Elementary Science Teacher Educators Learning Together: Catalyzing Change With Educative Curriculum Materials and Vignette Writing

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Abstract

In this article, we describe a professional learning community (PLC) for science teacher educators that supported changes in pedagogy through educative curriculum materials and vignette writing. The PLC was convened as part of a grant-supported project to build preservice elementary teachers' content knowledge for matter using educative curriculum materials. PLC members collaborated with one another over an academic year to learn about and discuss implementing curricular materials in their respective science teacher education courses. Due to the collaborative nature of the PLC, members were able to engage in sensemaking collectively around challenges of practice through vignette writing. The process of writing vignettes within the PLC allowed for productive reflection around content knowledge for matter and science teaching practices, ultimately, advancing preservice teachers' learning about teaching elementary science.

Introduction

Although K–12 teachers teach about science, teacher educators' responsibilities extend beyond this to include teaching about teaching science, which requires a different knowledge base (Abell et al., 2009; Bullock, 2009; Cooper et al., 2015). Teacher educators may not have had explicit preparation for teaching teachers in their graduate programs (Abell, 1997) and may find themselves "thrown into the practice of teacher education" (Wilson, 2006, p. 315) where they must learn on the job (Dinkelman et al., 2006; MacPhail et al., 2019). Self-studies by teacher educators have highlighted the difficulties they experience while transitioning into their roles (e.g., Wood & Borg, 2010) and the complexity of "developing a pedagogy of teacher education" (Loughran, 2013; see also Weinberg et al., 2021).

Science teacher educators may also be responsible for teaching a variety of courses (e.g., methods, content, and critical practice courses) that may or may not align with their background and preparation. For example, a teacher educator who taught secondary science may lack the knowledge necessary for preparing elementary science teachers, or a teacher educator who specialized in biology may need additional understanding to support

preservice teachers in enacting physical science lessons in an elementary practicum. Although mentoring or shadowing (Hanuscin et al., 2021) can help build this knowledge, science teacher educators who are the only faculty member in their program area may have limited opportunities to learn with colleagues who serve in the same role or teach the same courses. Not surprisingly, supporting the ongoing learning of teacher educators has attracted growing attention as a significant challenge for our field (Park Rogers et al., 2021).

We, the authors of this article, are a group of science teacher educators who were prepared in a variety of doctoral programs, became science teacher educators from different entry points, teach at institutions of a variety of types and geographic locations, and are responsible for teaching different courses. Despite these differences, we recognize that we share similar challenges in preparing elementary teachers and realize that we are limited in addressing these challenges by working in isolation. In this article, we describe how we collaborated to address shared challenges within the context of a professional learning community (PLC) for teacher educators of elementary science methods and content courses.

The work of the PLC was centered around the implementation of a set of educative curricular materials (ECMs; Davis & Krajcik, 2005) in our courses that were developed to be instructional for us as teacher educators and to support us in developing our preservice teachers' content knowledge for teaching (CKT; see Ball et al., 2008) about matter and its interactions. These materials are available on the CKT Science website (http://cktscience.org). Each ECM developed, known as CKT packets, addresses a particular content idea about matter and a specific science teaching practice, such as eliciting students' ideas (Mikeska et al., 2018). As the project leaders emphasized, the *Next Generation Science Standards* (NGSS Lead States, 2013) represent a fundamental shift in how matter is taught at the elementary level, including addressing the idea that "matter exists as particlesthat are too small to see" rather than identifying specific particles such as atoms (p. 41). This, combined with the fact that "research-based guidance for teaching the small particle model to 5th grade students is thin" (Smith & Plumley, 2016, p. 13), made it an important area for us to address in elementary science teacher preparation. This innovative experience supported our learning by engaging us in producing and sharing narrative vignettes of our implementation of these materials, highlighting our challenges and successes. In this article, we share how we engaged in a year-long PLC focused on learning about and enacting the CKT science packets; Davis & Krajcik, 2005) that target a set of science teaching practices and matter content. Our purpose is to illustrate how collective sensemaking through vignette writing following the enactment of flexible ECMs, such as the CKT packets, catalyzes our practice to advance preservice teachers' learning about teaching science to elementary students.

Collaboration and Professional Learning

Collaboration is important because it presents an opportunity for teachers to *re-vision* their practice (Horn, 2010; see also Cochran-Smith & Lytle, 1999; Grossman et al., 2001). As Van Lare and Brazer (2013) summarize:

> Potential opportunities for learning occur in places where teachers are negotiating problems of practice, engaging with one another to make sense of their practice, revisioning their classroom practices, and perhaps positioning themselves as novices as they take on new practices.
>
> *(Levine, 2010; Weick, 1995; Wenger, 1998) (p. 388)*

Professional Learning Communities

These collaborative opportunities for teachers often occur as stand-alone, single-day professional development experiences; however, empirical evidence suggests these one-day experiences are not enough to initiate a change in practice (Lumpe, 2007). An accepted and widely used approach to supporting teachers' professional growth through ongoing collaborative learning is through professional learning communities (PLCs). PLCs are a unique form of a community of practice that provides opportunities for professionals, in our case, science teacher educators, to engage in collaborative, reflective exercises focused on making changes toward a common goal (Foord & Haar, 2013).

Across the academic year, the PLC used the CKT packets for matter to identify problems of practice. We met every two weeks on Zoom to engage in professional learning activities. In the first half of the year, we worked through each of the ECMs as learners and then shared, in what Horn (2010) would call *rehearsals*, how they might use these materials to address issues or challenges within our own courses. In the second half of the year, the PLC continued to meet biweekly and focused on sharing *replays* (Horn, 2010) of how we enacted activities in our courses, how the educative features enabled us to facilitate student learning, and the problems of practice that we grappled with in the process of implementation. In this sense, the structure of the PLC itself reflected elements of effective professional development identified in Desimone's (2009) review of the literature, including "(a) content focus, (b) active learning, (c) coherence, (d) duration, and (e) collective participation" (p. 183).

PLC Participants

A key element of a successful PLC is that it is composed of participants who have volunteered to engage in these reflective practices, which has been noted as influential in creating an environment of excitement, relevance, and value for the participants (Wenger et al., 2002). PLC facilitators sought involvement from science teacher educators across the country, and 13 of us, all elementary science teacher educators, joined. Several of us taught a science content course for PSTs or an elementary science methods course for grades K-5,

and others taught both content and methods courses. Some taught variations of those courses, such as a combined field and methods course or a secondary science methods course for grades 5-12. We ranged in years of experience from a graduate student teaching a methods course to new faculty members to tenured and promoted professors. Of the 13, 8 of us came together to share our individual and collective story in this article.

Our motivations for joining the PLC varied. Jeni was hoping to make matter a more intentional focus of her course and was excited to “hang out” with other science teacher educators. Amanda was eager to connect with others as well. Sarah found the curriculum materials appealing because she was entering her first year of teaching and was still building her course plans. She thought the PLC would be beneficial to her in her early career. Also new to science teacher education, Heather saw this as an opportunity to enhance her learning. Both Melanie and Jackie had some familiarity with the project and the CKT matter assessments being developed for PSTs and saw this as an opportunity to support their students’ learning. Jackie did not have a background in elementary teaching and was the sole science teacher educator at her institution, so, like Amanda, she was eager to connect with others with similar roles and responsibilities. Sumreen was seeking to further refine her instructional practice as an elementary science methods instructor who had just submitted her tenure dossier and was seeking ways to update her curriculum. Also, the sole science teacher educator at her institution, Carrie-Anne wanted the opportunity to engage in meaningful discussions with, be challenged by, and learn from other elementary science teacher educators. Like Sumreen, Carrie-Anne wanted to breathe new life into her methods course. Thus, beyond simply obtaining access to the curricula, we all desired an opportunity to learn from others through collaboration.

Opportunities for Sensemaking in a PLC

Two important features of PLCs are that they involve opportunities for the participants to share their experiences and for the group to come together in sensemaking practices (Park Rogers et al., 2021). Although PLCs have been shown to provide K–12 teachers with support for both making sense of new ideas and putting those ideas into practice within their own classrooms (Dogan et al., 2016), research suggests that PLCs can support the learning of teacher educators just as they do for K–12 teachers (Buchanan et al., 2016), particularly new teacher educators transitioning into this role (Williams et al., 2012). To support our reflection and sensemaking about our implementation of the ECMs, we were asked to engage in the process of narrative vignette writing. Vignettes have been used in research to elicit teacher beliefs and understanding and how they influence practice (Skilling & Stylianides, 2020) and can also be used as an educative support for teachers. For example, Dietz and Davis (2009) found that narrative vignettes that describe teachers’ decision-making regarding implementing instructional materials promoted productive reflection among PSTs learning to use those materials. Writing vignettes is a process of meaning-making (Handa & Tippins, 2012) that can support the development of pedagogical content

knowledge (Hanuscin, 2013). In our work, vignettes provided a stimulus for discussion of our teaching in our PLC but also represented an episode of learning in their own right (Jeffries & Maeder, 2005).

In the section below, we discuss and categorize our vignettes based upon their focus. The CKT science packets center on the content area of matter and the work of teaching science (WOTS). According to Mikeska et al. (2018), beginning elementary science teachers should be prepared to tend to specific science teaching practices when engaged in science teaching. These science teaching practice categories are (1) selecting instructional goals, big ideas, and topics, (2) scientific resources, (3) scientific models and representations, (4) student ideas, (5) scientific language, discourse, vocabulary and definitions, (6) scientific explanations, and (7) scientific investigations and demonstrations.

Learning Through and From Our Vignettes

Vignette writing is often a collaborative process wherein the writer or observer can engage with those involved in the problem of practice (Angelides & Gibbs, 2006) or is interviewed and asked to reflect on their practice (Ellebæk, 2021). The process we engaged in around vignette writing is outlined in Figure 1 and described below.

Figure 1

Description of the Vignette Writing Process

Vignette Writing Process

1. PLC members individually compose a vignette in response to a prompt about their implementation of the CKT packets.
2. PLC conversations and feedback from others lead to elaboration on and revision of individual vignettes.
3. Sharing vignettes in the PLC makes them a tool for critical reflection, highlighting common facets of our practice, successes, and challenges.
4. A deeper analysis of the narratives revealed key areas of professional growth supported by the PLC in response to the question: "What story do our vignettes collectively tell?"

As part of the PLC activities, we were asked to respond to one of these two prompts.

- Write a vignette in first-person on the topic of your choice (related to the implementation of a CKT packet).
- Write a vignette highlighting a problem of practice you are trying to address with the CKT packet or encountered in implementing the CKT packet.

The focus of the vignette writing was for us to connect the CKT packets to our course goals and practices. In addition, we were encouraged to include aspects of planning, CKT packet implementation, PST engagement in the packet, and anticipating (or not anticipating) what PSTs might say.

Within the PLC, we engaged in multiple rounds of review and reflection with each other over the course of 2 months. Some rounds of review were held in break-out rooms with smaller groups, and those groups changed from meeting to meeting, which led to collaborative discussions. Initially, review was more for clarity of writing, purpose, and adding rich detail to give other readers a sense of context. We engaged each other in conversation around the vignettes establishing a relationship similar to the "insider" and "outsider" teacher described by Angelides and Gibbs (2006) acting as a "critical friend." Due to the longstanding nature of our connections within a PLC, or what Kuh (2016) would call a "critical friends group," we were able to both receive and ask the "provocative questions" (Costa & Kallick, 1993, p. 50) to home in on essential portions of our planning and practice exposed by the CKT packets. Reflection based on our conversations prompted revisions and extensions to our vignettes, deepening their purpose and better exposing their intent.

Once the vignettes were complete, we looked across the written vignettes, noting similarities and differences in formatting, capturing evidence of student and teacher learning, and engaged in a discussion of the benefits of vignette writing as a tool of self-reflection. For example, in one vignette, a teacher educator shared an example in which despite multiple activities like labs and discussions (including those from a CKT packet), they still held onto misconceptions about the particulate nature of matter. In the PLC, we discussed how to craft questions to elicit student thinking, the difficulty with applying content in new contexts, and the complexity of uncovering and supporting learners as they grapple with misconceptions. These conversations often uncovered shared problems of practice we faced, regardless of the context in which we taught.

A Collaborative Self-Study of Our Vignettes

Although the vignettes represent how the PLC helped us address problems in our own teaching, we believe that they can also yield insights and knowledge that "teacher educators in other settings can draw on and adapt to their own teacher education settings" (Dinkelman, 2003, p. 11). That is, the vignettes could serve as both "a means and ends tool for promoting reflective teaching" practice through self-study (Dinkelman, 2003). In our sharing and analysis of the vignettes, we encountered moments in which we uncovered and shared new understanding. We learned from each other, which motivated us to share our learning more broadly within the professional community. In a way, this article represents an extension of our collaboration in which we engaged in additional sensemaking and analysis of our vignettes over a 6-month period. In our continued conversations in biweekly writing meetings on Zoom post-PLC, we came to see ways in which our participation offered "catalysts" for our learning. In the sections that follow, we present the results of our thematic analysis of the vignettes. We highlight three key areas of our practice using excerpts from our vignettes that are representative of the ways in which the PLC focused on using the CKT packets allowed us to: (1) uncover and raise awareness of our students' ideas about CKT and the work of teaching science (WOTS, see Mikeska et al., 2018), (2) reflect on their pedagogy in light of the instructional goals and intended outcomes, and (3) recognize discrepancies between their beliefs and practices through the vignette writing.

Uncovering and Raising Our Awareness of Students' Ideas

For some of us, using the CKT packets uncovered or raised awareness of our PSTs' ideas in different ways. In the first excerpt below, Jeni's use of the CKT packets helped raise her awareness about her PSTs' science content knowledge. In the cases of Carrie-Anne and Jackie, their use of the CKT packets revealed information about their PSTs' thinking about elementary learners' science content knowledge.

Jeni

I selected the "Scientific Explanations of Changes in Matter" packet with the intended outcome of enhancing PSTs' content understanding and providing PSTs with the opportunity to practice assessing students' sensemaking and constructing a sound scientific argument with accurate scientific knowledge. After implementing the packet, I felt confident in the PSTs' ability to evaluate a student's claim, evidence, and reasoning for if a new substance formed. However, once I analyzed the PSTs' responses on the summative assessment, I realized that I had completely overlooked their content understanding. Sixty-four percent of PSTs indicated that "no new substance" was formed when water boils. Twenty-seven percent of PSTs explained that when water boiled, it formed a "new substance," and when reviewing the explanations, nearly 10% of the PSTs provided explanations that didn't even relate to the current scenario. In the explanations, four PSTs connected boiling water to chemical changes, and five PSTs connected it to physical changes. After grading the summative assessments, I realized that my planning and implementation were too focused on the teacher practice of assessing students' sensemaking and that the lesson lacked a focus on the scientific principle observed in the phenomenon. I had

elicited the PSTs' content understanding; however, I did not take up and use their thinking. I had missed opportunities to be responsive to the PSTs' content understanding.

Carrie-Anne

Interestingly, students' homework responses to number two on the task (how they thought fifth graders would respond) did not necessarily match their ideas about what a fifth grader would need to know to "correctly" answer the task. This indicated to me that the PSTs were distinguishing between knowledge that the students might use to answer a question like this (including prior knowledge, experiences, and misconceptions) and knowledge that they would need to answer the question in a scientifically accurate ("correct") way. Had I considered this more in the moment, I probably would have tried to leverage this discrepancy more in our discussions about teachers' ideas about their students' ideas. More specifically, I would want to use this as an entry point for discussing PSTs' ideas about what knowledge students might bring to their lessons, their own misconceptions about students' ideas (including students' misconceptions), and how to anticipate and intentionally plan to elicit students' ideas (including misconceptions). Next time I implement this packet, I will spend more time unpacking the PSTs' and the students' funds of knowledge.

Jackie

I can infer from their responses to the CKT task and their analysis of elementary students' responses that my prospective elementary teachers can only, or are only willing to, think about one or two variables at a time and have difficulty interpreting student work. The implication is that accurate student responses and those that reveal logical thinking may be marked incorrect because they either lack content knowledge, do not consider multiple correct responses, or do not have the skills to interpret student work.

The CKT Packets Catalyzed Learning About Student Ideas

Together, these vignette excerpts demonstrate the nuanced opportunities that ECMs, the CKT packets, provide for science teacher educators to develop their own practice alongside the practice of their PSTs. More specifically, the CKT packets may catalyze for teacher educators an increased awareness of student ideas, both with respect to CKT and the WOTS. For example, in the first excerpt, Jeni's focus on student ideas demonstrates how she identifies her PSTs as students who are developing their understanding of CKT. Through her vignette, Jeni provides reflective details on the dichotomous relationship between PSTs' pedagogical and content development that emerged from the enactment of the CKT packets. This is a different experience than the other two science teacher educators, Carrie-Anne and Jackie, who leveraged the CKT packets to focus on the development of their PSTs' instructional practices as outlined in the WOTS related to understanding K–12 student thinking..

Reflecting on Pedagogy Considering Instructional Goals and Intended Outcomes

The initial challenge we all faced was deciding how we would incorporate the CKT packets into our courses. We had the flexibility to choose which materials we would use and when those materials would be implemented within our courses. For Melanie, Amanda, and Sumreen, this decision-making process catalyzed reflection on how well their current pedagogy was helping students achieve the instructional goals and intended outcomes for their respective courses.

Melanie

As I analyzed my post-assessment results from the fall semester, I was surprised to notice scientific models as the area in which my teacher candidates earned the lowest average score. I was surprised because I believed my course design included a good foundation for nature of science skills that were later applied to using models as tools for teaching and learning. However, upon further reflection initiated by these assessment results, I quickly realized the lack of explicit, intentional instruction focused on this work of teaching science. In hindsight, I began to acknowledge the superficial approach to my preparation concerning scientific models. This awareness, as a result of the post-assessment scores, instigated a change in how I planned my course goals for the spring semester and the approach I would take to leverage the CKT packets to ensure I facilitated class sessions with more intentionality regarding the use of scientific models.

Amanda

A common experience that I have in teaching elementary methods is that preservice teachers (PSTs) assume that their instructional experiences as a student are sufficient to meet the expectations of the *Next Generation Science Standards*. It was not until I experienced and implemented the “Instructional Goals for Teaching About Matter” packet that I came to realize that what I was doing (e.g., unpacking the *Next Generation Science Standards* and focusing on having “fun” with science) was not addressing the issue and likely creating further misconceptions. My PSTs were not connecting the work of unpacking the standards with aligning instructional activities, and they put the idea of having fun over the work of the performance expectation.

Sumreen

Reflecting on course goals to pick a packet, I picked a packet that was the best fit for what I already do. Since one of my course learning objectives is to have teacher candidates design a lesson that incorporates a learning cycle model (e.g., 5E), I felt that I would choose a packet that best aligns with backward design. It is important to note that during spring 2022, I asked our students to focus on creating an engineering-focused lesson that also incorporates a global lens.

CKT Packets Catalyzed Learning Related to Instructional Goals and Intended Outcomes

The above excerpts provide support for how the CKT packets initiated moments of reflection regarding how science teacher educators intentionally design their courses. More specifically, they highlight how CKT packets might act as a springboard for how

teacher educators approach aligning course outcomes with what they teach. For example, Melanie and Sumreen both selected CKT packets that appeared to align well with what was already being covered within their courses. In Amanda's vignette, we read how enacting the packet helped her develop a sense of awareness and reflection on how she approaches preparing her PSTs to align course outcomes with standards. With consideration to course goals and outcomes, the CKT packet produced critical reflections for both Melanie and Amanda because they noticed tensions within their approaches.

Identifying Discrepancies Between Beliefs and Practices

For many of us, participating in the PLC and implementing the CKT packets revealed tensions between our beliefs about PST preparation and our enacted practice. Through engaging in reflection to identify such tensions, we were able to make improvements to our courses in real time (or to future courses). For Sarah and Heather, the CKT packets provided them with an opportunity to examine how well their current knowledge and practices supported their vision of effective science teaching. During implementing the CKT packets, Sarah came to recognize a discrepancy between her current practices and her belief about the importance of student-centered teaching. Through reflection, Heather recognized a gap in her current knowledge and the means to fill it, thus further developing both her knowledge and her vision of herself as a future teacher educator.

Sarah

I had already implemented two CKT packets when I decided to use the "Scientific Explanations of Changes in Matter" packet alongside a lesson on chemical reactions in my physical science course. During the opening discussion, I asked preservice teachers about common elements among the student responses included in the opening task they had just completed. I didn't get as many responses as I was hoping for, so I started asking the preservice teachers scaffolded questions to get them to notice some of the other parts of the student explanations. At the end of the discussion, I looked at the whiteboard and realized I had led them to a list that closely resembled the claim–evidence–reasoning framework. "Oh shoot!" I thought. I was supposed to develop that idea over the course of the entire class period, but instead, I had pushed students too far too fast in my effort to get more responses. As I reflected on this experience, I realized that my pushing students toward "correct" ideas before they were ready was not something specific to that one lesson on scientific explanations. I was regularly using a whole-class discussion to both introduce and develop ideas following an investigation. Through using the packets, I learned to slow down my instruction. Rather than simply leading students through a series of questions toward a desired outcome, I learned to guide students to resources (e.g., each other, investigations, or readings) that would help them develop an understanding of course concepts.

Heather

I believe self-reflection is the catalyzing moment of my vignette. For example, this caused me to miss an opportunity to instruct preservice teachers prior to completing my degree. As a means of rectifying this, I asked my advisor if I could shadow via Zoom during an Elementary Science Methods course. I felt that any portion of instructing preservice teachers would be better than nothing. I saw something that I wanted to improve at, and I sought out a means to correct it. In talking to experienced science teacher educators, I stated a plan that I would enact for when I will be the instructor of record for my own class. For example, I would like to organize a class where up to half of the course content is structured around the expanded lessons of a CKT packet because all the CKT packets' expanded lessons go through the 5E model as it is situated in the intersection of content and the work of teaching science.

CKT Packets Catalyzed Learning Related to Beliefs vs. Practices

The excerpts we selected here demonstrate how participating in a PLC or enacting CKT packets has the potential to create an environment that challenges what teacher educators believe to be best practice within their courses. In the first excerpt, Sarah shared how she believed in slowly scaffolding PSTs to understand the pedagogical focus of the class meeting but quickly recognized how during enactment, she was not engaged in this practice. Although Heather was not teaching her own course at the time of the PLC experience, she found opportunities to initiate reflection on what she believed was best practice so she could begin planning her own course with intentionality to practice these beliefs.

Conclusions and Implications

This article extends previous literature on PLCS that has focused on K–12 teacher professional development (Darling-Hammond et al., 2017; Garet et al., 2001; Guskey, 2009) in that it provides a clearer picture of the ways in which engaging in a PLC can also support science teacher educators. In collectively analyzing our experience, we have found that uncovering and raising awareness of student ideas, reflecting on pedagogy considering instructional goals and intended outcomes, and identifying discrepancies between beliefs and practices were personally meaningful and significant areas of professional learning catalyzed by our engagement in the PLC. We acknowledge that, however diverse, we represent a very small sample of science teacher educators. Consistent with self-study, our point is not to generalize. Though we are enthusiastic about recommending and encouraging the formation of PLCs, we are cautious in generalizing about what we view as a positive experience. In the sections that follow, we reflect on aspects of the experience that were unique and consider the potential implications of each to support readers in considering how they might apply these insights in their own contexts and situations.

Focusing Our Work on CKT Packet Implementation and Using Vignettes

One key feature of our PLC was that the CKT packets served as an anchor for our work, giving us a common focus, vernacular, and goal. Each one of us implemented the same CKT packets regardless of the types of courses we taught. The novelty of

the materials to each of us created a level playing field while also allowing us to leverage our existing expertise. Given the varied nature of our group's experiences and positions, using novel ECMs allowed for a common starting point in conversations. The different contexts in which the ECMs were implemented also enabled us to see the varied ways in which the materials could be implemented while highlighting the commonalities between what may appear as disparate courses.
The vignettes helped make our pedagogical decision-making regarding implementing the CKT packets visible—something that extends beyond what might be achieved by simply observing teaching. In our case, the vignettes helped to initiate meaningful discussions to improve practice in science teacher preparation. Thus, not only did we discuss improvement but also what actions we could take next when using the packets again. Without the CKT packets to firmly lay a footing for our learning, it may have been more difficult to focus our conversations, resulting in a disjointed experience. Therefore, we highly recommend that PLCs have something at the center to anchor the learning.

Becoming Critical Friends

In the retelling and re-visioning (Horn, 2010) of our year-long experience, regardless of whether it was positive or negative, time facilitated the formation of a bond such that we were able to be vulnerable and free to express emotions connected to our experiences. We cannot underestimate the impact emotions have on learning (Vea, 2020). Creating connections and relationships is an important piece of our work together as science teacher educators (Weinburg et al., 2021). We recognize that through this process, we have become "critical friends" (Curry, 2008), or "a community of critical discourse" (Stenhouse, 1981, p. 111), in that we learned to listen carefully, ask questions to evaluate and encourage reflective practice, and build professional relationships.
It is important to us to acknowledge that all members of this PLC chose to participate and were not required to do so by our respective institutions. We recognize that, for those with different motivations, participation in a PLC may not yield the same benefits that we have described here. It is also important to acknowledge that we had trust in the capability of those facilitating it. Therefore, although professional associations and conferences may serve as a nexus, the effectiveness of what can be accomplished may also depend on the training of those facilitating a PLC.
Although it is not our intention to place any one person or group on a pedestal, we would be remiss not to mention that the main lead was a past president of the Association of Science Teacher Educators (ASTE) as well as an established scholar who has a positive reputation in the science education community. The effectiveness of and what can be accomplished through a PLC may also depend on the skills and preparedness of those facilitating the PLC.

Concluding Thoughts

Overall, teacher educator professional development workshops using our model could be effective in developing science teaching practices and content knowledge. These findings and collective discoveries can be attributed to the PLC approach,

which was centered around the ECMs and gave us the time and space to reflect in an online learning environment, establish critical friendships, and create writing vignettes.

Since the formal conclusion of our PLC, we have continued to work together, and we also look forward to meeting up at professional conferences, such as ASTE's annual conference. Professional associations and conferences provide a space for teacher educators to learn, convene, and share work that influences and contributes to their practice through workshops and research dissemination. For us, ASTE provides a space for us to sustain our efforts and relationships from the PLC; however, we recognize that these spaces can also be an incubator for developing new relationships with critical friends or forming smaller professional learning communities. Indeed, promoting collaboration is part of the mission of ASTE (see https://theaste.org/about). Our PLC with collective sensemaking through vignette writing is novel to science teacher education, and we look forward to more opportunities in line with a PLC in a designed learning environment, such as our research conference spaces, to anchor the beginning of a PLC.

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