do this or this, then they're more willing to be engaged," or a third TC who saw that when she asked a simple question, "That kind of natural question seemed to engage several students because two or three of them started to explain to me what energy was." Interestingly enough, the videos also allowed TCs to acknowledge the successes they had during teaching that they had not previously recognized. For example, one TC found that she was always very hard on herself while teaching,

> But it helped going back and watching the videos because a lot of times I would think I just bombed and I was just like, "Gosh. I stumbled over my words so much and I had no idea what I was saying." But then actually watching it, I was like, "Oh wait. No. They actually understood and you did fine." Especially for me, when I'm teaching or talking, I feel like, "Oh my gosh. They're not understanding me." But then when I would actually watch the videos, I would be like, "OK. You did just fine!"

We believe the fact that the videos allowed TCs to notice both successes and opportunities for growth to be a particularly powerful benefit to the video reflection process.

Finally, the video reflection process allowed students to think through their actions and reconceptualize their instructional strategies. TCs took the request to consider future instructional actions based on their video reflections very seriously. Consequently, throughout the semester, TCs took action to refine the types of questions they asked as well as how to best present science content to students. One TC stated that, "This experience has made me grow as a teacher by allowing me to make mistakes and then learning from them." She went on to say that that the combination of watching the videos and writing allowed her to make sense of her teaching:

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> I also know that when I was writing, things would pop up and then I would think about it and as I would write about it, I was figuring out why I did those certain things or why I wasn't. So it slowed the process down of reflecting. And so that meant that I got more out of it…As I was writing, I was explaining myself and by explaining myself I figured out why it was good or why it was bad and that, I think, is the key to eventually learning about what I need to improve on.

All of the TCs recognized that reflection is an essential part of being a good teacher, and took the process to heart. As one TC shared,

> Analyzing the videos of me teaching the science lesson helped me realize how important it is to start being a reflective practitioner…Teaching the science lesson was half of the learning experience for me. The rest came from viewing the videos…and using this evidence to inform and improve for the next SCTM

<u>What Supported Shifts in Practice?: Structural Components in the SCTM</u>

In addition to the FfT and video reflection process, all of the TCs found that the structures inherent in the SCTM supported them in their professional growth (see Figure 1). First, as seen in Figure 1, one of the key components of the SCTM is that groups of TCs have multiple opportunities (typically eight times) to teach the same lesson. TCs appreciated this safe environment in which they could try out new strategies and improve throughout the day. Often TCs commented in their reflections that their lessons were much improved from the first time they taught to the last time they taught for the day; they noted that confidence was boosted, questioning and discussion techniques were adjusted, directions became clearer, and comfort levels increased. One TC correctly pointed out that teaching – as with any skill – requires purposeful repetition: "It's kind-of like a sport. You have to practice it to be good at it." The SCTM allowed TCs to practice teaching not only eight times in one day, but also three days within the semester – twenty-four lessons' worth of practice.

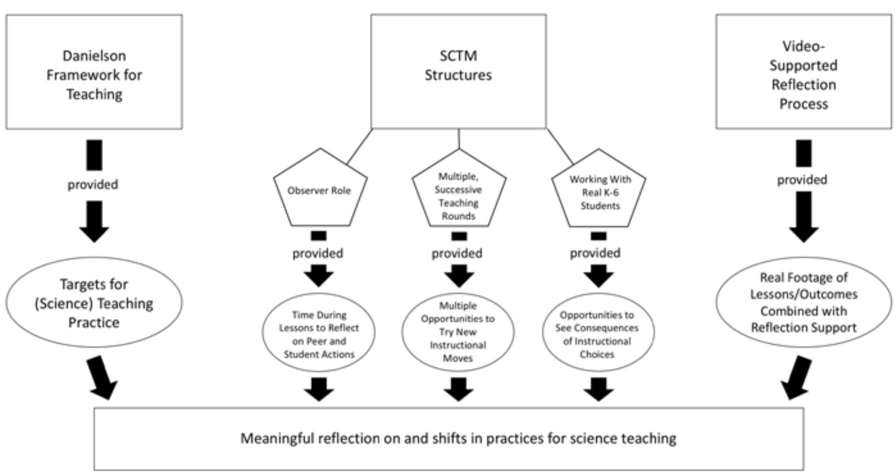

Figure 1. How the SCTM and focused video reflections support TCs.

An obvious yet important structure inherent to the SCTM is that the lessons are implemented with real students in real schools. TCs typically said that this was the best part of the SCTM, and the course more generally; in many other methods courses, lessons are often written but never implemented. And, as one TC observed, there can be a big difference between theory and practice: "Just writing a lesson plan…isn't always very helpful. I mean, it can be helpful, but it's not reality. You never know until you try something." TCs also saw the SCTM as an opportunity to try out what they were learning in class in a timely manner:

> …a lot of these courses in education, it's like, "This is theoretically how you're supposed to teach it." And you're just like, "OK. But then I'm not going to be teaching for like a year or something until student teaching and now I've forgotten." So that was really helpful to be able to take what we were learning and examples that [the instructor] showed of mini-lessons and then transfer that to actually teaching. I think that's more valuable than just hearing about it.

Through this model, TCs began to see what theory might look like in practice and tried their hand at the pedagogies described in their science methods course.

Finally, TCs appreciated having time to be an observer during the SCTM. Certainly the observer role served a practical purpose in that the observer was the person responsible for recording the lead instructor during the lesson. However, the observer was also able to distance him/herself from the lesson a bit and think about the teacher moves and student reactions more deeply. Many TCs took this opportunity to focus on the strengths of their peers. For example, TCs often shared comments such as, "I found things that they [peers] were saying that I wasn't saying that I could take," and, "I was very impressed with how [peer] would allow the students to explain and then she'd always have a really good spot-on question…And then [peer] was really good at explaining things." Other TCs focused their attention on students and their reactions to the lesson, which was equally if not more instructive. TCs would note, for example, when students "took to" a particular line of questioning or what the lesson looked like from the students' point of view. Consequently, while TCs certainly wanted to serve as the lead instructor as much as possible so they could refine their techniques, TCs also saw the value in stepping back to observe and learn from their peers and the students.

Discussion and Conclusion

Our intent in this study was to examine the usefulness of a purposefully designed activity to help TCs focus their attention on key aspects of science teaching. In particular, we were interested in the ways in which the SCTM and focused video reflections support TCs in crafting opportunities for students to develop deep understandings of science. Both the TCs and the researchers were able to document growth in the quality of TCs' question prompts, their discussion techniques, and the extent to which they witnessed student participation. And although the focus of this research is on the two new components of the SCTM (video reflections and the FfT), we would argue that it is the combination of the original SCTM structures and these new components that allowed TCs to gain a more nuanced understanding of how instructional moves support reform-oriented science instruction; each piece contributed meaningfully to TCs shifts in practice, as seen in Figure 1.

To begin, consistent with the literature, the use of a framework to guide reflection proved to be a key piece of TCs' success in reflection. In the past, the authors have struggled with this reflective piece, as we typically received the types of reflections that Baker El-Dib (2007) and Davis (2006) had described: a listing of what happened throughout the lesson and whether or not the TC was 'happy' with his/her performance. By using the FfT to guide TCs' reflections, the FfT informed their instruction in a cyclical manner. First, the FfT provided targets for TCs to aspire to. The levels of the FfT (1-3) demonstrate the differences between novices and experts, which allowed TCs to aspire to particular behaviors (Santagata & Angelici, 2010) and perhaps deliberately include these in their lessons and/or implementations. Then, after the lesson when TCs were reflecting on the videos, the FfT focused their gaze so that they did not have to attend to seemingly millions of things at once. Simultaneously, similar to Scherff & Singer's (2012) findings when they used a framework to focus preservice teachers' observations, the FfT allowed TCs to "notice elements of practice they had previously overlooked" (p. 271). As such, one could think of the FfT or any other reflective framework as both a magnifier and a blinder, which allows TCs to think deeply about their practice and plan thoughtfully for future instruction.

The main advantage of the SCTM is that it is rooted in practical experience, which aligns with practice-based pedagogy (Ball & Forzani, 2009). The SCTM allowed TCs to work with actual students three times throughout the semester, and with three different topics and grade levels, rather than engage in less authentic peer teaching. However, SCTM takes this authentic practice a step further by allowing TCs to teach the same lesson several times in one day. This presented TCs with multiple opportunities to see how students responded to their instructional choices in real time, and unlike other authentic school-based implementations of TCs teaching science (e.g. Bottoms, Ciechanowski & Hartman, 2015; Lampert, et al., 2013), the SCTM allows TCs to rapidly react and alter their instruction for future iterations of the same lesson, and then try out those alterations rather than hypothesizing about how those alterations would or would not play out. Additionally, the multiple iterations of the same lesson allow TCs to observe the variety in elementary students' reactions to the same instruction, which may prove helpful to the TCs in terms of future lesson differentiation.

Finally, the use of the video-supported reflection process alongside the SCTM proved to be invaluable in terms of having TCs focus on the realities rather than the perceptions or vague memories of their practice. As Hawkins and Park Rogers (2016) and Rosaen et al. (2010) suggested, the use of video can provide TCs with opportunities to stop, rewind, and slow down the teaching process so they can better dissect the actual implementation. Along with the FfT, videos enabled TCs to point to opportunities for growth in their teaching and be thoughtful about the cause and effect relationships in their teaching moves. That said, having the video recordings not only allowed TCs to examine their struggles, but also appreciate their successes. Given how the myriad challenges novice teachers encounter when they begin their career, particularly in terms of teaching science in ways that are new and different (Avraamidou & Zembal-Saul, 2010), we believe it is important for TCs to begin to feel successful in their science teaching and start building self-efficacy in this realm.

Note that there are limitations to this study. The participants in this study were a convenience sample, as they were in one science methods course easily accessible to the authors. Additionally, this study only focused on a subset of students in the methods course who had a complete data set. As such, we would welcome replication studies to build upon the findings in this study so as to provide additional support for the outcomes of the SCTM combined with focused video reflections.

The SCTM as described in this study was an intentionally structured, practical experience that allowed TCs to focus on aspects of questioning and leading discussions in science. All the elements of the SCTM worked together with the focused video reflections to allow TCs to see ways in which their practice improved over time. Young and Bender-Slack (2011) note, "Without guidance, preservice teachers find it challenging to recognize what matters in teaching and to make meaning about what they see" (p. 15). This study demonstrates how teacher educators might meet that challenge and prepare TCs to be reflective practitioners.

Appendix A: Video Reflection #3

While participating in SCTM, your colleagues videoed your teaching. This means that you may have videos of 2-3 lessons. Please watch ALL of the videos you have and write a reflection that responds to the areas below.

Focus Areas

For this third SCTM, you will focus your attention on three components: *Component 3a: Communicating With Students, Component 3b: Questioning and Discussion Techniques,* and *Component 3c: Engaging Students in Learning.*

Component 3a: Communicating With Students	**Component 3b: Questioning and Discussion Techniques**	**Component 3c: Engaging Students in Learning**
• Expectations for learning • Directions for activities • Explanations of content • Use of oral and written language	• Quality of questions/prompts • Discussion techniques • Student participation	• Activities and assignments • Grouping of students • Instructional materials and resources • Structure and pacing

Please see the Danielson Framework handout from class for more specific information on these components.

You will find evidence in the ***conversations*** that you are having with students, ***explanations/responses*** that the students provide, as well as in the ***statements*** you are making about the lesson.

Rate Yourself

Rate yourself on each component according to the Danielson Framework from 1 to 3. Justify your rating.

Questions to Consider

Reflect on your actions and their impacts. These are a few questions that may help drive your reflection:

- What is the *quality* of your conversations with students?
- What is the *purpose* of your conversations with students?
- What are the key science learning moments?
- How did you facilitate the key science learning moments?
- In what ways could you alter your questioning/discussion techniques to elicit more high-quality discussion in your future science lessons?
- Where was there clarity? Where was there confusion?
- How do you know students understood what you were saying?
- Was the explanation of the content correct?
- Were there times that your choice of words could have caused misconceptions about the content?
- Were the students *intellectually engaged* in your lesson? How do you know?
- Were there instances in which students exhibited higher-order thinking?
- Did students have opportunities to provide evidence and explain reasoning?
- What was the impact of the materials you chose for your lesson?
- How does what you saw in the videos impact how you think about science as a teacher?

References

Avraamidou, L. (2016). Intersections of life histories and science identities: The stories of three preservice elementary teachers. *International Journal of Science Education, 38*(5), 861–884.

Avraamidou, L., & Zembal-Saul, C. (2010). In search of well-started beginning science teachers: Insights from two first-year elementary teachers. *Journal of Research in Science Teaching, 47*(6), 661–686.

Baker El-Dib, M. A. (2007). Levels of reflection in action research. An overview and an assessment tool. *Teaching and Teacher Education, 23*, 24–35.

Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*(5), 497–511.

Bottoms, S. A. I., Ciechanowski, K. M., & Hartman, B. (2015). Learning to teach elementary science through iterative cycles of enactment in culturally and linguistically diverse contexts. *Journal of Science Teacher Education, 26*(8), 715–742.

Cochran-Smith, M., Villegas, A. M., Abrams, L. W., Chavez-Moreno, L. C., Mills, T., & Stern, R. (2016). Research on teacher preparation: Charting the landscape of a sprawling field. In D. H. Gitomer & C. A. Bell (Eds.), *Handbook of research on teaching* (5th ed., pp. 439–547). Washington, D.C.: AERA.

Danielson, C. (2013). *The framework for teaching evaluation instrument, 2013 edition* (2nd ed.). Princeton, NJ: Danielson Group.

Darling-Hammond, L., Hammerness, K., Grossman, P., Rust, F., & Shulman, L. (2005). The design of teacher education programs. In L. Darling-Hammond, J. Bransford, P. LePage, K. Hammerness and H. Duffy (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 390-441). San Francisco: Jossey-Bass.

Davis, E. A. (2006). Characterizing productive reflection among preservice elementary teachers: Seeing what matters. *Teaching and Teacher Education, 22*, 281–301.

Davis, E. A., & Smithey, J. F. (2009). Beginning teachers moving toward effective elementary science teaching. *Science Education, 93*(4), 745–770.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013–1055.

Harris, C. J., Phillips, R. S., & Penuel, W. R. (2012). Examining teachers' instructional moves aimed at developing students' ideas and questions in learner-centered science classrooms. *Journal of Science Teacher Education*, *23*, 769-788.

Hawkins, S., & Park Rogers, M. (2016). Tools for reflection: Video-based reflection within a preservice community of practice. *Journal of Science Teacher Education, 27*(4), 415–437.

Hiebert, J., Morris, A.K., Berk, D., & Jansen, A. (2007). Preparing Teachers to Learn from Teaching. *Journal of Teacher Education*, *58*(1), 47–61.

Hollins, E. R. (2011). Teacher preparation for quality teaching. *Journal of Teacher Education*, *62*(4), 395–407.

Johnson, H. J., & Cotterman, M. E. (2015). Developing preservice teachers' knowledge of science teaching through video clubs. *Journal of Science Teacher Education, 26*(4), 393–417.

Kittleson, J., Dresden, J., & Wenner, J.A. (2013). Describing the upported Collaborative Teaching Model: A designed setting to enhance teacher education. *School-University Partnerships*, *6*(2), 20-31.

Lampert, M., Franke, M. L., Kazemi, E., Ghousseini, H., Turrou, A. C., Beasley, H., … Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education, 64*(3), 226–243.

Laparo, K. M., Maynard, C., Thomason, A., & Scott-Little, C. (2012). Developing teachers' classroom interactions: A description of a video review process for early childhood education students. *Journal of Early Childhood Teacher Education*, *33*(3), 224–238.

Larrivee, B. (2008). Meeting the challenge of preparing reflective practitioners. *The New Educator*, *4*(2), 87–106.

Lemke, J. (1990). *Talking science*. Norwood, NJ: Ablex.

McNeill, K. L., & Pimentel, D. S. (2010). Scientific discourse in three urban classrooms: The role of the teacher in engaging high school students in argumentation. *Science Education, 94*, 203-229.

Menon, D., & Sadler, T. D. (2016). Preservice elementary teachers' science self-efficacy beliefs and science content knowledge. *Journal of Science Teacher Education, 27*(6), 649–673.

Mikeska, J. N., Anderson, C. W., & Schwarz, C. V. (2009). Principled reasoning about problems of practice. *Science Education*, *93*(4), 678–686.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classrooms*. Philadelphia: Open University Press.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

Rosaen, C. L., Lundeberg, M., Cooper, M., & Fritzen, A. (2010). Interns' use of video cases to problematize their practice: Crash, burn, and (maybe) learn. *Journal of Technology & Teacher Education, 18*(3), 459–488.

Roulston, K. *Reflective interviewing: A guide to theory and practice.* Los Angeles, CA: Sage.

Saldaña, J. (2016). *The coding manual for qualitative researchers.* (3rd ed.). Los Angeles, CA: Sage.

Sandholtz, J. H., & Ringstaff, C. (2011). Reversing the downward spiral of science instruction in K-2 classrooms. *Journal of Science Teacher Education, 22*(6), 513–533.

Santagata, R., & Angelici, G. (2010). Studying the impact of the lesson analysis framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education, 61*(4), 339–349.

Santagata, R., & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM Mathematics Education*, *43*, 133–145.

Scherff, L., & Singer, N. R. (2012). The preservice teachers are watching: Framing and reframing the field experience. *Teaching and Teacher Education, 28*(2), 263–272.

Star, J. R., & Strickland, S. K. (2008). Learning to observe: using video to improve preservice mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education*, *11*(2), 107–125.

The Danielson Group. (2017). *The framework*. Retrieved from https://www.danielsongroup.org/framework/

Trygstad, P. J. (2013). *2012 National survey of science and mathematics education: Status of Elementary School Science*. Chapel Hill, NC.

Wilson, R. E., Bradbury, L. U., & McGlasson, M. A. (2015). Integrating service-learning pedagogy for preservice elementary teachers' science identity development. *Journal of Science Teacher Education*, *26*(3), 319–340.

Wilson, S. M., Schweingruber, H. A., & Nielson, N. (2015). *Science teachers learning: Enhancing opportunities, creating supportive contexts.* NASEM: Washington, D.C.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*(1), 112–143.

Young, T., & Bender-Slack, D. (2011). Where do I look? Preservice teachers' classroom observation patterns. *Mid-Western Educational Researcher, 24*(2), 15–20.

Zeichner, K. (2010). Rethinking the connections between campus courses and field experiences in college- and university-based teacher education. *Journal of Teacher Education, 61*(1-2), 89-99.

Zembal-Saul, C. (2009). Learning to teach elementary school science as argument. *Science Education, 93*(4), 687–719.