Implementing Tool-Supported Rehearsals for Ambitious Science Teaching in an Elementary Science Methods Classroom

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Abstract

In this article, we focus on the implementation in our elementary science methods course of a suite of tools supporting peer rehearsals designed to provide opportunities for preservice teachers to notice and analyze important features of ambitious science instruction prior to teaching in elementary classrooms. The tools include (1) an Engage-Explore-Explain (EEE) Framework for Science Teaching and Learning, which is similar to the first three phases of the 5E learning cycle (2) a list of Developing Student Ideas targeting science concepts in the lessons (3) a list of Common Challenges to Scientific Practices often experienced by elementary science learners; and (4) a EEE Framework feedback form. In rehearsals, novices use the tools to teach specific ambitious practices to their peers and the teacher educator. As the novices elicit and support students' thinking, the peers and teacher educator use the tools to determine how to respond in ways that reflect children's sensemaking and use of scientific practices. We developed the tools to guide novices in (a) designing lessons that engaged elementary students in sensemaking about natural phenomena using scientific practices; (b) anticipating, eliciting, and constructively responding to student ideas during instruction; and (c) reflecting on important features of their own science instruction. We describe the learning opportunities tool-supported rehearsals provide for novices to try out and collectively analyze moves for supporting students' sensemaking. We also discuss how the just-in-time coaching from teacher educators and peer feedback may develop novices' pedagogical content knowledge and prepare them to engage children in ambitious practice in elementary school classrooms.

Introduction

Like many science teacher educators, we strive to prepare our preservice teachers to teach science in ways advocated by new science education reforms. These reforms acknowledge the complexity of meaningful, deep science learning and call for an integrated approach to instruction where teachers help students use scientific practices to develop, deepen, and apply their knowledge of core ideas and crosscutting concepts (National Research Council, 2012; NGSS Lead States, 2013). Supporting this vision of teaching and learning is complex. Novice teachers need support in recognizing the subtleties of this kind of ambitious instruction in science classrooms (Windschitl, Thompson, Braaten, & Stroupe, 2012). Indeed, we are challenged to prepare novices to facilitate students' sensemaking in ways with which they may not be familiar (Appleton, 2007). Moreover, novices may need support in learning how to deepen their own science content knowledge to successfully facilitate children's science understanding (Abell, 2007).

Developing science content knowledge and learning to engage students in scientific practices involves two important aspects. First, it entails learning to notice (van Es & Sherin, 2008), understand, and shape the existing ideas that students may have about particular phenomena (Zembal-Saul, Blumenfeld, & Krajcik, 2000). Second, it involves learning to anticipate and notice students' use of scientific practices to investigate science phenomena and to support those that move learners toward meaningful science learning and understanding. Learning to notice, understand, and shape student science ideas and practices requires not only action on the part of the novice but also guided reflection on their instruction.

Science and mathematics teacher educators have recently been using peer-teaching rehearsals in methods classrooms to prepare novices to engage children in ambitious practice when they later work with them in classrooms (Benedict-Chambers, 2016; Davis & Boerst, 2014; Lampert, Franke, Kazemi, Ghousseini, Turrou, & Beasley, 2013; Windschitl et al., 2012). Rehearsals are different from run-throughs of lessons that sometimes occur in methods classrooms where peers and teacher educators observe instruction and offer feedback at the end (Grossman, 2005). There are three main differences in rehearsals in regards to the roles of peers, the teacher educator, and the type of instruction enacted. First, rather than just observe the instruction or offer feedback at the end, in rehearsals the peers actively respond to the instruction in ways that represent children's thinking and the range of interactions teachers may encounter in a classroom setting. Second, in rehearsals, the teacher educator does not wait until the end to give feedback, but rather takes an active role during the lesson. The teacher educator may offer examples of common alternative conceptions that children could have about a science concept for the teacher to take up during the instruction. The teacher educator might also pause the rehearsal to offer just-in-time coaching or to engage the class in a discussion where they reflect on ways to respond to student performance. These discussions allow the teacher educator to use the novices' instruction as a venue for helping them notice the principles, practices, and content knowledge entailed in the complex work of teaching (Lampert et al., 2013). As the class collectively discusses problems of practice, they can develop a shared understanding for how to interpret and manage the difficulties of ambitious practice. Finally, in rehearsals novices enact specific teaching practices that are deliberately chosen to enable novices to elicit student understanding and to make judgments about how to respond to student performance. These are practices the class had previously studied in video clips of instruction (e.g., videos where teachers probe student thinking or help students write claims supported by evidence).

Although some might feel that rehearsals do not offer the benefits of classroom experiences, many teacher educators argue that the opportunity to focus on the difficult work of responding to student ideas and to have in-the-moment discussions of alternative teaching moves may outweigh the perceived constraints of this approach. Similarly, scholars who study rehearsals argue that while novices are certainly learning to teach during student teaching, their attention may not be focused on the principles and practices entailed in ambitious teaching (Davis & Boerst, 2014; Lampert et al., 2013; McDonald, Kazemi, & Kavanagh, 2013; Windschitl et al., 2012). In sum, although the students in the rehearsals are not elementary children, the rehearsals are designed to be approximations of actual classroom interactions where novices must interpret and manage the complexities of authentic practice (Grossman, Compton, Igra, Ronfeldt, Shahan, & Williamson, 2009).

Drawing on this research, we developed a suite of tools to use with rehearsals in our elementary science methods classroom. The tools scaffolded three critical learning opportunities for novices as they prepared to teach science lessons in classrooms at the end of the semester. These opportunities included (1) designing lessons that engaged elementary students in sensemaking about natural phenomena using scientific practices; (2) anticipating, eliciting, and responding to developing student science ideas and common challenges of using scientific practices; and (3) noticing and analyzing the instructional moves they made in their rehearsals to support student learning. In this article, we focus on the ways the tool-supported rehearsals provided novices with opportunities to notice and analyze important features of science instruction prior to teaching lessons in actual elementary classrooms.

Theoretical Framework

To develop the tool-supported rehearsals in the elementary science methods course, we used the research of Grossman et al. (2009) on the ways that novices in different professions are prepared to enact and notice features of complex practice. Their framework of practice includes three components: (1) representations of practice such as video recordings of instruction, (2) decompositions of practice involving the identification of features that may not be visible to novices, and (3) approximations of practice such as teaching rehearsals. For instance, in a beginning class for clinical psychologists, Grossman and colleagues found that professors first represented, or modeled ways to develop a therapeutic alliance between a therapist and client. After the representation, professors decomposed the practice, and used a particular language for talking about different approaches for responding to clients. After discussing these moves, the novice psychologists approximated the interactions and took on the roles of a therapist and a client as they worked to build a therapeutic alliance. These approximations provided novices with opportunities to experiment with specific aspects of complex practice. Support and feedback during the approximations prepared them for the uncertainties of real clinical practice.

Developing tools to support novice teacher noticing and analysis

To help the novice teachers learn to notice and analyze important features of science instruction, we used a suite of tools that were developed by the first author (Benedict-Chambers, 2016). The tools included (1) an Engage-Explore-Explain (EEE) Framework for Science Teaching and Learning, which is similar to the first three phases of the 5E learning cycle (Bybee, Taylor, Gardner, Van Scotter, Powell, Westbrook, & Landes, 2006); (2) a List of Developing Student Ideas targeting concepts addressed in the rehearsals and classroom lessons; (3) a List of Common Challenges to Scientific Practices often experienced by elementary science learners; and (4) a EEE Framework feedback form.

Engage-Explore-Explain (EEE) Framework for Science Teaching and Learning

The first tool, the Engage-Explore-Explain (EEE) Framework for Science Teaching and Learning, was created to guide novices in designing, enacting, and noticing important features of ambitious science instruction (see Benedict-Chambers, 2016). The EEE Framework identified science teaching practices linked with each EEE phase that integrated the work of using scientific practices to promote student learning:

- *Engage phase:* Elicit and engage students' ideas with an investigation question
- *Explore phase:* Support students' observations and data collection explorations
- *Explain phase:* Help students notice patterns in data and develop evidence-based explanations

The teaching methods and scientific practices emphasized in the framework were based on recent research identifying high-leverage practices (e.g., Windschitl et al., 2012) and current reforms including the *Next Generation Science Standards* (NRC, 2012; NGSS Lead States, 2013). The scientific practices included asking questions, developing and using models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, and engaging in argument from evidence. The EEE Framework guided novices in identifying and embedding instructional moves to elicit students' ideas and use them as resources for learning throughout the science lesson.

Lists of Developing Student Ideas and Common Challenges to Scientific Practices

The second and third tools, a List of Developing Student Ideas and a List of Common Challenges to Scientific Practices, were designed to help novices anticipate, notice and understand the logic of typical ideas students may have about specific phenomena (see Appendix A), and difficulties elementary students commonly face in learning to use scientific practices (see Appendix B). The information about student science ideas was derived from research on student thinking related to the concepts in the lessons (e.g., Driver, Guesne, & Tiberghien, 1985). The scientific practice challenges, such as students' difficulties in making and recording qualitative observations in an accurate manner, came from the teacher educators' research and teaching experiences in elementary schools (see Arias, Davis, Marino, Kademian, & Palincsar, 2016). Novices were expected to include questions in their lesson plans to elicit and build off children's existing science ideas and to understand the logic of their possible developing and alternative ideas. During the rehearsals, peers roleplayed students with developing science ideas representing children's sensemaking strategies and the range of responses the novices might encounter in an elementary classroom. Peers also enacted scientific practice challenges to simulate interactions where "students" struggled to use the practices to construct scientifically acceptable explanations.

EEE Framework Feedback Form

The fourth tool, the EEE Framework feedback form, was developed to help novices attend to important features of each phase of EEE instruction during their own and peer rehearsals (see Appendix C). The feedback form names key teaching practices associated with each phase of the EEE science lesson. It describes three levels of performance for each teaching practice and provides space for observers to comment on peers' use of the teaching practices, ways to improve their instruction, and to pose questions to help clarify instruction during rehearsals. After the rehearsal, peers and the teacher educator record evidence of practice on the form to support their feedback claims about the teaching team's rehearsal. The teaching teams used the feedback to improve aspects of their instruction before teaching the lesson in elementary classrooms at the end of the semester.

Tool-Supported Rehearsals and Reflections

Novice teachers in the science methods courses were introduced to the suite of tools early in the semester, and the teacher educator provided rich in-class opportunities for novices to understand and use each of the tools (see Table 1). The EEE Framework form was applied to videos of science lessons where novices enacted key teaching practices associated with each phase of the Framework. The feedback form provided space for novices to sort through the complexity of the video case and to identify, describe, and analyze important teaching practices in writing. During and after each video example, the teacher educator facilitated discussions designed to help novices notice where practices occurred in the lesson, how practices were implemented, and general effectiveness of each practice in responding to existing and emerging student ideas and challenges to scientific practices.

The novice teaching teams applied their understanding of the tools as they planned the rehearsals. They used the EEE Framework for Science Teaching and Learning to develop the Engage, Explore, and Explain phases of the science lesson. They also designed the lessons to elicit and address the science conceptions and challenges to scientific practices reported in the Student Ideas and Challenges tools. The grade level of the elementary classroom and the state science learning standards determined the phenomenon investigated in each lesson.

Each teaching team's Engage, Explore, and Explain rehearsal was videotaped and the rehearsals lasted approximately 20 minutes. During the rehearsals, the peers simulated the role of elementary students exhibiting developing student ideas and common challenges to scientific practices. The peers also used the EEE Framework Feedback form during the rehearsals to record evidence of the teaching team's performance. During the instruction, the teacher educator offered approximately three just-in-time feedback comments, giving novice teachers opportunities to adjust their teaching as needed. Following rehearsals, the teacher educator, teaching teams, and their peers collaboratively discussed what they noticed about the teaching performance and how to manage any difficult interactions. Written feedback from both teacher educator and peers on the feedback forms guided this analysis. Sometimes these discussions focused on the teachers' own understanding of the phenomena, as a way to develop their science content knowledge. Other times the discussions focused on helping the novices more effectively facilitate students' conceptual understanding. For instance, in the rehearsal, a novice teacher may have explained to a peer student the accepted science idea and how it conflicts with an alternative idea offered by the peer student. After the rehearsal, the class may discuss ways to probe the peer student's thinking as a means for the novice teacher to acknowledge and try to understand the peer student's view. These discussions may help novices develop pedagogical content knowledge as they learn how to anticipate and respond to student thinking about particular phenomena in productive ways (Zembal-Saul et al., 2000).

After each class in which a rehearsal took place, novices individually reviewed their lesson videos, taking notes including time-stamps to cite as evidence, and completed the Science Teaching Rehearsal Reflection. The reflections were driven by prompts that directed the novices to focus on and analyze specific aspects of their instruction—science content, student ideas, and scientific practices.

Between the Engage and Explore lesson phase rehearsals on campus, novices visited their assigned elementary classroom to observe and gain entré into the existing classroom culture. They also drafted a pre-test, the results of which would inform their science lesson planning. Novices again visited their elementary classroom the week between the Explore and Explain lesson rehearsal to administer the pretests. At the end of the semester, teaching teams combined the phases to teach a complete EEE Framework lesson in the elementary classroom. Afterwards they administered a post-test designed to gauge student learning. The novices then analyzed their pre- and post-test student data, examined the video of their classroom lesson, and submitted a final reflection to address all three phases of the EEE science lesson.

Table 1 (Click on image to enlarge)

Tool and Rehearsal Use During a Semester Long Science Education Course

Week	Novice Teachers	Teacher Educator
1	• Participate in an *Engage-Explore-Explain (EEE) Framework* science lesson taught by the teacher educator • Use the *EEE Framework* to notice and analyze features of the science lesson	• Introduce the *Engage-Explore-Explain (EEE) Framework* by modeling and engaging novice teachers in an hour long science lesson • Help novices use the framework to notice and analyze aspects of the instruction
2	• Use the *EEE Framework feedback form* to notice and analyze aspects of the Engage phase in a teaching video • Begin co-planning Engage phase of EEE lesson plan on assigned concept with teaching team	• Assign novices to 3-person teaching teams • Assign science concept and grade level to each team for rehearsals and subsequent classroom teaching • Introduce and assign *Lists of Developing Student Ideas* and *Common Challenges to Scientific Practices* to each novice to role-play as a learner during rehearsals • Introduce *EEE Framework feedback form*, focus on the Engage phase by presenting a videoclip of an Engage phase for novices to analyze with the tool • Support novices in planning their Engage rehearsal
3	• Teaching teams rehearse the Engage phase to the whole class and collect "student" work • Peers role-play *Student Ideas and Common Challenges to Scientific Practices* as learners during rehearsals • Peers use the *EEE Framework feedback form* to offer teaching teams written feedback after the rehearsals • After class, novices analyze "student" work and videotaped rehearsal and submit Rehearsal Reflection on the Engage phase of EEE lesson	• Participate as a learner in novices' Engage rehearsals, offer just-in-time feedback during and after rehearsals • Facilitate whole-class discussion and encourage the other teaching teams to take up feedback offered to the rehearsing team
4	• Use the *EEE Framework feedback form* to notice and analyze aspects of the Explore phase in a teaching video • Begin co-planning Explore phase of EEE lesson plan with teaching team	• Introduce Explore phase of *EEE Framework feedback form* by presenting a videoclip of an Explore phase for novices to analyze with the tool • Support novices in planning their Explore rehearsal
5	• Observe assigned elementary classroom in local school; notice contextual factors related to science teaching	• Facilitate novice classroom observations at local elementary school
6	• Teaching teams rehearse the Explore phase to the whole class and collect "student" work • Peers role-play *Student Ideas and Common Challenges to Scientific Practices* as learners during rehearsals • Peers use the *EEE Framework feedback form* to offer teaching teams written feedback after the rehearsals • After class, novices analyze "student" work and videotaped rehearsal and submit Rehearsal Reflection on the Explore phase of EEE lesson	• Participate as a learner in novices' Explore rehearsals, offer just-in-time feedback during and after rehearsals • Facilitate whole-class discussion and encourage the other teaching teams to take up feedback offered to the rehearsing team
7	• Use the *EEE Framework feedback form* to notice and analyze aspects of the Explain phase in a teaching video • Begin co-planning Explain phase of EEE lesson plan with teaching team • Begin developing a pre-test to administer to children in assigned elementary classroom	• Introduce Explain phase of *EEE Framework feedback form* tool by presenting a videoclip of an Explain phase for novices to analyze with the tool • Support novices in planning their Explain rehearsal • Support novices in developing pre-tests
8	• Visit and observe assigned elementary classroom in local school • Administer science pre-test to children; analyze results and student ideas	• Facilitate novice school visit to administer science pre-tests
9	• Teaching teams rehearse the Explain phase to the whole class and collect "student" work • Peers role-play *Student Ideas and Common Challenges to Scientific Practices* as learners during rehearsals • Peers use the *EEE Framework feedback form* to offer teaching teams written feedback after the rehearsals • After class, novices analyze "student" work and videotaped rehearsal and submit Rehearsal Reflection on the Explain phase of EEE lesson	• Participate as a learner in novices' Explain rehearsals, offer just-in-time feedback during and after rehearsals • Facilitate whole-class discussion and encourage the other teaching teams to take up feedback offered to the rehearsing team
10	• Revise science lesson as needed to prepare for elementary classroom enactment	• Meet individually with each teaching team to provide feedback as teams prepare for classroom science lesson
11	• Teaching teams teach hour long science lesson in elementary classrooms and administer post-tests	• Facilitate novice school visit to teach science lessons
12	• Analyze pre and post-test student data, examine video of classroom lesson, and submit reflection to address all three phases of the EEE science lesson • Synthesize learning from tool-supported rehearsals, reflections, and classroom science lesson	• Facilitate discussion of novice learning from tool-supported rehearsals, reflections, and classroom science lesson

Novice Teacher Rehearsal Reflections

To examine the ways the tool-supported rehearsals provided novices with opportunities to notice important features of science instruction, we looked at rehearsal reflections from 49 novice teachers enrolled in the course. A total of 147 Engage, Explore, and Explain reflections were collected across three sections of the course. We focused on the last question of the reflection, "First, indicate one new area you or your team *could revise* from your lesson and what you *could have done* to improve the instruction. Second, provide evidence (timestamp or student work evidence) from the lesson to prove that revision is needed to better support student learning. Third, provide a rationale to explain why your idea for revision could have more effectively supported student learning of the *specific science concept of your lesson.* Fourth, indicate specific moves that describe what you *could have done* to improve the instruction." We independently read a sample of the reflections and looked for what novices identified or noticed as important to revise in their lesson. Some novices identified multiple areas for revision, but the most substantive topic per reflection was selected.

Reflections of Novice Teachers

Novices focused on three aspects of their instruction: (1) moves related to student use of scientific practices; (2) moves related to student science content learning; and (3) general pedagogical moves. Scientific practices instruction included students making predictions, making and recoding observations, identifying patterns and interpreting data, and writing evidence-based claims. Science content learning related to the phenomena emphasized in the lesson rehearsals such as the structure and function of stems and roots, conservation of matter, and sound energy. General pedagogical moves included teaching strategies not specific to science instruction but applicable to teaching any subject matter. For example, novices discussed their need to revise the amount of time they spent during each part of their lesson or their ways of engaging and maintaining student attention. As shown in Table 2, in 82% of the rehearsal reflections, novices named an area for revision in their rehearsal that related to student use of scientific practices (45%) or student science content learning (37%).

Table 2 (Click on image to enlarge)

Aspects of Science Teaching Noticed in Novice Teachers' Videotaped Rehearsal Reflections

Aspects of Science Teaching	Frequency (n=147 reflections)
Moves related to student use of scientific practices	66 (45%)
Moves related to student science content learning	55 (37%)
General pedagogical moves	26 (18%)

For example, in her rehearsal reflection, Sara focused on revising the moves she made related to *student use of scientific practices*:

> One area that my team could revise would be providing students with the correct information to fill in their claim and evidence. When we collected students' data, there were some errors in the data and we did not know how to tell students that for their final claim, they need to use the correct data. This happened at 10:04 in our video. This idea for revision would more effectively support students' learning of how changing the shape of an object does not change the volume of the object because students need to see that the volumes are the same. If there is an error in the data collected, they will think that the volume did change because they can compare the numbers and see that one is a lot smaller than the rest. We would correct this in our lesson, by addressing the errors as we walk around the classroom as students are completing the investigation. During the Explain Phase, we plan to have an error on the board so that we can teach students the importance of having accurate data and that re-investigating a situation can be helpful. (Sara's Explain Reflection).

In this excerpt, Sara identified an issue related to helping "students" in the rehearsal collect accurate data about how the shape of an object does not change its volume. She realized that students did not collect accurate water displacement data during the investigation. She considered two ways to revise her instruction. She considered walking around the room to help students address their errors during the investigation, and then she imagined discussing an incorrect example with the class after the investigation. She noted that these revisions might emphasize the importance of accurate data in supporting one's claims about how the shape of an object does not change its volume. The focus of her revision relates to student use of scientific practices, and in particular helping students construct evidence-based claims.

Another novice, Ben, noticed the moves he made related to *student science content learning* in his rehearsal:

> Instead of using our diagram of a plant and a story, we should use celery stalks both in colored water and out of water to show the phenomena of how stems work. At 1:15 in the video we tell the story about watering plants, but it doesn't capture the phenomena of stems and it seems to be that we will be talking about roots instead, which could be very confusing for first graders. Specific moves that we could have done would have been to bring in celery in a jar with colored water and shown the students that the colored water had made it all the way up to the leaves of the celery and turned the leaves a different color. By asking the students how they think the water got up to the leaves, this would begin to make them question the phenomena and would get them focused on the job of a stem. Making the students question the phenomena is the first step in scientific inquiry. (Ben's Engage Reflection).

Here, Ben focused on the story he provided in the Engage phase to activate his "students" thinking about the structure and function of celery stems. He noticed that his hook, which focused on watering plants in his yard, might lead students to pay attention to the function of roots rather than the function of stems. In his analysis, he considered another way to help students begin to think about the structure and function of stems. He imagined bringing celery in a jar of colored water into the class. He wondered if this demonstration might help students develop some initial ideas about how stems carry water and nutrients from the roots to the leaves of a plant. The focus of his revision relates to student science content learning as he imagined ways to revise his instruction to better support students' learning of stems.

In Melissa's reflection, she considered the importance of revising her instruction to maintain student attention. Her focus is on *general pedagogical moves* she made in her rehearsal:

> I feel like we can fill out the t-chart, identify the patterns, and write the [Explain] handout together, but we can allow the students to fill out the bottom of the handout [the evidence-based claims] on their own using their charts so that we can see if they are understanding rather than them just copying what we write up on the chart.
>
> Every single [student] worksheet has all of the correct answers filled in, but it is because we wrote the answers up on the board for them to copy…I think that the revision could have supported student learning because we can actually see whether or not the students are understanding the lesson. By [asking] students to fill [it] out themselves, they will have to understand just how important it is to pay attention (Melissa’s Explain Reflection).

In this excerpt, Melissa noted that all of the peer students in her rehearsal completed the data table and evidence-based claims accurately, but she realized that they might have copied the answers the teacher wrote on the board. She considered asking students to use the data table to complete the evidence-based claims on their own. She also mentioned that asking students to complete the explanations could help them to focus on the instruction. She reasons that holding students accountable for paying attention to the instruction may contribute to her ability to effectively assess her students’ thinking and her students’ opportunities to generate explanations of their developing science ideas.

Conclusion

Tool-supported rehearsals may support novice teachers in learning to notice important aspects of their instruction, such as students’ use of scientific practices and student science content learning. As other teacher educators have found (e.g., Grossman et al., 2009; Windschitl et al., 2012), it may be that the suite of tools helped to make visible some of the complex features of practice that can be difficult for novices to see in busy classroom settings. For instance, naming the developing ideas that children may hold about phenomena and the common challenges students may face in learning to conduct investigations might remind novices to pay attention to those aspects of student sensemaking when they reflect on their instruction.

It may also be that using these tools provided a vision of exemplary science teaching and a shared language for parsing practice that helped the class engage in collective sensemaking (Goodwin, 1994). Starting the first day, the class was immersed in studying, practicing, and reflecting on instruction that engaged students in using scientific practices to develop conceptual understanding in ways that are consistent with practicing scientists. Working collaboratively to identify and productively engage with the challenges of ambitious practice may be a singular affordance offered by the methods classroom context (Lampert et al., 2013). Pausing a rehearsal, highlighting an interaction where a “teacher” could notice an important student idea, and asking them to rewind and revise their instruction are unique science pedagogical learning opportunities.

We are aware of the potential limitations of tool-supported rehearsals. Some novices may find it hard to buy-in to the authenticity of the simulated interactions and adopt the role of “elementary students” in their peers’ rehearsals. Novices may be unnerved by the teacher educator’s feedback and the request to rewind and redo an aspect of their lesson. To mitigate these scenarios, methods instructors are encouraged, day one of their course, to include their students in building mutual trust and in clarifying the anticipated learning outcomes of the rehearsals. We must celebrate all learning, especially those of novice teachers. Indeed, teacher educators do well to respect preservice teachers as beginners and to recognize that learning to notice complex features of instruction does not come naturally, but must be learned (Rodgers, 2002). At the same time, we are challenged to design methods courses to better prepare preservice teachers for success in K-12 classrooms. We must develop, test, and implement innovative pedagogical approaches that prepare novices to think and act like an effective science teacher who is equipped with and confident in using a full array of ambitious science practices.

Supplemental Files

Appendix-A1.jpg
Appendix-A2.jpg
Appendix-B.jpg
Appendix-C.jpg
Explore-Phase.jpg
Explain-Phase.jpg

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