Preservice Secondary STEM Teachers' Reflective Practice in Microteaching

An Analysis of Journal Writing and Video-Mediated Reflections

Deepika Menon & Rosetta Ngugi

Abstract

Reflective practice is an important component of preservice teacher education programs and is frequently used during field experiences; however, less is known about reflective practice in microteaching. This qualitative case study examined preservice secondary STEM teachers' reflective practices after their microteaching experience in a STEM methods course at a large Mid-Atlantic public university. Particularly, the study investigated two reflection approaches, a written reflective journal and a video-mediated reflection on the same microteaching episode. We used content analysis to identify and compare the salient features in 27 preservice secondary teachers' video-mediated and journal (nonvideo) reflections. Our analysis led to three categories representing the salient features from the two sets of reflection—teaching strategies to foster student learning, student engagement and classroom discourse, and teacher personality and nonverbal communication. Within each category, and for the two reflection approaches, we describe

Deepika Menon is an assistant professor of science education in the Department of Teaching, Learning, and Teacher Education of the College of Education at the University of Nebraska-Lincoln, Lincoln, Nebraska. Rosetta Ngugi is a lecturer in the Department of Physics at Kennesaw State University, Kennesaw, Georgia. Email addresses: dmenon2@unl.edu & rngugi@kennesaw.edu

(a) the content or the focus of participants' reflective thinking, (b) challenges in microteaching recognized by the participants, and (c) suggestions for future teaching practices. Our findings provide valuable insights for teacher educators to make informed decisions about selecting reflection approaches that fit the course context and the goal of reflection.

Introduction

Reform recommendations for teacher education emphasize high-quality training programs to prepare effective and reflective teachers (Amobi, 2005; Amobi & Irwin, 2009; Karlström & Hamza, 2019). Suggested effective approaches in science methods courses for teacher preparation include incorporating field experiences (Liakopoulou, 2012), microteaching experiences (Amobi, 2005; Fernández, 2005), and reflection on teaching practices (Amobi & Irwin, 2009; E. Davis, 2006; Karlström & Hamza, 2019; Loughran, 2002). However, studies have argued that teacher education programs fall short in preparing preservice science teachers (Darling-Hammond & Cobb, 1996; Lee, 2005; Windschitl et al., 2012), primarily due to the disconnect between theory and practice (Loughran, 2006). Microteaching is an on-campus practice-based model that provides a supportive environment for them to nurture their planning, teaching, and reflection (Bell, 2007; Kpanja, 2001) and communication skills (Amobi & Irwin, 2009; Grossman, 2009). Microteaching was formulated at Stanford University in the 1960s (Allen & Eve, 1968) and consisted of three phases: (a) a planning phase where a preservice teacher plans a lesson, (b) a teaching phase where the lesson is taught to peers, and (c) a reflection phase to reflect on their teaching experience (Bell, 2007; Fernández & Robinson, 2006).

Reflection on teaching is one of the essential tenets of microteaching (Amobi & Irwin, 2009). Reflective practice provides opportunities for preservice teachers to challenge their preexisting beliefs about science teaching in light of the new experiences (Loughran, 2002) that can potentially help their teacher professional growth (Lee, 2005). However, research has suggested that preservice teachers are often not engaged in high-quality reflective thinking (E. Davis, 2006; Lee, 2005) because reflection is "premature in the preservice years" (Bain et al., 2002, p. 9). Studies found that providing preservice teachers with a supportive environment and explicit prompts to stimulate reflection does not always guarantee in-depth self-analysis on teaching actions (Amobi, 2005; Amobi & Irwin, 2009). Both studies, Amobi (2005) and Amobi and Irwin (2009), found that despite preservice teachers asserting that microteaching was a valuable learning experience, not all are receptive to self-criticism.

Reflection is stimulated using various techniques, including action research, case studies, essays, discussion, and writing tasks (Karlström & Hamza, 2019; Sherin & van Es, 2005). More recently, video-mediated reflection tools are used to develop preservice teachers' reflective skills (Bayat, 2010; Fernández, 2005; Hawkins & Rogers, 2016; Nagro et al., 2017; Sherin & van Es, 2005). Even with the tools and strategies available for reflection, it is particularly challenging for science educators to

promote productive reflection among preservice teachers because the tasks or prompts do not always lead to desired or expected results (Amobi, 2005; Amobi & Irwin, 2009). Also, reflection or reflective practice has been defined and conceptualized in various ways, which has created confusion among teacher educators who implement reflection within their teacher preparation courses (Clarà, 2015; Gelfuso, 2016).

Focus of This Research and Research Questions

Although studies on preservice teacher reflection within the context of field experiences are abundant (Arsal, 2014; Loughran, 2002; Ralph, 2014), fewer studies have focused on reflective practices within microteaching. Studies that focus on reflective practices document using journal writing or video-stimulated recall interviews within their preservice courses (Bain et al., 2002; Bayat, 2010). One pertinent question is how to determine whether some reflective tools or strategies work better than the others in terms of the intended outcome. Does the use of different approaches allow preservice teachers to focus and reflect on the same or different aspects of their teaching? More research is needed to determine the *extent* to which various approaches can promote productive reflection (E. Davis, 2006), and the present study addresses this gap in the literature. One way to consider this is by allowing preservice teachers to reflect on the same teaching episode using different reflection approaches. Such an exploration will provide evidence-based insights on how teacher educators can make informed decisions about selecting reflection strategies that fit the course context and the goal of reflection, and how and in what ways different reflection approaches create opportunities to support learning. With this intention, we framed our research in which preservice secondary science and mathematics teachers reflected on their microteaching episodes using two different modes of reflection, a written reflective journal (nonvideo) and a video-mediated written reflection. Specifically, the following research questions (RQs) guided this investigation:

1. What are the salient features in preservice science and mathematics secondary teachers' general (nonvideo) and video-mediated reflections on their microteaching?

2. How do preservice secondary teachers' reflective practices compare for the two modes (video mediated vs. nonvideo) when reflecting on the same microteaching episode?

Theoretical Framework and Background Literature

The following sections describe the theoretical framework and the central research issues relevant to this exploration.

Reflective Practice in Teacher Education

As a field, teacher education has conceptualized and defined reflective practice in many ways. Early conceptualization of reflection stems from Schon's (1983, 1987)

and Dewey's (1933) work that highlighted "reflective thinking" as a process that involves identifying, framing, and reframing a problem and allowing inquiry-based approaches to resolving the problem. Drawing from Dewey's ideas, Amobi (2005) defined the reflective practice as "a tendency to revisit the sequence of one's teaching for the purpose of making a thoughtful judgment" (p. 116). Reflective practice allows the "actions of teaching to be exposed so that various elements can be examined, discussed, analyzed, modified, and incorporated into one's practice" (Hawkins & Rogers, 2016, p. 417). According to E. Davis (2006), reflection is productive when teachers are able to demonstrate a "complex view of teaching" (p. 281), which encompasses seeing and reacting appropriately to classroom interactions and helping learners communicate their ideas (E. Davis, 2006; M. Davis, 2003). Authors describe the features of productive reflection as consisting of "the integration of ideas about multiple aspects of teaching, such as learners and learning, subject matter knowledge, assessment, and instruction" (E. Davis, 2006, p. 281). On the other hand, unproductive reflection is "mainly descriptive, without much analysis, and involves listing ideas rather than connecting them logically" (E. Davis, 2006, p. 282).

While teacher educators attempt to develop preservice teachers' reflective practices, there is a consensus in the literature that preservice teachers are rarely able to demonstrate a high level of reflective thinking (Ward & McCotter, 2004). Reflection is stimulated using various techniques, such as action research, case studies, discussion and written tasks, and video-based reflections (Karlström & Hamza, 2019; Sherin & van Es, 2005). Teacher educators commonly use written tasks to develop preservice teachers' reflective thinking skills. However, researchers have found that writing descriptive reflections does not necessarily result in productive reflection (E. Davis, 2006; LaBoskey, 1994; Spalding et al., 2002). Without training, preservice teachers may lack the ability to analyze their teaching and may not offer evidence in support of their assertions, interrogate their presumptions, or come up with new suggestions to implement in their teaching (LaBoskey, 1994; Zembal-Saul et al., 2000).

Affordances of Video-Based Reflections

More recently, video-based reflective analysis is gaining popularity within the methods courses to develop preservice teachers' reflection skills. Video-based reflections can be used for preservice teachers to "notice" and "develop new ways of seeing" the events that occurred in their classrooms (Sherin & van Es, 2005, p. 471). The practice of viewing videotapes of their microteaching and writing a self-critique of their instruction encourages the development of self-introspection (Amobi, 2005). Videos encourage "complacency" as preservice teachers bridge the gap between memories of their teaching experience and the unaltered video evidence (Rosaen et al., 2008, p. 358). It can also be argued that video reflections help preservice teachers to shift their focus from classroom management issues to areas of their professional growth that need attention (Rosaen et al., 2008). Another

advantage of video reflection is that preservice teachers can watch the footage of their teaching multiple times, pause, and move back and forth. This process may encourage what van Es and Sherin (2008) described as "learning to notice" and further enhances preservice teachers' ability to perceive the strengths and weaknesses in their instruction.

It is emphasized that opportunities be available for preservice teachers to observe their actions and gestures to nurture preservice teachers' ability to reflect (Liakopoulou, 2012). In Bayat's (2010) study, video recordings of field experience and journal writing were used to facilitate productive reflection among preservice teachers. Findings from Hawkins and Rogers's (2016) study show that using the video-based reflective tool helped preservice teachers realize the importance of eliciting and attending to student thinking. Benefits of video reflections are noted in the literature; however, another line of research claims that preservice teachers do not respond well to video analysis due to the stress of being filmed and being anxious about their inexperience in speaking to audiences (Coffey, 2014). Not all preservice teachers feel comfortable watching their episodes (Zhang et al., 2011), which may expose their insecurities or challenge their presumptions about teaching. On the contrary, Seidel and colleagues (2011) found that teachers were more motivated and felt "inside the lesson" (p. 266) when analyzing videos of their own teaching than they were watching peers teaching. Continued research is needed to understand the affordances of video-based reflections to assist preservice teachers in developing their reflective skills, especially within the context of microteaching.

Methodology

Research Design

This qualitative case study incorporated multiple sources of data collection and analysis. A qualitative case study is a research design that "explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information" (Creswell, 2013, p. 97). We used a case study methodology to describe a phenomenon (reflective practice) in a specific context (microteaching). Preservice secondary teachers enrolled in the science, technology, engineering, and mathematics (STEM) methods course serve as a *case* (Baxter & Jack, 2008; Yin, 2009).

Study Context

This study was conducted at a large Mid-Atlantic public university in a semester-long secondary STEM education methods course within the secondary education program (Grades 7–12). Students enrolled in the secondary education program choose their majors in either a science (biology, chemistry, earth-space, or physics) or mathematics discipline. Typically, preservice teachers are enrolled

in the STEM methods course in their junior year, after completing the science and mathematics content courses. The class meets three times a week for 50 minutes for 15 weeks.

The design components of the course offer opportunities to expose preservice teachers to the historical developments of science and mathematics aspects relevant to future teachers. The course goals included enhancing preservice teachers' inquiry skills by exposing them to research-based pedagogies and science and engineering practices aligned with the Next Generation Science Standards (NGSS) three-dimensional framework. The STEM integrated lessons and activities were designed by a collaborative faculty team consisting of a scientist (chemistry-nano chemist), a science educator, and a mathematics education faculty. One of the model lessons focused on energy as the disciplinary core idea (Menon & Devadas, 2019) and the 5E model as the pedagogical approach, including engage, explore, explain, elaborate, and evaluate as key components for inquiry-based instruction (Bybee, 1997). The lesson targets a real-world problem of energy deficiency and solar cells using nanoparticles as the potential solution to the problem. The lesson engaged preservice teachers in discussing the historical significance of nanoparticles, followed by exploring the nature of nanoparticles using mathematical concepts. They calculated the surface-to-volume ratios of the real cube models to understand the size-dependent optical property changes that nanomaterials exhibit and formulated evidence-based explanations to understand the use of nanoparticles in making efficient solar cells for light harvesting.

The preservice secondary teachers paired up to plan and design a science lesson and coteach for 25 minutes to their peers in a microteaching setting. Preservice teachers were encouraged to work in groups of four for planning the science lesson, especially those pairs who were designing lessons centered around a similar core idea (e.g., light or waves). Participants were provided with a template to give the information about the target audience, topic, science (NGSS) and mathematics (Common Core) standards, safety precautions, and target science and engineering practices used. They also described each of the 5E phases (Bybee, 1997) and formative and summative assessments embedded seamlessly throughout the lesson. There were various opportunities for preservice teachers to get feedback on the draft lesson plans. The faculty team provided feedback on the content, pedagogy, and overall STEM integration of the lessons twice to the group of preservice teachers. Moreover, one class period was spent on peer feedback on the draft lesson plans. Groups of preservice teachers (groups comprising four to six) were asked to share their plans with their peers to get additional feedback before the lesson implementation. Although different from field experiences, microteaching exposes preservice teachers to the realities of the classroom in a simplistic form and provides a low-risk supportive environment to nurture their teaching and reflective skills (Amobi & Irwin, 2009; Fernández, 2005).

Participants and Data Sources

A total of 27 preservice secondary science and mathematics education majors were enrolled in the STEM education methods course. All agreed to participate in the study by signing the informed consent forms. The demographics of the participants are provided in Table 1. We collected a variety of primary and secondary sources of data. The primary data sources included two reflection sets, a general reflection (GR) guided by open-ended prompts, a video-mediated reflection (VR) based on the teaching episode's videotape, and open-ended prompts. The secondary data sources included lesson plans and researchers' field notes on microteaching in real time.

Preservice teachers were paired up to plan, design, and teach their science lessons (see Appendix A for details on the science topics taught by student teachers), and the teaching sessions were videotaped. They were asked to reflect and write reflective journals within a week after their teaching. The open-ended prompts for general reflections included reflecting on things that went well and why, things that did not go well, changes, and suggestions for future lessons and their overall professional growth. These prompts were not prescriptive; instead, they served as a guideline to identify the successes, the onset of difficulties, and a plan to mitigate these for their future teaching. A week after the preservice teachers submitted their general reflections, they were provided with the video files of their teaching episodes and given a week to view, reflect, and write their video reflections (a total of 3 weeks

Table 1
Participant Demographics

	n
Major	
Science	13
Mathematics	14
Gender	
Female	18
Male	9
Race/ethnicity	
Caucasian	20
African American	4
Hispanic	2
Native American	1
Year of program	
Freshman	2
Sophomore	7
Junior	17
Senior	1

Note. N = 27.

after their teaching episodes). The video self-reflection assignment was structured to elicit responses from participants who were more critical of their instruction based on science education reforms. For example, the video self-reflection profile prompts were structured in chronological order according to the 5E model (see Appendix B). According to Postholm (2008), compelling teachers to think in novel ways or view situations from other perspectives helps stimulate their development as reflective practitioners.

Data Analysis

We used content analysis (Bengtsson, 2016) to identify and compare the salient features in preservice secondary teachers' video-mediated and general (nonvideo) reflections. According to Krippendorff (2004), content analysis is defined as "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" (p. 18). The content analysis is particularly suitable for our study. We utilized the analytical framework by Bengtsson (2016) for analyzing the data in four distinct stages: (a) the decontextualization, (b), the recontextualization, (c) the categorization, and (d) the compilation. Data were revisited several times at each of the four stages to ensure the validity, reliability, and trustworthiness of the analysis. In the following pages, we describe the four stages in detail (see Table 2 for the example of the analysis).

Decontextualization

Data were read and reread several times during this stage, and open coding procedures were implemented to derive initial codes that emerged from the data. We divided the written texts into meaningful *units* and assigned codes. To ensure validity, three researchers analyzed one video-mediated reflection and one general (nonvideo) written reflection randomly picked by the team. Two of them were experts in qualitative analysis; one was a faculty member in science education, the other in mathematics education, and a graduate student (master's). The three researchers met to discuss the *units* and the codes that each researcher located and discussed any alternative interpretations until we reached a consensus.

Recontextualization

In this stage, the research team revisited the data to capture additional *units* and label codes. We also revisited the list of codes for selecting relevant codes and deselecting those that seemed to be of less importance in understanding preservice teachers' reflective practice. At this stage, an initial coding scheme was developed that centered around three fundamental patterns framed as three key questions (the theoretical bases for these questions were also based on Karlström & Hamza, 2019): What is the participant focusing on (salient features) in their reflections? What are

the major challenges that the participant emphasized when narrating their teaching episodes? What does the participant recognize as a need for change as they reflect on their teaching?

Categorization

We rearranged the codes to sort into categories and subcategories in this stage. The categories and subcategories were then reassembled into emergent themes. At this point, we revisited the data to draw relevant links between the codes and identify any additional category or subcategory. Keeping the key questions intact (as described earlier), we found three categories that emerged from general reflec-

Table 2
An Example of Content Analysis

Meaningful unit	*Code*	*Subcategory*	*Category*
The microteaching activity helped my learning of how to teach a science/ mathematics lesson based on the NGSS-3D models because it allowed us to focus specifically on the engage, explore, and explain sections. The NGSS-3D models help us focus on making sure students are meeting the necessary standards in various ways that most effectively activate their learning.	• Learning how to teach science/ mathematics • Engage, explore explain NGSS-3D models • Focus on activate [students] learning effectively	• Focus on the importance of teaching strategies • Focus on the use of teaching strategies to activate student learning	• Teaching strategies to foster student learning (the focus)
I would have liked to have had students build their own telephones as well so that they feel more engaged in their experiment. This would have allowed students to focus on a lot of extraneous variables that affected both the results and student understanding, such as the space between the can hole and strings and the string material.	• Students build their own telephones • More engaged in the experiment • Student understanding of extraneous variables (space, material)	• Suggestions for increased student engagement	• Student engagement and classroom discourse (suggestions for increasing student engagement)
I was monotone, and I sounded like I was scared to talk when I actually got the chance to speak during the presentation. I could have talked with the students a lot more, verifying their comprehension and having them talk me through what they were doing.	• Monotone and sounded scared to talk • Teacher-student discourse	• Teacher personality and verbal communication (suggestions for future improvement)	• Teacher personality and communication

tions: teaching practices, student engagement, and challenges faced in teaching. The three categories from video-mediated reflections were teaching practices, student engagement, and personality.

Compilation

At this stage, we created a matrix (see Table 3) to organize our categories and subcategories with codes. For example, although the categories for the two sets of reflections are similar, there were differences in each criterion, (a) focus, (b) challenges, and (c) suggestions for future improvement, for video-mediated versus nonvideo reflections. For the purposes of confirming the results, primary and secondary data sources were triangulated. Other trustworthiness measures included ensuring the credibility, transferability, and confirmability, as these are concerned with the "external validity" of the research (Shenton, 2004). The rigorous procedures adopted for investigating the phenomena under investigation (i.e., the setting, participants, and timeline) provide a clear understanding of the study and ensure replicable results in similar settings or situations. In this study, three researchers carried the analysis independently to minimize the researchers' bias. The final themes are presented as findings.

Table 3
A Matrix of Video Reflection Categories and Codes

	Teaching strategies to foster student learning	*Teacher personality and nonverbal communication*	*Student engagement and classroom discourse*
Focus	• Group discussions • Asking questions • Giving directions • Activity/experiment • Small-group discussions • Time allotment for activities	• Tone • Verbal • Nonverbal • Gestures • Position in classroom • Body language	• Student understanding • Student responses • Group work • Partner work • Student interest • Worksheets/handouts • Student concerns
Challenges	• Pacing too slow/fast • Need more time/ limited time • Technical difficulties • Time management • Forgetting something	• Lack of confidence • Unprepared • Distracting • Speaking out of turn • Monotone	• Student focus • Student confusion • Off-task • Student concerns • Worksheet or assessment clarity for students • Pace for students
Suggestions for future improvement	• Time management • Questioning • Backup plan • Addition of something (e.g., closure activity) • Demonstrating an example	• Confidence • Future preparation • Speech habits (umm) • Posture • Expressions • Tone • Professionalism • Enthusiasm	• Increasing involvement • Peaking students' interest • Adding more content • Checking understanding • Additional time

Findings

The results from the content analysis are organized under the two RQs of the study. We present the salient features from the two sets of preservice teachers' reflections (RQ 1). We also compare the salient features from the two modes of reflection (RQ 2). Within each category, and for the two modes, we describe (a) the content or the focus of participants' reflective thinking, (b) challenges in microteaching recognized by the participants, and (c) suggestions for future teaching practices.

Teaching Strategies to Foster Student Learning

General Reflections: The Focus. One of the salient features illustrated in preservice teachers' written reflections was the importance of teaching strategies to foster student learning. The data indicated a range of pedagogical strategies described by participants, including teaching methods and tools, hands-on activities, and whether the teaching methods effectively enhanced students' scientific knowledge about the topic. Following is the excerpt from a participant's reflection while responding to the prompt "what went well and why?" The episode is about a lesson on static electricity where students rubbed a balloon with different materials to record the number of confetti dots picked up by the balloon. Students were asked to draw a bar graph of their findings. The participant reflection suggested the importance of clear directions on how students can interpret the data and draw meaningful conclusions:

> The directions guided the students in completing the task and then constructing a bar graph in which they could compare side to side the conductivity of the materials. The follow-up questions following the activity helped students to see triboelectric charging in action and form an idea of what would happen if two balloons were rubbed together. The students followed the directions given and successfully completed interpreted the graph. (GR, Participant 10)

In the preceding excerpt, the participant concluded that clear directions led to the students' successful interpretation of the graph. Although other participants also realized the importance of the link between teaching methods and student learning, they did not sufficiently explain why certain instructional decisions did or did not work as intended. We categorized these reflections as descriptive or "simply recalling" events. The following excerpt is shown as an example of a lesson on sound waves:

> My partner and I taught a lesson on energy through sound waves. Some things that went well during this lesson is that the class understood the activity using the tin can phones. We introduced the lesson effectively by allowing the students to experiment with the tin can telephones. I think that we responded relatively appropriately to the statements that were given and the questions that were asked. (GR, Participant 15)

While the participant used terms like "experiment" and "asking questions" as a teaching strategy, use of words like "I think" or "relatively appropriately" indicates

an "in-progress" reflection related to the connection between the instructional decisions and the impact on student learning.

Participants often referred to the 5E model, the three-dimensional model of the NGSS, and science and engineering practices. Interestingly, participants started to notice and realize how these models are interconnected and powerful when the models work together rather than as "stand-alone" or piecemeal. The following excerpt highlights this notion:

> The microteaching activity helped my learning of how to teach a science/mathematics lesson based on the NGSS-3D models because it allowed us to focus specifically on the engage, explore, and explain sections. The NGSS-3D models helps us focus on making sure students are meeting the necessary standards in various ways that most effectively activate their learning. By using the science and engineering practices we could ensure that our essential E's [referring to the 5E model] are supported and implemented in a way that would enhance student learning. (GR, Participant 2)

Video-Mediated Reflections: The Focus. We were particularly interested in whether engaging in video-mediated reflections shifted the focus of the teaching strategies highlighted in the written reflections or stayed the same. We found that video-mediated reflections drew their attention to notice how specific strategies were operating for them as teacher-interns and their students (peers) within the shared space (classroom). They also began to realize their positioning (as teachers), students' positioning (splitting into smaller groups), and how the strategies provided opportunities or increased challenges for their students, which did not appear part of their written reflections. One participant said that engaging in "video reflections allowed me to see my own tendencies as a teacher" (VR, Participant 10). This participant had earlier noted in the written reflections about her static electricity activity as a success due to clear directions and students' interpretation of the bar graphs. After seeing the video, she realized that "teachers presented the PowerPoint on static electricity and why it does what it does [referring to the balloon when rubbed with different materials] and they seemed to enjoy these visuals; however, the PowerPoint was hard to see" (Participant 10). The participant realized the importance of using visuals only if done correctly. The teacher-intern (Participant 24) who worked together with Participant 10 on the lesson on static electricity noted in her video reflections that learning objectives were not part of the PowerPoint and were "only presented verbally." In this case, Participant 24 started to recognize the importance of using *multiple representations* in teaching. As she further noticed after watching the video, the "instructions for the activity were only written on the worksheet and not presented verbally or on the PowerPoint."

Other participants particularly noted the elements that seemed to play an important role in the successful implementation of the teaching strategies, such as the pace and timing allotted for the activity and the overall instructional flow and

transitions between the various phases of the lesson, which were not highlighted in the written reflections. For example, Participant 4 reflected on an episode highlighting a group of four students working together on the lesson on light propagation, when students had a laser shining through a diffracting grating:

> Students' preconceptions were challenged when they saw the results, 09:15 [referring to the time points on the video]. They were given time to make a prediction, which they had drawn on the white board. Some gave quiet exclamations about their surprise, and Mia [pseudonym] expressed confusion in saying "wait, how are you . . ." Once the experiment was conducted, they each saw the result, and Kelsey [pseudonym] drew on the board what actually happened. They all compared their results to their predictions they drew earlier. The flow of this portion allows students to move through the lesson together. The pacing for this experiment relies on the students. (VR)

The preceding example demonstrates that Participant 4 paid attention to and sensed how the group dynamics worked with the instructional strategies and the importance of taking time for students to realize that their preconceptions are being challenged and to formulate new conceptions based on the evidence.

Challenges Identified in General and Video-Mediated Reflections. In this section, we describe the findings that emerged from the general and video-mediated reflections related to the challenges that participants identified about the instructional strategies (as part of the question "what did not work well and why?"). By comparing and contrasting the challenges students expressed in their reflections, we found that students tended to notice things differently when relying on memory (written reflections) versus reflecting while watching videos. The major challenges noted in the written reflections were the appropriateness of the content for the middle school classroom, time management, and the lack of clarity in giving instructions. For instance, a participant reflected on the activities and the relevance of the content for a middle school classroom:

> It seemed as though students were understanding the basic concepts of sound waves; however, I don't think it would have been up to a middle school level with the basic information we covered. I think we could have gone more in depth about what variables affect the traveling waves the most and why exactly this happens. (GR, Participant 8)

The use of words like "seemed as though" and "I think" suggests deeper thinking to support her inference making about the content's appropriateness for middle school. In another example from the general reflections, a participant referred to the lack of clear directions during the lesson on light waves, where students were conducting an activity with mirrors:

> Throughout the lesson it was apparent that the directions were not given with great clarity. An example of this came during the setup for the main activity (the stations exploring refraction and reflection). The students did not understand how

> the mirror activity was supposed to be executed; unfortunately, the reexplanation of the directions was still insufficient. (GR, Participant 21)

In the video reflections, it appeared as though participants paid more attention to the context in which the events were positioned and to verbal and nonverbal cues. While referring to the challenge about the content appropriateness in her video-based reflection, the participant provided evidence:

> I come to this conclusion based on the reaction and body language of the students. They were too focused on playing with the cans. I noticed students sitting there and doing nothing [6:40–13:30, time points]. I even found myself walking around looking for something to do or someone to question to fill the time. (Participant 12)

In the description, the visuals enabled the participant to reflect on the verbal and nonverbal cues and her role as a teacher, emphasizing the importance of nonverbal cues that are only visible when watching videos. Another participant referred to the video and stated,

> I did not realize until watching the video that the objectives were neither displayed on the board nor verbally given to the students. Because there was a lack of objectives and learning goals, the intent of the lesson was not clear to the students from the beginning. (VR, Participant 2)

Suggestions for Improvement in Teaching. In this section, we describe the findings from preservice teachers' general and written reflections on suggestions and recommendations highlighted for improving their future teaching practices. One of the major categories that participants discussed in general and video reflections was improving their skill for *asking questions*. In general reflections, participants suggested including probing questions that promote "deep thinking" (Participant 12). For example, one participant reflected on her desire to improve on questioning to promote meaningful discussions in her lesson on energy associated with the egg drop experiment:

> I feel like I could have asked more thought-provoking and less superficial questions during this section. A lot of questions were just emphasizing multiple times that energy is not destroyed but rather goes to other places. I would have liked to go deeper into that by having a discussion about where the energy actually goes and why. (GR, Participant 6)

Other participants also suggested "moving beyond asking for repetition of definition or asking the student to repeat by simply putting something into their own words" (GR, Participant 14).

Interestingly, in participants' video reflections, they made connections between what the questions was intended for and its outcome in terms of how the students responded to the question. For example, Participant 24 (who worked with Participant 10) suggested changes to their questioning patterns by having higher-level questions instead of yes/no-type questions:

> In reviewing the lesson video, I realized that if we were to reteach this lesson, having higher leveled questions would be necessary. I noted that we had minor low cognitive thinking questions. We had three yes/no questions at time 2:12 [time point] with pictures of a child with hair sticking up, and a shock by a doorknob and asked "have you ever felt a shock from touching a door knob"? One thing I did notice that students were talking amongst themselves or shaking their heads in response to the question, but no one answered out loud how we expected. The engage was really about 12 seconds long, which was disappointing to see in the video. (VR, Participant 24)

The preceding excerpt suggests that the participant determined the effects of questioning on students (peers) and noticed that the yes/no-type questions did not provide opportunities for students to talk. She used the evidence from videos to realize the importance of higher-level questioning using words like "I notice" or "I noted after reviewing video" versus the phrases "I feel" or "I think," which many participants used in their general reflections. Other suggestions for improving teaching strategies were related to integrating science and engineering practices throughout the lesson. For example, Participant 15 (who worked on the egg drop experiment, where students created barriers for the egg) suggested "students to weigh their barriers and mathematically reason why some barriers worked, and others did not."The participant pointed out watching videos as helpful "to pinpoint a few areas to improve on, such as instructional strategy and thought-provoking questions" (VR).

Student Engagement and Classroom Discourse

The Focus. Another dominant feature highlighted in reflections was classroom discourse opportunities that increase student engagement in the science lesson. In general reflections, we found that most participants focused on students' involvement in activities, the exchange of ideas within small-group discussions, the importance of questioning, and their appreciation of scientific ideas. While responding to the prompt on things that went well, a general theme was that students responded well to the activities and questions that challenged them to think critically. Participant 1 described an episode from her lesson on the conservation of energy where the lesson shows how "potential energy from the balls transfers to kinetic energy and then it is all transferred to the top ball, which goes flying off when stacked." She further elaborated on holding "class discussions and think-pair-share to get students to critically think and reflect about the topic." Her teaching partner, Participant 13, emphasized the importance of classroom discussions to get multiple perspectives:

> Instead of having one person answer the question, I had two or more students give me an answer before I moved on. Having multiple responses was very beneficial to the discussion. I also gave multiple answers and cleared up any misconceptions in their understanding of the topic. (GR)

While the salient themes in the video reflections were the same as those in the general reflections, the supporting evidence was different as participants paid

close attention to students' reactions (nonverbal cues) to make conclusions about students' engagement within the topic. The video reflections added an extra layer of clarity for participants to see whether students were engaged in their activities. For example, Participant 4 shared how an experiment "can truly drive curiosity and interest" and that students (peers) were surprised by their findings related to a light pattern:

> I believe the best part of my lesson was the reaction from the audience after seeing the result of the experiment. The students, intuitively, believed that the resulting light pattern would be a small dot with a dark line cutting through the center. However, what happened (interference patterns) surprised the students. There were "ooo's" and "aaah's." I find this to be the best part because it shows how the students' misconception was realized. (VR)

We also found that participants were making inferences as they used phrases to describe how students responded to the questions posed and whether those questions helped students connect with the content or clear a misconception. As Participant 17 (teaching partner with Participant 4) noted in her video reflections,

> the engagement was a class discussion about their preconceptions of light and its behavior properties. This seems to have been effective in getting the students thinking because many of their facial expressions reflected being in thought. At 01:00 [time point], both Mia and Myra [pseudonyms] seemed to be interested in Kelsey's idea of what light is.

Challenges and Suggestions for Increasing Student Engagement. We found that participants were keen on describing alternative ways to improve student engagement. Most of the preservice teachers indicated a desire to enhance the lesson with more in-depth classroom discussion, trying a different approach to the activities, or changing the order of the activities to maximize inquiry. For example, a participant suggested incorporating a game to involve students before they watch a video:

> I think that if we had the students play the matching game with the pictures and captions first, then watch the movie and then go back to the matching timeline game to reevaluate the choices they made and switch the orders or captions if need be. I think that would have a more inquiry-based approach to the lesson rather than giving them all the information up front and then having them just take that and do the timeline activity. (GR, Participant 5)

Another participant mentioned increasing student involvement by building the tin can telephones rather than giving premade ones. She elaborated,

> I would have liked to have had students build their own telephones as well so that they feel *more engaged* in their experiment. This would have allowed students to focus on a lot of extraneous variables that affected both the results and student understanding, such as the space between the can hole and strings and the string material. (GR, Participant 12)

From the video reflections, it appeared that participants were benefited by "seeing" their actions as teachers and provided suggestions to improve student engagement. One participant referred to the benefits of watching videos where she "can notice if students are off-task, and if I am working with a student or not" (VR, Participant 10). Another participant proposed a note-taking strategy for better engagement after watching the video:

> As I was watching the playback, it became very apparent that the students needed somewhere to put the information we were throwing at them. At 3:18 [time point], I even found myself thinking as I was watching it, "Wow, they really did need a guided note-taking handout." (VR, Participant 11)

Teacher Personality and Nonverbal Communication

We found that participants mentioned their personality traits in their video reflections, which was not a theme that was prominent in their written reflections. While reflecting, participants noted several traits, such as tone, gestures, body language, and positioning in the classroom. It appeared that participants were paying more attention to their posture and expressions when watching their videos than when writing general reflections relying on memory. While reflecting on an episode where the participant-intern was facilitating student discussions on the topic of photosynthesis, she noted, "My presence during the explanation was powerful, but at times it was distracting because I spoke over and interrupted my partner [intern] often. This likely did not contribute positively to a learning environment" (VR, Participant 27). It appeared that participants had started to understand the importance of "teacher presence" and "teacher talk" and how they contribute to the overall learning environment. Another participant referred to the importance of the teacher's movement and position during discussions:

> In my future classroom, I will make sure to keep my presence known throughout the entire room, even when I am the only teacher. This includes avoiding turning my back to the class and when discussing with students individually, making sure I am at least facing the rest of the class. (VR, Participant 17)

In their reflections, participants often confirmed whether their tone and body language suggested enthusiasm, confidence, and professional attitude or needed improvement. For instance, one participant mentioned,

> I was monotone, and I sounded like I was scared to talk when I actually got the chance to speak during the presentation. I could have talked with the students a lot more, verifying their comprehension and having them talk me through what they were doing, so that they realize what they are doing and how it related to the whole topic of light waves. (VR, Participant 7)

During reflections, participants referred to the teacher's posture when probing students' questions. Participants realized that a teacher's posture could be welcoming to students and that "it is always a good idea to keep an open posture" because

"folded arm project a defensive or closed-off body language" (VR, Participant 4). Also, participants paid attention to using "words too often as 'fillers,' such as the word 'right' or 'OK'" (VR, Participant 5). Another participant stressed language and professionalism, as she mentioned, "I noticed from watching the video that I say 'uhm' and 'like' a lot; this sounds unprofessional and it only encourages the students to say those words when they present as well" (VR, Participant 8). Several participants appreciated videotaping and reflecting on their videos, which allowed them to watch for areas of improvement. One participant mentioned, "In future, I will videotape myself teaching every once in a while to see if I can spot some areas of improvement that I didn't notice as I was teaching" (VR, Participant 10).

Discussion and Conclusion

This study contributes to the literature on preservice teachers' reflective practices in several ways. First, while most studies have focused on reflective practices during field experiences, this research focused on reflective practices of secondary preservice teachers in a microteaching context. Considering that most of the preservice teachers benefited from reflective practices, this study points to microteaching as a powerful context for promoting reflective thinking among preservice science teachers. Amobi and Irwin's (2009) study pointed out that "microteaching with its practice of scaled-down teaching, feedback and self-analysis" (p. 32) supports the development of preservice teachers' effective reflective skills. Although research has suggested that reflecting on one's field experiences supports the development of reflective skills (Arsal, 2014; Loughran, 2002; Ralph, 2014), studies have also noted that reflection is often "premature in the preservice years" (Bain et al., 2002, p. 9) and that reflection alone is not sufficient to develop better practitioners. When it precedes field experiences, microteaching provides a supportive environment for preservice teachers to nurture their reflective thinking and teaching skills (Amobi & Irwin, 2009).

Second, the study compared the unique elements of preservice teachers' reflections on the same teaching episode utilizing two distinct modes of reflection that required preservice teachers to rely on their memory after their microteaching episode (general written reflections) versus video-mediated reflections. An interesting question investigated here is what difference it makes when preservice teachers rely on their memory for writing written reflections versus when they watch themselves teach (video episode) and reflect on their teaching. Another important consideration is what salient features of teaching and "episodes that matter" to preservice teachers are being emphasized in the two modes (general vs. video mediated) of reflection. Gelfuso (2016) challenged preconceived notions about reflection as "spontaneous" because preservice teachers often struggle to focus on and infer from their teaching experiences. In fact, reflection is "content specific," and it requires teacher educators to support preservice teachers "in seeing aspects of their experience" (Gelfuso, 2016, p. 77), which can be well supported by providing preservice teachers with multiple opportunities to reflect on their teaching episodes. As in the case of this

study, both modes of reflection provided scaffolding or guided prompts for preservice teachers to process their teaching in parts rather than feeling overwhelmed with recalling information. A high-quality reflection not only describes salient aspects of teaching but will also interrogate teachers' presumptions, offer evidence in support of their assertions, and suggest improvements for future teaching (E. Davis, 2006; LaBoskey, 1994; Zembal-Saul et al., 2000).

Our data found that video reflections allowed preservice teachers to shift their focus from "general" to "specific" aspects of teaching. Other studies have also noted affordances of teachers watching videos of themselves and reflecting, especially around attending to student thinking (Hawkins & Rogers, 2016; Jin et al., 2017). Our results show that participants focused on three areas of their teaching practices more broadly—teaching strategies, student engagement, and personality; however, the levels of reflectivity demonstrated within the two modes of reflection were different. For instance, preservice teachers paid more attention to *how* and *why* to provide sufficient evidence to support the teaching aspect they were describing. It was also found that preservice teachers pay attention to the nuances of facial expressions and body language, for both themselves as teacher-interns and their peer-learners, which were not part of general reflections.

The video analysis design allowed preservice teachers to reflect on their teaching in both a critical and a comprehensive manner. Studies have suggested that preservice teachers need sufficient guidance and prompting to notice "seeing what matters" for effective science instruction (E. Davis, 2006, p. 281). Video-mediated reflections enabled preservice teachers to capitalize on the flexibility of video playback and watch their videos in a staggered fashion, correspondingly allowing them to reflect critically on each stage of the lesson. The study demonstrates that preservice teachers can reflect productively with scaffolds and open-ended writing tasks. E. Davis (2006) and many others also stress that open-ended tasks stimulate reflective thinking (Amobi, 2005; Fernández, 2005).

Implications

Three implications emerge from the study. First, *multiple modes of reflection are needed to enhance preservice teachers' reflective thinking skills to develop as reflective practitioners long term.* Instead of one, the combination of two or more opportunities helped preservice teachers realize the role and importance of verbal and nonverbal cues in delivering effective science instruction. Video-mediated reflection allows preservice teachers to "dig deeper" into making connections between what Clarà (2015) postulated, based on the previous work on reflection by Dewey and Schon, as "a continuous interplay between observation and inference" (p. 267). Teacher educators must create opportunities to include video-mediated reflections for preservice science and mathematics teachers with sufficient support to nurture their reflective skills. In addition to individual video reflections, video

clubs, which allow a group of teachers to come together to discuss their respective teaching episodes, are yet another promising tool that also model professional collaboration (Sherin & van Es, 2005).

Second, *microteaching offers a powerful context for fostering novice preservice teachers' reflective and teaching skills before entering formal classroom teaching.* Based on the findings from this study, we can expect that microteaching provides a safer and supportive environment for preservice teachers before they step into "real-world" settings, as those formal environments can be intimidating and detrimental to developing reflective and teaching skills.

Third, *more longitudinal studies are needed to understand the affordances of video-mediated reflections in preservice teacher education.* One may argue that watching videos increases possibilities where preservice teachers are put into situations where they could naturally see glimpses of their personalities (nonverbal cues, body language, facial expressions). However, one of the challenges of video is overemphasis on self and potentially misfocused attention on superficial items, which may shift preservice teachers' focus from noticing other aspects of teaching. More research is needed to understand how preservice teacher preparation programs can effectively utilize video-mediated reflections and the long-term effects of such approaches on developing reflective skills to understand how productive reflection translates to classroom practice. In this study, we did not investigate the individual differences between preservice science and mathematics teachers' written reflections nor the impact of demographic variables, but these could be interesting areas of future research.

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Appendix A

Science Topics by Participants

Teaching partners (participant no.)	*Science topic*
1, 13	Conservation of Energy and Momentum with Bouncing Balls
2, 6, 14	Conservation of Energy in Egg Drop
3, 15	Eggciting Force and Energy in Egg Drop
5, 16	Fruiticity Lab (Using Fruit to Generate Electricity)
4, 17	Light and How It Travels
7, 18, 21	Light Waves
8, 19	Sound Waves
9, 20	Power Grids
10, 24	Static Electricity
11, 23, 26	Wave Motion and Energy Transfer
12, 25	Characteristics of Sound Waves
22, 27	Photosynthesis

Appendix B
Video Analysis Self-Reflection Template

Description	*Reflection*	*Self-improvement (what could be improved?)*
	In this column, reflect on your successes and shortcomings (with evidence and examples from Video, and timing, example [video: 0:01–0:21]).	In this column, provide suggestions for your continuous improvement based on video analysis of the lesson.
Instructional Objectives • Were the objectives and intent of the lesson clearly presented? • Did you rephrase your instructions if your students were at a loss, or did you translate them?		
Introduction (Engage) • Was an idea or activity used to stimulate interest in the lesson able to motivate students?		
Exploration • Were students given ample time to conduct exploration? • What modes of interaction were used (whole class, individual work, pair work, group work, etc.)? • How do you think students benefited from these? • How do you feel about the choice of activities? • Was there any technology involved? Were they suitable for the grade being addressed? • Were students' concerns addressed? • Was pacing too fast or too slow for a majority of students? • Were activities provided to students who finished early? • What was planned for students who did not finish? • Were your strategies effective?		
Explain (Meaning-making) • Did you confirm the right answers? • How did you correct wrong answers? • Did students learn what the lesson/ exploration intended? • Reflect on your facial expressions, posture, use of gestures, language, and tone. Were you monotonous? Was your use of gestures sufficient?		
Elaborate • Was activity connected to students' prior understanding? • Were students given ample time to conduct the activity? • What modes of interaction were used (whole class, individual work, pair work, group work, etc.)? • Do you think students benefited from these? • How do you feel about the choice of activities? • Were they suitable for the grade being addressed? • Were students' concerns addressed? • Was pacing too fast or too slow for a majority of students?		
Evaluate (Assessment) • Were assessments used to find out the extent to which the objectives were achieved? • How did the closure to the lesson happen?		