Inside the Black Box: How Elementary Teacher Educators Support Preservice Teachers in Preparing for and Learning from Online Simulated Teaching Experiences

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Author Note

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Abstract

Limited research has explored the pedagogies teacher educators use to support preservice teachers as they learn to enact core teaching practices. In this study, we used qualitative content analysis from class observations of elementary mathematics and science methods courses and survey responses to examine the pedagogies of practice eight elementary teacher educators used to support preservice teachers in preparing for and learning from an online simulated teaching experience. We also examined the teacher educators' and their preservice teachers' perceptions of the value of using simulated teaching experiences. Findings suggest the importance of engaging preservice teachers in decomposing and recomposing practice through structured analysis and reflection within larger cycles of enactment.

Keywords: simulations; mathematics; science; elementary teacher educators; core teaching practices; pedagogies of practice

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The field of teacher education faces ongoing significant challenges around how to best support teachers, especially elementary preservice teachers (PSTs) at the beginning of their professional careers, in learning how to engage productively in the work of teaching (Cochran-Smith et al., 2014; Korthagen, 2017). When learning to teach, elementary PSTs face several challenges as they learn how to plan for, engage in, and reflect on their instructional decision-making. These challenges include developing their understanding of key concepts and how knowledge is constructed within specific disciplines, their understanding about how students learn and how to leverage the assets and funds of knowledge that students bring with them, their ability to engage in ambitious teaching practices, and their ability to create productive classroom learning environments that provide equitable learning opportunities for all learners (Borko et al., 1992; Davis et al., 2006; Dube, 2020; Levin et al. 2009; Rodriguez, 2013).

Current student learning standards internationally and across various disciplines (Butt & Lambert, 2014; National Governors Association, 2010; NGSS Lead States, 2013) require the use of ambitious and complex teaching practices to address these standards successfully (Association of Mathematics Teacher Educators, 2017; Australian Institute for Teaching and School Leadership, 2014; Call, 2018; Forde et al., 2016; National Science Teaching Association, 2013; Santoro & Kennedy, 2016). The primary mechanism by which PSTs have traditionally had opportunities to practice the work of teaching has been via supervised, mentored clinical experiences within K-12 classrooms. Effective in-school clinical experiences, however, are not always available. Reasons for this include limited access to high-quality mentors, difficulties with proximity to appropriate school placements in rural locations, or more recently, the

COVID-19 pandemic, which has limited field-based practice teaching opportunities for PSTs (Reich et al., 2020; Saenz-Armstrong, 2020). As such, this challenge is both familiar and more acute now than ever, demanding that we determine how to productively pivot and provide practice teaching opportunities outside of in-person schools to support PSTs' learning.

The use of technology provides one response to this challenge. During the last decade, one such tool – simulated classrooms in which PSTs can practice teaching digitally animated student avatars, which have been developed by both TeachLivE and Mursion – has seen increasing uptake in teacher education programs across the nation (Mikeska, Howell, Dieker, & Hynes, 2021; Murphy et al., 2018; Sargent, 2020). To date, the simulated classroom has been used in over 100 teacher education programs as a practice space for PSTs to learn how to manage classroom interactions, to communicate effectively with parents, to facilitate content-focused discussions, and to engage with students with disabilities (Cohen et al., 2020; Fox et al., 2015; Mikeska & Howell, 2020; Straub, 2018). Such tools provide practice that complements in-person field experiences or, more recently, replaces them where they are unavailable. Despite the clear potential of the approach, limited research has examined the ways in which teacher educators (TEs) use this technology tool and integrate it within teacher education courses. Understanding how TEs support their PSTs in preparing for and learning from simulated teaching experiences is an important gap that needs to be addressed to build the field's understanding of how to support substantive teacher learning with such tools.

Research Focus

This study directly addresses this gap by examining the pedagogical activities[1] that eight elementary TEs used within their mathematics or science methods course to support their PSTs in learning how to engage in one core teaching practice important in mathematics and science classrooms – facilitating discussions that engage students in argumentation. In mathematics and science classrooms, engaging students in argumentation is one important means by which they develop their conceptual understanding through a social process of exchanging, comparing, and critiquing ideas (National Council of Teachers of Mathematics, 2014; National Research Council, 2013). The study employs qualitative content analysis using both content-driven and data-driven approaches (Schrier, 2014) to describe the types and the purposes of the pedagogies of practice (Shulman, 2005) these TEs used, and to examine the TEs' and their PSTs' perceptions of the value of the experience. Findings from this study provide concrete examples of uses of the technology and provide insight into the opportunities and challenges that arise. Our research questions include:

- **Research Question 1 (Nature of Pedagogies Used)**: What pedagogies of practice do elementary TEs use to support PSTs in preparing for and learning from an online simulated teaching experience? In service of which specific instructional purposes are these various pedagogies of practice used to support teacher learning? How, if at all, did the TEs modify their instruction when integrating the simulated teaching experience into their course?

[1] We note that the term *pedagogies* or *pedagogies of practice* are used interchangeably throughout the manuscript to describe the activities TEs engage in to support their PSTs in learning from engagement in core practices. Although these terms are used somewhat inconsistently in the literature, we adopt them as a part of the McDonald et al. (2013) framework on which we based our analytic coding.

- **Research Question 2 (Perceptions of Value for Using Simulated Teaching Experiences)**: To what extent and for what reasons do TEs and PSTs perceive these simulated teaching experiences to be valuable in supporting PST learning?

In this manuscript, we begin by first describing how this study is situated in a theory of practice-based education and how this theory relates to building teachers' ability to engage in core teaching practices using various pedagogies of practice. Then, we provide some background on how simulated teaching experiences can be used to support PSTs in engaging in one pedagogy of practice – approximations of practice – within practice-based teacher education. After that, we provide details about the study's methodology and then report on the study's findings. We end with a discussion on the study's contributions and limitations.

Background

Shifting Teacher Education Towards a Focus on Knowledge in Use

This study is situated in a theory of practice-based teacher education, which hypothesizes that opportunities for PSTs and in-service teachers to learn in and from their practice are critical in helping them develop the knowledge, skills, capabilities, and dispositions they need to be effective practitioners (Ball & Cohen, 1999; Ball & Forzani, 2009; Grossman et al., 2009; Grossman, 2018; Lampert, 2010). Scholars have called for "repeated opportunities for novices to practice carrying out the interactive work of teaching" (Ball & Forzani, 2009, p. 500). Studies have shown that prospective teachers are more likely to be effective when their preparation is directly linked to classroom practice and opportunities to practice specific instructional strategies (Association of Mathematics Teacher Educators, 2017; Boyd et al., 2009; Forzani, 2014; Francis et al., 2018; Goodson et al., 2019).

To link PSTs' learning to the work of teaching, scholars have advocated for organizing PSTs' learning around a set of core practices that target PSTs' use of knowledge in action. Core practices, such as facilitating discussions, are ones that occur often in teaching, are complex in nature, are linked to student learning outcomes, and novices, including PSTs, can learn to master through appropriately scaffolded learning opportunities (Grossman et al., 2009). A core practice focus requires shifts in pedagogy; "…identification of K-12 core practices should be accompanied with the identification, development, and implementation of teacher education pedagogies aimed at preparing teachers with those practices" (McDonald et al., 2013, p. 379). However, an understanding of the specific pedagogies that TEs use to support PSTs in learning how to engage in core practices is underspecified in the field, making substantive dialogue across content and context difficult. Research suggests that building shared understandings and common language can help support TEs in engaging in core practices such as facilitating discussions (Grossman & Dean, 2019).

It is important to note that some progress has been made on this front by the Core Practices Consortium, which is a cross-institutional group of TEs who have examined the use of various teacher education pedagogies to support PSTs in learning how to enact core teaching practices (Grossman, 2018; Grossman et al., 2019). For example, Kloser et al. (2019) recently analyzed the frameworks that two secondary TEs used to explicate and teach their secondary science PSTs about the core practice of facilitating sensemaking discussions. Their analysis highlighted commonalities and differences in their approaches to using rehearsals to teach this core practice in their methods course. In a similar vein, Reisman et al. (2019) investigated the connection between PSTs' facilitation of text-based historical discussions in classrooms and various instructional scaffolds used in their methods courses with findings illustrating the productive impact of these scaffolds. However, these studies focused on the use of face-to-face rehearsals, not digital simulated teaching experiences, and did not explicate the nature of the teacher pedagogies used across the full cycle of implementation, including the preparation activities prior to the rehearsals and the debrief and reflection activities after the rehearsals. While there are many ways in which face-to-face rehearsals are similar to digital simulations, the literature on digital simulations strongly supports the notion that the enactment of simulation alone is not the site of teacher learning, rather that learning takes place across a full cycle of enactment (Howell & Mikeska, 2021). This suggests that while approaches such as those taken by Kloser and Reisman represent a valuable start to addressing McDonald et al. (2013)'s call to explicate pedagogies, the examination of digital simulations may require a more expansive focus on the full learning cycle, not just on the enacted core practice alone. This gap is one that the present study sought to address by examining how TEs used simulated teaching experiences as approximations of practice within elementary mathematics and science methods course.

Using Simulated Teaching Experiences as Approximations of Practice

One of the primary modalities of PST learning within a core practice framework is the *enactment* of the practice (Ball & Forzani, 2009; Grossman et al., 2009). Approximations of practice, including rehearsals (Kazemi et al., 2016) or role playing (e.g. Dotger et al., 2014; Shaughnessy & Boerst, 2018), have been identified as important "opportunities to rehearse and enact discrete components of complex practice in settings of reduced complexity" (Grossman et al., 2009, p. 283). One technology-focused approach is the use of human-in-the-loop digital simulations, such as those utilized in this study. Digital simulations can take several forms, but the predominant current approach in the field (and the approach we took in this project) is the use of live human actors controlling digital avatars on a screen during a synchronous interactive session with a PST. Such simulations are similar to live actor role playing but hide the human actor(s) behind digital avatars (Ingraham et al., 2021).

The technology used on this project was a version of the Mursion™ platform, a system in which one trained actor, called the *interactor or simulation specialist*, controls five student avatars simultaneously, using specialized hardware and software to jump rapidly between students and trigger automatic movements (such as the whole class raising their hands simultaneously) and to modulate the voices of the students so that they always sound as they should regardless of which interactor is running the simulation. Other similar technologies exist [see for example Talespin (Talespin, 2021) for an AI-driven approach, or simSchool [simSchool, 2022) for a text-driven one], but at the time of writing Mursion™ is the most widely used in teacher education, with endorsement from prominent professional organizations such as the American Association of Colleges for Teacher Education (AACTE, 2020). There is evidence that the simulated classroom supports participants' authentic engagement in specific teaching practices in ways that live rehearsal cannot. For example, the participant cannot recognize the interactor as someone they might know and is less distracted by the idea that an adult is pretending because the character does not sound or look like an adult (Dalinger et al., 2020; Dieker et al., 2017; Girod & Girod, 2008; Mikeska & Howell, 2020; Piro & O'Callaghan, 2018; Straub, 2018).

Digital simulations have other affordances. For instance, they allow designers to customize instructional challenges and support standardization to desired levels of fidelity (Chazan & Herbst, 2012; Cohen et al., 2020; Howell & Mikeska, 2021). Research shows that PSTs who engage in such simulations during their preparation find the experience to be valuable and supportive of their learning (Mikeska, Howell, Dieker, & Hynes, 2021) and that prospective teachers are more likely to develop high-quality teaching practices when such opportunities are coupled with feedback (Benedict et al., 2016). The simulated classroom environment creates this space to practice, gain feedback, and reflect and has been shown to promote teachers' learning (Driver et al., 2018; Ledger et al., 2019; Pandowski & Walker, 2016; Straub et al., 2014; 2015). However, the nature of the specific pedagogies used to support PST learning when integrating the use of simulated classrooms into teacher education has not been examined in-depth in the current literature.

Methods

Sample

Eight elementary TEs – four in mathematics and four in science education – who were teaching an elementary mathematics or science methods course during the fall 2020 semester participated in this study, along with PSTs from one section of each TE's methods course. In total, approximately two-thirds of the PSTs (102 of 166 PSTs) across these eight sections consented to participate in the research study. Due to the COVID-19 pandemic, each TE had to modify the structure and format of their methods course instruction for online delivery via a mix of synchronous and asynchronous formats. As shown in Table 1, most participants were at public universities and had no previous experience using simulations.

Performance Tasks for Facilitating Discussions in the Simulated Classroom

The study used a digitally simulated classroom environment (Figure 1) where participating PSTs practiced facilitating a short discussion among five student avatars. Each PST was given a set of preparatory materials describing the discussion they were to plan for and facilitate, either in mathematics or science, based on the course in which they were enrolled. These materials provided background information about what the students (avatars) already knew and had done in the lesson leading up to the simulated discussion, copies of the students' written work, a short analysis of the student work to help the PSTs make sense of the students' initial ideas, and general guidance about how to facilitate an effective discussion.

The goal of the mathematics discussion, *Ordering Fractions,* was for the PSTs to support the fifth-grade students in determining the order of three given fractions (3/4, 3/10, and 9/10) from least to greatest and to consider whether the student-generated strategies for ordering these fractions are generalizable. Prior to the simulated discussion, the students worked in small groups to respond to prompts asking them to place three fractions in order, explain their strategy, and make and support a claim about whether their strategy would work to order any three fractions. The goal of the science discussion, *Mystery Powder*, was for the PSTs to support the fifth-grade students in coming to consensus about: (a) the identity of an unknown powder based on its observable properties and (b) which properties are most useful for making this determination. Prior to the simulated discussion, the class worked together to test the properties of several known powders and record the results in a class data table. They also worked in smaller groups to examine the properties of the unknown powder, develop a claim grounded in evidence as to its identity, and explain which properties were most useful in making that determination. Previously published manuscripts report on the design-based decisions and development process for creating each performance task, as well as provide a complete copy of the *Ordering Fractions* (Howell et al., 2021) and *Mystery Powder* (Mikeska, Howell, Ciofalo, et al., 2021) tasks that the PSTs used in this study. Readers can also access example videos of PSTs facilitating these discussions in the simulated classroom and the full set of interactor training materials in the [name removed for blinding] qualitative repository (Go Discuss Project, 2021).

A less visible component of the task is the design of the students themselves. In the Mursion™ platform, because students are enacted by a human interactor, the design of the students resides in the interactor and consistency with the design relies heavily on interactor training. Each task is designed to engage the PSTs in a semi-standardized way, meaning that the interactor has to learn, in addition to the students' personalities and ways of talking, their content understandings at the start of the discussion and the ways in which each of them might learn along the way. Each discussion plays out uniquely as the interactor tailors the avatar responses adaptively to the PST's instruction – in fact, once past the first few lines of dialogue, very little of the interaction is scripted. However, the students' content understandings, misunderstandings, willingness to engage, and ways of moving forward in their thinking are designed to be consistent within and across the discussions. This level of standardization depends on extensive interactor training, allowing each PST to contend with a similar and comparable teaching challenge.

In a prior research study, we examined PSTs' perceptions of three aspects of authenticity related to these online simulations – task authenticity, student avatar authenticity, and performance authenticity – across eight different performance tasks in elementary mathematics and science (Mikeska & Howell, 2021a). Findings from this earlier study suggested that the PSTs perceived that the tasks well represented the work of teaching in these content areas, although their perceptions of the authenticity of the other two components were more variable. For example, to reduce the teaching complexity in the simulations, our team purposefully set up the situation so that the PSTs did not have to contend with any classroom management challenges and, instead, could focus their attention on the content-focused aspects of learning an ambitious teaching practice. These earlier findings suggest that the focus should be on whether these simulations are sufficiently authentic for their intended purposes, which means that there may be valid reasons for having certain aspects vary somewhat from more "typical" student engagement.

For this project, three interactors learned how to enact the *Ordering Fraction* and *Mystery Powder* tasks and engaged in the delivery of the simulation sessions during data collection. All were employees of Mursion with backgrounds in theater and highly trained in the use of the system and in portraying the five upper elementary students. Our team provided approximately 32 hours of training for each interactor using a set of training materials developed on a prior project (Go Discuss Project, 2021). The training includes opportunities for the interactors to complete self-study where they learn about the activities the students engaged in, the discussion goal, the students' initial ideas, and when and how the students' ideas could change during the discussion. This training also includes time for the interactor to meet with one or more trainers to practice responding as each student with specific ideas and ways of thinking, as well as time to practice engaging in several practice discussions where the trainer uses different approaches to facilitate the discussion and then provides the interactor with feedback on their delivery. After each of the eight data collection windows (one per university site), a trainer reviewed a random sample of video records for each interactor in order to: (a) provide feedback to interactors as needed, (b) ensure that the content specifications of each task were met at an adequate level of fidelity, and (c) monitor for any evidence of bias in the representation of the students, a known risk of having interactors play roles that do not map onto their own backgrounds and cultural identities.

Data Collection

Each TE used the simulated teaching experience as part of their elementary mathematics or science methods course during fall 2020. The complete simulated teaching experience includes three components that fit together as part of a cycle of activities. First, prior to the simulated teaching session, each TE facilitated one or more preparation activities or assignments with their PSTs. Second, each PST completed a one-hour session individually in the simulated classroom. During this session, each PST completed a short warm up task (taking the students' lunch orders) and facilitated either the *Ordering Fractions* or *Mystery Powder* discussion for up to 20 minutes with the student avatars. Each discussion performance was video recorded and shared back with the individual PST and their TE. Finally, each TE facilitated one or more debrief activities or assignments with the PSTs after the simulated teaching session. Each TE used their own professional expertise and knowledge about their PSTs' needs and course structure to determine when to implement the simulated teaching experience into their course, how to best prepare their PSTs for the simulated teaching session, and how to help their PSTs debrief and learn from that experience afterwards. Thus, when we refer to the "simulated teaching experience," we mean the three-part cycle of activities that includes preparing for, engaging in, and debriefing/reflecting on the simulated teaching session.

Prior to the start of the semester, the research team conducted a kick-off meeting with all eight TEs to provide an overview of the project and share information about the student avatars, simulated teaching session, performance tasks, and project resources. During this meeting, the TEs were introduced to the student avatars and were each allotted some time to interact with the students in the simulated classroom. It was important to provide this opportunity to the TEs as five of the eight TEs indicated they had never worked with a simulated classroom before and the remaining three TEs had only used simulations once or twice prior to the current study. Additionally, TEs were given access to a resource folder including a quick start guidebook outlining the purpose of the performance tasks and ideas for preparation and debrief activities.

The resource folder also contained selected readings about argumentation and discussions, copies of videos showing other PSTs' discussions in the simulated classroom, corresponding transcripts for each video, and scoring information about the ability of the PST in the video to facilitate an argumentation-focused discussion across five scoring dimensions used in a previous study (Mikeska, Howell, & Kinsey, 2021). In addition to the resource folder, the research team also facilitated monthly meetings with the eight TEs in which they discussed their planning and implementation, ideas about which preparation and debrief activities they planned to use, their experiences with activities they had already implemented with their PSTs, and the challenges they were experiencing as they integrated the simulated teaching experience into their course. The TEs also shared assignments and grading rubrics with one another.

During the preparation and debrief activities, one of the first two authors, who have extensive experience generating field notes from class observations, observed the class sessions and captured field notes detailing their observations (Saldaña & Omasta, 2018). They also collected any class artifacts, such as written assignments, assigned readings, PowerPoint slide decks, videos, and other class materials, that the TEs and PSTs used during these class sessions. Finally, after the preparation, simulation, and debrief were complete, the TEs and PSTs completed online task surveys. The TE task survey included questions about how the TEs prepared the PSTs for the simulated teaching session, how they helped the PSTs debrief afterwards, their use of the PSTs' discussion videos, their general reflections about incorporating the simulated teaching experience into their course, and their perceptions about discussion and argumentation. The PST task survey included questions about the PSTs' experience preparing for and completing the *Ordering Fractions* or *Mystery Powder* performance task in the simulated classroom, the debrief, any additional course assignments they completed related to the simulated teaching experience, and their perceptions about discussion, argumentation, and the simulated teaching experience. To examine the TEs' and PSTs' perceptions of the value for using simulated teaching experiences within teacher education, a task survey item was included asking them if they would recommend including simulated discussion(s) in a future section of the course and the reason why they would or would not make that recommendation.

Data Analysis

Our research study used a qualitative content analysis approach (Schreier, 2014) to understand what the TEs did and how they supported their PSTs in preparing for and learning from the simulated teaching experience. First, we started by using our field notes from the class observations and the class artifacts to generate written analytic memos – one per TE – describing the full cycle of preparation and debrief activities that each TE engaged his or her PSTs in as part of the simulated teaching experience. We organized the analytic memos by class session and segmented each instructional activity within a class session; a new instructional activity was denoted every time the focus or intention of the activity the TE and PSTs were engaged in changed. In the analytic memo, the research team member described what the TE and PSTs did and their responses during each of the instructional activities. The research team used member checking for the analytic memos to verify the accuracy of the class observations with each TE (Birt et al., 2016).

To analyze the instructional activities, we began by leveraging McDonald et al.'s (2013) initial framework which specified pedagogies TEs can use to help novices, including PSTs, learn how to enact core practices. These pedagogies include instructional activities that provide novices with representations of practice they can interrogate, such as modeling, examining video exemplars, or examining written cases, as well as activities where novices can decompose their own and others' instruction, such as video analysis, transcript analysis, and reflection writing (McDonald et al., 2013). However, for our analysis, we purposefully cast the net wider than only the set of initial pedagogies identified by McDonald et al. (2013) in that we also inductively coded these data sources to identify other pedagogical activities used by the TEs. To do so, we reviewed the written analytic memos from each observed class session, which described what instructional activities the TEs and PSTs engaged in, their responses, and the class artifacts they used, to generate a complete list of pedagogical activity codes across all eight sites. This concept-driven and data-driven analysis approach was used to capture the full picture of the TEs' pedagogies of practice. Table 2 provides a list and description of the codes used to identify various pedagogical activities.

We also examined these pedagogical activities to identify the purpose(s) for which they were used during instruction. To create the pedagogical purposes coding categories, we again reviewed the written analytic memos summarizing the class observations and the class artifacts and generated a comprehensive list of the various purposes related to the intended goals of each instructional activity. For example, some activities were intended to develop the PSTs' content knowledge while other activities were focused on helping the PSTs broaden their understanding of discussion or argumentation teaching moves or strategies they could use during instruction. This approach to identifying the pedagogical purpose(s) of these activities was entirely data-driven, based on what we observed and documented via the analytic memos and artifacts. Each pedagogical activity code that was applied also received one or more of the pedagogical purpose codes. Table 3 provides the full set of pedagogical purpose codes and their descriptions.

For each class instructional activity, one or more of the pedagogical activity codes and one or more of the pedagogical purpose codes could be applied, depending on what and how the

TEs engaged the PSTs in during that part of the class session. Two researchers double coded 25% of the classroom observation analytic memos and achieved 92% rater agreement (ICC = 0.77). One researcher independently coded the remaining classroom observation memos. We then identified which pedagogical activities and the purposes of those activities that each TE used prior to and after the simulated teaching session. To synthesize the results from this qualitative content analysis, we created tables to show the extent to which these TEs used specific pedagogical activities and purposes by site during the preparation and debrief components and in what combinations. We also used a similar process to help us discern whether, how, and why these TEs adapted their syllabus from the previous semester to integrate the simulated discussion and associated assignments into their methods course.

To answer the second research question, we used iterative analytical methods (Maxwell, 2013; Saldaña & Omasta, 2018) to code the TEs' and PSTs' task survey responses to better understand and identify patterns in their perceptions about the value of the simulated teaching experience. We used an inductive approach to generate a set of codes to characterize the reasons why they did or did not value incorporating such an experience into future method courses. Table 4 provides the full set of codes and code descriptions we used to understand their varied perceptions. Each written task survey response could receive one or more codes, if merited, based on the response. Two researchers double coded 25% of the participant responses and achieved 93% and 92% rater agreement when coding the reasons for why TEs and PSTs did value the experience, respectively (ICC = 0.86 and 0.87, respectively) and 88% rater agreement when coding the reasons for why PSTs did not value the experience (ICC = 0.84). All disagreements were reconciled. One researcher independently coded the remaining responses. Finally, we created a descriptive frequency table to illustrate the main patterns and the extent to which and in what ways study participants did or did not value the simulated teaching experience as part of future teacher education courses.

Results

Research Question 1: Nature of Pedagogies Used

A summary of the pedagogies we observed in use within the preparation and debrief class sessions for each TE are shown in Table 5. There are a few key patterns to note in the distribution of codes. One pattern is that, with the exception of TE 02, the total number of distinct pedagogical activities used by the TEs in preparation (Table 5: Prior) was greater than the number used in debrief and reflection (Table 5: After). This greater prevalence of pedagogies used during preparation can also be observed in the frequency of use of specific pedagogies. Of the 14 different pedagogical activities observed in these TE's method courses, all 14 were used by at least one TE in the preparation with eight of the 14 activities used by half or more of the TEs. However, during the debrief, only seven of the 14 pedagogical activities were used by at least one TE and only two of the activities were used by half or more of the TEs. This pattern indicates that these TEs used a wider diversity of teacher pedagogies to support the PSTs in preparing for their simulated teaching session compared to when they led the PSTs in debriefing the experience afterwards.

Second, we observed clear differences in the frequency with which these pedagogical activities were used across sites. Individual planning, reflective writing and reflective discussion were most frequently observed, along with direct instruction, but the use of videos was also frequent. Other pedagogies, such as modeling, collaborative planning, examining written cases, and transcript analysis, were used more sparingly.

Third, we generated or refined several pedagogical activity codes that were needed to describe the instruction we observed, including individual planning, reflection discussion within the class, doing the work of the students, examining artifacts of student work, and direct instruction. For example, while direct instruction is not a prominent component of the pedagogies described by McDonald et al. (2013), we observed that most TEs used some amount of direct instruction in conjunction with other pedagogies to meet their instructional objectives, therefore we added direct instruction as a code. Similarly, the use of videos as a foundation for reflection was a code that we refined to distinguish between collective and individual reflection. These pedagogies were both prevalent in our data, likely because video recordings of the PSTs' individual discussions were provided after the simulated teaching session, making individual reflection strongly available, and video exemplars were also provided to the TEs, increasing the likeliness of their use in collaborative reflection. Convenience alone, however, did not explain all the use patterns. Transcripts of exemplar videos were also provided to TEs but only one TE made use of transcripts; in contrast all but one TE made some use of video to support collective or individual reflection.

We also observed considerable variation in the pedagogical purposes for which TEs used these pedagogical activities, as shown in Table 6. Not surprisingly, since the core teaching practice was focused on supporting the PSTs in learning how to facilitate argumentation-focused discussions, these TEs showed a strong emphasis on using these pedagogical activities to develop their PSTs' knowledge of discussion and argumentation teaching strategies. For example, all eight TEs used these pedagogical activities to support their PSTs in learning about discussion teaching strategies, such as different kinds of talk moves, and most (seven of the eight TEs) engaged their PSTs in activities to learn about mathematical or argumentation, such as specific language frames they could use to engage students in argumentation. Many of the TEs also used these pedagogical activities to develop the PSTs' content knowledge (seven TEs), provide opportunities for the PSTs to apply what they were learning to lesson planning (eight TEs), and support focused self-evaluation of the simulated teaching experience (seven TEs), although there was some variation in terms of when in the cycle they did so. For example, these TEs were more likely to engage their PSTs in activities to help them understand the mathematics or science content that was the focus of their discussion prior to their experience in the simulated classroom. Similarly, these TEs tended to engage their PSTs in structured and scaffolded reflection on their discussion performance after their experience in the simulated classroom.

Generally, we did not observe simple patterns in the relationship between pedagogical activity and purpose, despite the TEs' collective engagement in the use of the same tool with the same supports. As shown in Table 7, while TEs used multiple pedagogies in pursuit of similar purposes, they also used similar pedagogies in pursuit of different, and sometimes multiple goals simultaneously. These findings suggest that pedagogies of practice can serve different purposes and be used by TEs for varied purposes.

To highlight the complexity across these combinations of pedagogical activities and purposes, we examine two examples of the use of pedagogies for particular purposes. In the first example, we focus on a single purpose, developing the PSTs' content knowledge, and illustrate how, across the set of TEs, various pedagogies were used in service of this purpose. In the second example we take a complementary approach in focusing on a single pedagogy, the use of videos for collective reflection, and discuss how this pedagogy was used to support various purposes. We selected these combinations to highlight in more depth as they were ones that more than half of the TEs leveraged to support PST learning and collectively they provide sufficient variation to illustrate the complex nature of the pedagogies used across these eight sites.

Example 1: Pedagogies Used to Develop PSTs' Content Knowledge

One of the TEs' pedagogical purposes was to develop the PSTs' understanding of the mathematics or science content that was the focus of the discussion performance task. In the case of the *Ordering Fractions* task, the main conceptual ideas related to how to compare and order fractions, particularly the nature of the strategies for doing so and whether the strategies could be generalized. In the *Mystery Powder* task, the main content understandings focused on properties of matter, how they could be used to distinguish between various powders for the purpose of identifying an unknown powder, and whether specific properties were more useful for identifying an unknown powder. Many TEs recognized the importance of ensuring that their PSTs had a strong conceptual understanding of these content-focused ideas so that they would be able to leverage them productively while planning for, facilitating, and reflecting on their simulated discussion.

There were multiple pedagogies that the TEs used to develop their PSTs' content knowledge of the mathematics or science concepts relevant to each discussion performance task, including modeling, the use of videos for collective and individual reflection and as exemplars, individual planning, transcript analysis, reflection writing and reflection discussion, direct instruction, and, most commonly, examination of student work or engagement in student level work. For example, TE 02 had his PSTs collect data on three of the various powders from the *Mystery Powder* investigation during a face-to-face class. In this investigation, the PSTs had the "opportunity to do the mystery powder activity like the student avatars" (TE 02 – observation notes). They had a chance to reflect on the evidence they collected (describing the visual appearance and texture of three known powders and a mystery powder; determining what happens when you mix each one with water and then with vinegar) and make an argument about the mystery powder's identity based on the evidence they collected. This is exactly the ways in which the *students* in the *Mystery Powder* task are described as having engaged in prior to the discussion. Other TEs similarly engaged their PSTs in doing student-level work from the discussion activity or closely aligned to it. TE 07, for example, led her PSTs through a series of mathematical exercises in which they compared different sets of fractions, although they were not the same fractions the PSTs encountered in the *Ordering Fractions* task.

Other TEs engaged their PSTs in examining written student work relevant to – and many times actually from – these performance tasks, in service of developing the PSTs' content knowledge. For example, TE 01 had her PSTs review each of the three student group's written work from the *Mystery Powder* task, asking the PSTs to identify the students' claim about the mystery powder's identity and the evidence and reasoning each group used to justify their claim. She pressed them in discussion about whether weight makes a difference in figuring out what the mystery powder is, a key content idea in the *Mystery Powders* task, and one which unearthed some disagreement among the PSTs. Similarly, TE 08 shared a video of students discussing a mystery powder investigation and discussing their claims and asked her PSTs to analyze what they saw in terms of the content, any visible misconceptions, and the students' use of data. TE 05 asked similar questions about student work samples taken not from the *Ordering Fractions* mathematics task but from an aligned performance task, titled *Eight Divided by One Fourth*, asking PSTs to engage in reflective writing in which they responded both to questions about the correctness and nature of the students' content understandings and, separately, to questions about what teaching moves the PSTs might employ to move those students forward, showing that the same activity can support multiple purposes, as we discuss in the next example.

Example 2: The Use of Videos for Collective Reflection in Service of Multiple Purposes

Five of the TEs used videos to support collective reflection in the course of the cycle of instructional activities, with three of those TEs using videos as part of both preparation and debrief and the remaining two using them only in preparation. Of the three TEs who did not use videos for collective reflection, two were teaching in formats that were predominantly asynchronous, making this pedagogy less feasible to implement. Of note is that the TEs addressed variable pedagogical purposes when using the videos for collective reflection. In fact, every coded pedagogical purpose was represented in one or more TE's use of this pedagogy including, most commonly, support for the PSTs' development of discussion and argumentation teaching skills. In some cases, TEs used the pedagogy to support different purposes at different time points or to support multiple purposes simultaneously. In addition, the TEs used different video sources, including outside video sources, their own PST's simulated discussion videos, and our project provided video examples for the simulated discussion task and for a related but different performance task.

TE 06, for example, drew on all three video sources at different points in her instruction and for different purposes. In preparation, she shared a video clip from a public video bank that the PSTs had viewed in an earlier class session for another purpose, instructing them to pay close attention to the teaching moves in the video and how they support the students' engagement in discussion (coded as purpose: discussion teaching moves). Later in the same class session, she shared clips from two of our *Ordering Fractions* example videos, one from a lower scoring performance and one from a mid-range scoring performance, asking them to focus again on the teaching moves but also on what the PST in the video might have done differently. This was the first time the PSTs have seen the simulation in action, and some of their discussion focused on the simulation characteristics and how they should think about planning their own lessons (coded as purpose: discussion teaching moves, application to lesson planning, simulation logistics/familiarity). This use of video represents not just a different video source, but an expansion of the intended purposes as the TE narrowed from a focus on observing discussion teaching moves in a familiar video to a more proximal example of the work the PSTs would be doing. In the debrief class session, TE 06 asked PSTs to identify two 2-minute clips, one clip showing a strength and one clip showing an area for growth, from their simulated discussion performance. She then had the PSTs share their 2-minute clips with one another and encouraged the PSTs to comment on what they noticed in each other's videos (coded as purpose: discussion teaching strategies, focused self-evaluation). Similarly, TE 01 had her PSTs share 10-minute video clips from their discussion with one another and asked them to take notes on what they observed when watching the clips. The PSTs then shared their positive feedback and constructive criticism with each other, as well as the PST who had shared their discussion (coded as purpose: focused self-evaluation).

TE 03, in contrast, shared an example of a high-scoring performance video provided by our research team from an alternative science task involving conservation of matter and asked them to comment on the strategies used by the teacher in the video and asked her PSTs to comment on where they saw argumentation and what the teacher did to support it. She also presented the Argumentation Toolkit videos that were linked in the task materials and asked them to note where they saw student interaction and what they saw the teacher doing to prompt it. Across all the video sources, her focus on argumentation and discussion teaching strategies was consistent.

Adapting Course Activities When Using Simulated Teaching Experiences

When integrating the simulated teaching experience into their elementary methods course, these TEs noted that they adapted their course in three main ways: (a) by adding course content (88% of TEs), (b) by replacing course content (63% of TEs), and/or (c) by rearranging course content (13% of TEs). For example, TE 01 noted how she added additional course content about argumentation because "participating in this study permitted me the opportunity to revamp my course syllabus to accommodate the inclusion of argumentation which was not one of the strategies previously taught…" However, TE 04 "replaced a project (field experience with follow up written paper) with the simulation discussion and assignments…" while TE 02 talked about how she "rearranged some content, such as text chapters and discussion topics, to bring promoting discussion and questioning techniques forward in the schedule." In terms of how they decided to make these accommodations to their PSTs' course work and experiences, the TEs noted that they did so by taking into consideration: (a) the context of the course itself (50% of TEs), (b) the needs, prior experiences, and/or characteristics of their PSTs (38% of TEs), and (c) recommendations from the TE guidebook (25% of TEs). For many of these TEs, this simulated teaching experience was the only one their PSTs engaged in this semester, as this study occurred during the COVID pandemic when many schools could not accommodate field experiences (online or in-person). Therefore, the context of the reduced or eliminated field experiences served as the main reason why the TEs decided to incorporate some of these activities into their course work. For example, TE 08 explained that:

> This was actually really easy this semester due to the pandemic. Usually the last four class periods are when the students [PSTs] pair with a classmate, develop a mini-lesson, plan to teach it, and teach it in their elementary host classrooms. Since none of this was able to occur this semester, I was able to put the Mystery Powder task/simulation within these four class periods.

Other TEs attended to the needs of their PSTs when making these decisions. For example, TE 01 decided to include a greater focus on argumentation in her instruction, including the use of videos from the Argumentation Toolkit website to better address "…the needs of students [PSTs] learning CER [claims, evidence, and reasoning] to feel confident in their simulation experience…"

Research Question 2: Perceptions of Value for Using Simulated Teaching Experiences

The majority of TEs (100%) and PSTs (89%) reported that they valued using the simulated teaching experience. As shown in Table 8, there were a variety of reasons the TEs and PSTs indicated for why they recommended the simulated teaching experience to be included in future method courses. The most frequently mentioned reason for valuing the simulated discussion experience was because it gave the PSTs an opportunity and a space to practice and learn about how to engage in the work of teaching (50% of TEs and 53% of PSTs). For example, one TE noted that the "simulated classroom gives students a chance to feel like they are teaching…" (TE 03) while another expressed how "…the simulated classroom discussion is certainly a great learning opportunity to learn the core practice of facilitating a discussion" (TE 06). Similarly, one PST noted that, "[The] simulated discussion…is great practice and everyone can learn from it" (PST 416) while another explained that "…it really does help you become a better teacher with learning how to actually teach…" (PST 405).

Beyond the importance of providing a practice-based space to try out novel teaching moves, TEs also valued the simulated teaching experience because it provided a safe environment for beginning teachers to practice (25%), allowed PSTs to watch their performance and reflect on their teaching (38%), and gave their PSTs a space to apply the information learned from the TE's course (38%). For instance, one TE commented on all three aspects and said that, "Providing students a 'safe space' such as the simulation classroom gives PSTs the opportunity to put into practice what they learned about the pedagogy of instruction. Plus, they can obtain feedback and vital reflection mechanisms…." (TE 01). Providing a safe environment, having the ability to reflect on their performance, and applying the skills and knowledge learned from the TE's course were also reasons that the PSTs valued the simulated discussion experience, however, these reasons were mentioned less frequently than by the TEs (12%, 9%, and 2%, respectively). In general, findings showed that these response patterns were consistent across the two content areas. The only significant difference we found was that 13% more mathematics PSTs than science PSTs valued the simulation because it provided them an opportunity to watch their performance and reflect on their teaching, X^2 (1, N = 84) = 4.739, p = .029.

While most PSTs reported that they valued the simulated teaching experience, a few PSTs (11%) reported that they did not. PSTs most commonly reported not valuing the experience because they prefer learning in a different environment (e.g., real-life classroom). For instance, PST 803 noted that they "…would not recommend this [experience] if there are actual students available…". A few PSTs also cited a negative emotion or feeling (e.g., discomfort, nervousness) as the reason for not valuing the simulated discussion experience. For example, PST 408 stated that "for me personally it just made me feel all nervous…". Finally, two PSTs called out inauthenticity, such as the simulation feeling robotic (PST 308), as a reason for not valuing the experience.

Discussion

Findings from this study yield three important contributions. The first contribution is theoretical in nature. The study's findings related to the nature of the pedagogies these TEs used to support their PSTs in preparing for and learning from the simulated teaching experience both substantiates and expands upon McDonald et al.'s (2013) initial framework. This initial framework proposed a set of core pedagogies that TEs may use to engage novices, including PSTs, in learning how to enact a core teaching practice. Our findings provide existence proof for the importance and use of many of the pedagogies that McDonald and her colleagues identified as signature pedagogies for this approach to practice-based teacher education. Video analysis, examining video exemplars, and reflection writing were three pedagogies included in this initial framework. Likewise, our study illustrated an emphasis on incorporating opportunities for the PSTs to reflect on their own and others' practice and to use videos as tools for observation and analysis – either as exemplars of specific teaching skills or as artifacts to be decomposed and studied.

However, our study also expands this framework by identifying and describing other substantive pedagogies that TEs use to engage PSTs in learning how to engage in a core practice. In our study, we found that all TEs engaged their PSTs in reflection, but via varied means and for varied purposes. In particular, our findings point to the importance of having PSTs engage in reflection discussions, in addition to reflection writing, where they can collectively build their understanding of discussion and content-focused teaching strategies and how to apply these strategies in future instruction. Research on practice-based teacher education supports the importance of opportunities for teachers to reflect on their instructional decisions, whether as part of face-to-face rehearsals or as part of coaching-based reflection, and consider the implications of those decisions to support student learning (Cohen, 2020; Kloser et al., 2019; Reisman et al., 2019).

Study findings also showed the importance of engaging the PSTs in pedagogical activities to develop their own understanding of the content so that they would be better prepared to engage in this content-intensive teaching practice productively. As noted in other research, high-quality instruction in the content areas requires that teachers have a strong understanding of both the subject matter and students' ways of understanding, making sense of, and interacting with conceptual ideas (Ball et al., 2008; Baumert et al., 2010; Sadler et al., 2013). We also found that some extensions were necessary to account for the pedagogies we observed in the data, including distinguishing between collective and individual reflection on video and accounting for direct instruction. As described in the methods section, our approach was deliberately broad, attempting to capture the breadth of observed pedagogies without judgment as to their appropriateness or productive outcomes. This decision may have put us slightly out of alignment to the original framework authors' intent, but we feel that taking a broad view is needed in order to appropriately capture the breadth of approaches.

Overall, these results are aligned to McDonald et al.'s (2013) call to identify and account for a broader set of supporting pedagogies for core practices, but also suggests that simulated teaching pushes the boundaries of their existing framework in two ways. First, because simulated teaching is theorized to be impactful within a cycle of enactment, it suggests looking at a broader section of instruction. Second, it suggests that when the core practice of rehearsal is enacted in this way, some pedagogies that TEs gravitate toward are not fully accounted for without extending the framework.

The second contribution focuses on implications for teacher education. By providing a window into the nature of the pedagogies used by one group of TEs, our study illustrates how the larger cycle of enactment, which includes the preparation and debrief, can be organized towards varying pedagogical purposes. Our findings suggest that certain pedagogical purposes can be central across multiple pedagogical activities. For example, all the TEs in this study focused on developing their PSTs' understanding of specific discussion teaching strategies, such as eliciting and probing for student thinking or prompting students to interact directly with each other. However, they did so across a variety of pedagogical activities ranging from reflection discussions to using videos as exemplars for collective or individual reflection to collaborative or individual planning. They also focused on this pedagogical purpose – developing their PSTs' understanding of discussion teaching strategies and how to use them – both prior to and after the simulated teaching session. Pedagogy and purpose were clearly intertwined in deep and meaningful ways, as we did not observe simple patterns of co-occurrence. This finding reminds us that the work of teaching is complex, with multiple layers of instructional purpose often layered and simultaneous in enactment. It also raises the idea of multiple entry points for TEs and raises the important consideration of pedagogical intent – for what purpose and how can (or should) a specific pedagogical activity be used to support PST learning. This study suggests that TEs need to consider not only the pedagogical activity that is being used but its purpose and how those aspects are best aligned to support PST learning. Future studies should take up these issues with more nuanced examination and comparison to better understand under what conditions and for what purposes specific pedagogical activities show differential value for PST learning.

Further, we would argue that while our analysis was conducted within the context of digital simulations, this suggests that an additional layer of analyses, such as those suggested by the core practice movement, might account not just for pedagogies but for the purposes toward which they are directed.

The final contribution illustrates the productive possibilities for how this technology tool can be integrated into practice-based teacher education settings to engage PSTs in useful practice teaching opportunities that can complement, or in certain cases replace, in-person instruction. The eight TEs in this study worked in varied contexts with different PST challenges, needs, experiences, and backgrounds. Despite this variation, almost universally the PSTs and their TEs reported that they perceived the value of such an experience for use in future elementary mathematics and science method courses, similar to earlier studies examining how teachers use, respond to, and learn from mixed-reality simulated classrooms to support their learning (Driver et al., 2018; Ledger et al., 2019; Mikeska, Howell, & Kinsey, 2021; Murphy et al., 2018; Pandowski & Walker, 2016; Sargent, 2020; Straub et al., 2014; 2015). While one limitation of the study is that we did not use a pre and post assessment to examine PST learning over time, these initial insights indicate that – at least from the TEs' and PSTs' perspectives – the pedagogies used during the larger cycle of enactment supported PST learning and provided them with productive avenues for developing PSTs' ability to facilitate argumentation-focused discussions. An important goal of future studies would be the use of quasi-experimental and experimental designs to examine impact of the simulated teaching experience on PSTs' knowledge and understanding about argumentation and discussion and changes to their ability to engage in this core teaching practice.

Limitations

There are a number of limitations associated with the study and the technology used, as well as the conditions of use, and delimitations induced by the study's deliberate focus on a single teaching practice and a single content problem in each content area. One limitation of the technology is that the avatars, in terms of identity and lived experience, are underdeveloped as characters. Interactors are highly trained to represent the avatars' ways of speaking, personalities, and mannerisms, but at the end of the day they are not real children. Nor did our tasks call attention to the students' identity characteristics in a way that would foreground them to PSTs. This is not to say that such a use case is impossible. For example, one TE enrolled in our study elected to bring such a focus to their instruction, asking their PSTs to complete bias surveys in advance of using the simulation and layering on additional research in which the PSTs were asked to identify the race and gender of each avatar so that they could interrogate their own perceptions and potential biases. That only one of the TEs elected to bring this secondary focus to the work likely reflects multiple considerations. The semester of study was turbulent due to the COVID pandemic, and TEs had limited time to get to know the approach and think through its affordances, both of which make experimentation and extension difficult to implement. Additionally, the materials are clearly framed around content practices. While our team sees argumentation as a critical skill for PSTs to develop because of its importance in supporting equitable opportunity to learn, TEs might need more explicit framing in order to help their PSTs see argumentation in that way.

An additional limitation of the technology lies in the use of one interactor to voice five student avatars. While this is part of what makes the approach cost-effective, it also renders inevitable that interactors will end up playing the part of students whose apparent ethnic or racial characteristics do not map onto the interactors' own identity, creating a potential source of bias.

This is a bias source that Mursion is aware of and incorporates into their training and, as discussed previously, our project staff monitored videos actively for adherence to our student profiles and for evidence of stereotypical behaviors, finding no evidence that this occurred in the monitored sessions. However, it remains a limitation of the approach and one that warrants this kind of careful monitoring. Additional technological limitations include the inability to physically move around the classroom or to ask the students to change seats or write on the board (the PST can hold a piece of writing up to the camera for the student avatars to see, but the avatars cannot do the same).

Other limitations reflect the context of implementation. The study was designed to meet an immediate need, during a semester of extraordinary strain on TEs and PSTs alike. While our results showed broad support for the utility of the approach, appreciation for having such a tool available, and an ability to articulate clearly what participants believed was learned, we were not able to measure PST learning directly via a pre and post measure as we have done in other studies (Mikeska & Howell, 2021b). Instead, our findings rely on self-report and observations of TEs' practice within their methods course. Nor did we have the opportunity to explore the question of whether the dosage, one simulated teaching experience, was optimal for this use case. Additionally, while the TEs utilized a variety of pedagogies in their approaches, we did not have sufficient data to compare to the pedagogies they had employed in past, non-simulation semesters, nor to what they might have done to compensate for COVID challenges absent the simulation. In all cases the TEs were teaching the course in a significantly different format than they had pre-COVID, which makes such comparisons tenuous. While a few of our survey questions did ask what changes were made in the course during the semester of study, the answers provided did not allow us to disentangle the degree to which the changes were to accommodate the simulation as opposed to simply changes warranted to the changes to course structure due to the COVID pandemic. It is likely that additional pedagogies or approaches might have emerged during a semester with fewer challenges, or during which the TEs were able to plan ahead with less expectation of sudden changes. It is possible that some of the variability we observed might have been present even without the use of simulations.

Conclusion

Findings from this study suggest the importance of paying attention to the varied ways in which TEs engage PSTs in learning how to enact core practices, like facilitating argumentation-focused discussions, as they integrate simulated teaching experiences into their teacher education courses. Technology tools like the simulated classroom can be complemented with an array of pedagogical activities used in multiple ways for varied purposes, depending on the course context and PST needs. In this study, the variety of pedagogies used by the TEs targeted multiple pedagogical purposes as the TEs prepared the PSTs for and helped them learn from the simulated teaching experience. Overall findings suggest the importance of engaging PSTs in activities that engage them in decomposing and recomposing practice through structured analysis and reflection within a larger cycle of enactment. The main implication is that it is not the simulated teaching session in and of itself that supports PST learning, but it is the simulated teaching session coupled with strategically scaffolded and intentional pedagogical activities prior to and after the simulated teaching session that work in concert to support PSTs in learning how to enact core teaching practices. Future research should target questions to better understand the full range of pedagogies that are used in practice-based teacher education, especially when using novel technology tools such as simulated classrooms to support PST learning.

References

American Association of Colleges for Teacher Education. (2020). *Teaching in the Time of Covid-19: State Recommendations for Educator Preparation Programs and New Teachers.* AACTE Report Series.

Association of Mathematics Teacher Educators (AMTE). (2017). *Standards for Preparing Teachers of Mathematics*. https//amte.net/standards

Australian Institute for Teaching and School Leadership (AITSL). (2014). Evaluation of the Australian Professional Standards for Teachers.

Badiee, F., & Kaufman, D. (2014). The effectiveness of an online simulation for teacher education. *Journal of Technology and Teacher Education, 22*(2), 167-186. https://www.learntechlib.org/primary/p/45934/

Ball, D. L., & Cohen, D. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In G. Sykes and L. Darling-Hammond (Eds.), *Teaching as the Learning Profession: Handbook of Policy and Practice* (pp. 3-32). Jossey Bass.

Ball, D. L., & Forzani F. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*, 497-511. https://doi.org/10.1177/0022487109348479

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal, 47*(1), 133-180.

Benedict, A., Holdheide, L., Brownell, M., & Foley, A. M. (2016). Learning to teach: Practice-based preparation in teacher education [Special issue brief]. *Center on Great Teachers and Leaders at American Institutes for Research*.

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation?. *Qualitative health research*, *26*(13), 1802–1811. https://doi.org/10.1177/1049732316654870

Borko, H., Eisenhart, M., Brown, C. A., Underhill, R. G., Jones, D., & Agard, P. C. (1992). Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily?. *Journal for research in mathematics education*, *23*(3), 194-222.

Boyd, D. J., Grossman, P. L., Lankford, H., Loeb, S., & Wyckoff, J. (2009). Teacher preparation and student achievement. *Educational Evaluation and Policy Analysis, 31*(4), 416-440. https://doi.org/10.3102/0162373709353129

Butt, G., & Lambert, D. (2014). International perspectives on the future of geography education: an analysis of national curricula and standards. *International Research in Geographical and Environmental Education*, *23*(1), 1-12.

Call, K. (2018). Professional teaching standards: A comparative analysis of their history, implementation and efficacy. *Australian Journal of Teacher Education*, *43*(3), 93-108.

Cochran-Smith, M., Ell, F., Ludlow, L., Grudnoff, L., & Aitken, G. (2014). The challenge and promise of complexity theory for teacher education research. *Teachers College Record, 116*(5), 1-38.

Cohen, J., Wong, V., Krishnamachari, A., & Berlin, R. (2020). Teacher coaching in a simulated environment. *Educational Evaluation and Policy Analysis, 42*(2), 208-231. https://doi.org/10.3102/0162373720906217

Dalinger, T., Thomas, K. B., Stansberry, S., & Xiu, Y. (2020). A mixed reality simulation offers strategic practice for pre-service teachers. *Computers & Education, 144*. https://doi.org/10.1016/j.compedu.2019.103696

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, *76*(4), 607-651.

Dieker, L. A., Hughes, C. E., Hynes, M. C., & Straub, C. (2017). Using simulated virtual environments to improve teacher performance. *School-University Partnerships, 10*(3), 62-81.

Dotger, B., Masingila, J., Bearkland, M., & Dotger, S. (2014). Exploring iconic interpretation and mathematics teacher development through clinical simulations. *Journal of Mathematics Teacher Education, 18*(6), 577-601. https://doi.org/10.1007/s10857-014-9290-7

Driver, M., Zimmer, K., & Murphy, K. (2018). Using mixed reality simulations to prepare preservice special educators for collaboration in inclusive settings. *Journal of Technology and Teacher Education*, *26*(1), 57-77.

Dube, M. C. (2020). Teaching and learning challenges preservice teachers face during teaching practice. *Gender & Behaviour*, *18*(1), 14646-14659.

Forde, C., McMahon, M. A., Hamilton, G., & Murray, R. (2016). Rethinking professional standards to promote professional learning. *Professional Development in Education*, *42*(1), 19-35.

Forzani, F. M. (2014). Understanding "core practices" and "practice-based" teacher education: Learning from the past. *Journal of Teacher Education*, *65*(4), 357-368. https://doi.org/10.1177/0022487114533800

Fox, J., Ahn, S., Janseen, J. Yeykelis, L., Segovia, K., & Bailenson, J. N. (2015). Avatars versus agents: A meta-analysis quantifying the effect of agency on social influence. *Human-Computer Interaction, 30*(5), 401-432. https://doi.org/10.1080/07370024.2014.921494

Francis, A. T., Olson, M., Weinberg, P. J., & Sterns-Pfeiffer, A. (2018). Not just for novices: The programmatic impact of practice-based teacher education. *Action in Teacher Education, 40*(2), 119-132. https://doi.org/10.1080/01626620.2018.1424053

Girod, M., & Girod, G. R. (2008). Simulation and the need for practice in teacher preparation. *Journal of Technology and Teacher Education*, *16*(3), 307-337. https://www.learntechlib.org/primary/p/24469/

Go Discuss Project. (2021). *Go Discuss* [Qualitative Data Repository]. https://data.qdr.syr.edu/dataverse/go-discuss

Goodson, B., Caswell, L., Dynarski, M., Price, C., Litwok, D., Crowe, E., Meyer, R., & Rice, A. (2019). Teacher Preparation Experiences and Early Teaching Effectiveness. Executive Summary. NCEE 2019-4010. *National Center for Education Evaluation and Regional Assistance*.

Grossman, P. L. (2018). *Teaching core practices in teacher education*. Harvard Education Press.

Grossman, P., Hammerness, K., & McDonald, M. (2009). Redefining teaching, re-imagining teacher education. *Teachers and Teaching: Theory and Practice*, *15*(2), 273-289. https://doi.org/10.1080/13540600902875340

Grossman, P., Kazemi, E., Kavanagh, S.S., Franke, M., & Dutro, E. (2019). Learning to facilitate discussions: Collaborations in practice-based teacher education. *Teaching and Teacher Education, 81*, 97-99. https://doi.org/10.1016/j.tate.2019.02.002

Howell, H. & Mikeska, J. N. (2021). Approximations of practice as a framework for understanding the role of authenticity in simulations of teaching. *Journal of Research on Technology in Education, 53*(1), 8-20. https://doi.org/10.1080/15391523.2020.1809033

Howell, H., Mikeska, J.N., Tierney, J., Baehr, B., & Lehman, P. (2021). *Conceptualization and development of a performance task for assessing and building elementary preservice teachers' ability to facilitate argumentation-focused discussions in mathematics: The ordering fractions task.* (Research Memorandum No. RM-21-10). ETS.

Ingraham, K. M., Romualdo, A., Fulchini Scruggs, A., Imperiale, E., Dieker, L. A., & Hughes, C. E. (2021). Developing an immersive virtual classroom: TeachLivE – A case study. In D. Choi, A. Dailey-Hebert, & J. Estes (Ed.), C*urrent and prospective applications of virtual reality in higher education* (pp. 118-144). IGI Global.

Kazemi, E., Ghousseini, H., Cunard, A., & Turrou, A. C. (2016). Getting inside rehearsals: Insights from TEs to support work on complex practice. *Journal of Teacher Education*, *67*(1), 18-31. https://doi.org/10.1177/0022487115615191

Kloser, M., Wilsey, M., Madkins, T.C., & Windschitl, M. (2019). Connecting the dots: Secondary science teacher candidates' uptake of the core practice of facilitating sensemaking discussions from teacher education experiences. *Teaching and Teacher Education, 80*, 115-127. https://doi.org/10.1016/j.tate.2019.01.006.

Korthagen, F. (2017). Inconvenient truths about teacher learning: Towards professional development 3.0. *Teachers and Teaching, 23*(4), 387-405. https://doi.org/10.1080/13540602.2016.1211523

Lampert, M. (2010). Learning teaching in, from, and for practice: What do we mean?. *Journal of Teacher Education, 61*(1-2), 21-34. https://doi.org/10.1177/0022487109347321

Ledger, S., Ersozlu, Z., & Fischetti, J. (2019). Preservice teachers' confidence and preferred teaching strategies using TeachLivE ™ virtual learning environment: A two-step cluster analysis. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(3), em1674. https://doi.org/10.29333/ejmste/102621

Levin, D. M., Hammer, D., & Coffey, J. E. (2009). Novice teachers' attention to student thinking. *Journal of Teacher Education*, *60*(2), 142-154.

Maxwell, J. A. (2013). *Qualitative research design: An interactive approach*. Sage.

McDonald, M., Kazemi, E, & Kavanagh, S. (2013). Core practices and pedagogies of teacher education: A call for a common language and collective activity. *Journal of Teacher Education, 64*(5), 378-386. https://doi.org/10.1177/0022487113493807

Mikeska, J.N. & Howell, H. (2020). Simulations as practice-based spaces to support elementary science teachers in learning how to facilitate argumentation-focused discussions. *Journal of Research in Science Teaching, 57*(9), 1356-1399. https://doi.org/10.1002/tea.21659

Mikeska, J. N., & Howell, H. (2021a). Authenticity perceptions in virtual environments. *Information and Learning Sciences, 122*(7/8), 480-502. https://doi.org/10.1108/ILS-10-2020-0234

Mikeska, J. N., & Howell, H. (2021b, March 30). Pushing the boundaries of practice-based teacher education: How can online simulated classrooms be used productively to support STEM teacher learning? *Advancing Research & Innovation in the STEM Education of Preservice Teachers in High-Need School Districts.* https://aaas-arise.org/2021/03/30/pushing-the-boundaries-of-practice-based-teacher-education-how-can-online-simulated-classrooms-be-used-productively-to-support-stem-teacher-learning/

Mikeska, J. N., Howell, H., & Kinsey, D. (2021). *Exploring the potential of simulated teaching experiences as approximations of practice within elementary teacher education: Do simulated teaching experiences impact elementary preservice teachers' ability to facilitate discussions in mathematics and science?* [Manuscript submitted for publication]. K-12 Center for Teaching, Learning, and Assessment, Educational Testing Service.

Mikeska, J. N., Howell, H., Ciofalo, J., Devitt, A., Orlandi, E., King, K., Lipari, M., & Simonelli, G. (2021). *Conceptualization and development of a performance task for assessing and building elementary preservice teachers' ability to facilitate argumentation-focused discussions in mathematics: The mystery powder task.* (Research Memorandum No. RM-21-06). ETS.

Mikeska, J. N., Howell, H., Dieker, L., & Hynes, M. (2021). Understanding the role of simulations in K-12 mathematics and science teacher education: Outcomes from a teacher education simulation conference. *Contemporary Issues in Technology and Teacher Education*, 21(3).

Murphy, K. M., Cash, J., & Kellinger, J. J. (2018). Learning with avatars: Exploring mixed reality simulations for next-generation teaching and learning. In *Handbook of research on pedagogical models for next-generation teaching and learning* (pp. 1-20). IGI Global. https://www.igi-global.com/gateway/chapter/190357

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Author.

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). *Mathematics standards*. Mathematics Standards | Common Core State Standards Initiative. http://www.corestandards.org/Math/

National Research Council. (2013). *Next Generation Science Standards: For States, By States*. The National Academies Press.

National Science Teachers Association. (2003). Standards for science teacher preparation. *Faculty Publications: Department of Teaching, Learning and Teacher Education*, 86.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. The National Academies Press. https://doi.org/10.17226/18290

Pankowski, J., & Walker, J. T. (2016). Using simulation to support novice teachers' classroom management skills: Comparing traditional and alternative certification groups. *Journal of the National Association for Alternative Certification*, *11*(1), 3-20.

Piro, J. S., & O'Callaghan, C. (2018). Journeying towards the profession: Exploring liminal learning within mixed reality simulations. *Action in Teacher Education, 41*(1), 79-95. https://doi.org/10.1080/01626620.2018.1534221

Reich, J., Buttimer, C. J., Fang, A., Hillaire, G., Hirsch, K., Larke, L. R., Littenberg-Tobias, J., Moussapour, R. M., Napier, A., Thompson, M., & Slama, R. (2020, April 2). Remote Learning Guidance From State Education Agencies During the COVID-19 Pandemic: A First Look. https://doi.org/10.35542/osf.io/437e2

Rodriguez, G. M. (2013). Power and agency in education: Exploring the pedagogical dimensions of funds of knowledge. *Review of Research in Education*, *37*(1), 87-120.

Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N., & Miller, J. L. (2013). The influence of teachers' knowledge on student learning in middle school physical science classrooms. *American Educational Research Journal*, *50*(5), 1020-1049.

Saenz-Armstrong, P. (2020, April 16). *Student teaching and initial licensure in the time of coronavirus. National Council on Teacher Quality*. National Council on Teacher Quality. https://www.nctq.org/blog/Student-teaching-and-initial-licensure-in-the-times-of-coronavirus

Saldaña, J. & Omasta, M. (2018). *Qualitative research: Analyzing life*. Sage.

Santoro, N., & Kennedy, A. (2016). How is cultural diversity positioned in teacher professional standards? An international analysis. *Asia-Pacific Journal of Teacher Education*, *44*(3), 208-223.

Sargent, D. L. (2020). The evolution of teacher education through emerging technologies of mixed reality simulation. In M. Grassetti, & J. Zoino-Jeannetti (Eds.), *Next generation digital tools and applications for teaching and learning enhancement* (pp. 16-30). IGI Global. http://doi:10.4018/978-1-7998-1770-3.ch002

Schreier, M. (2014). Qualitative content analysis. In U. Flick (Ed.). *The SAGE Handbook of qualitative data analysis* (pp. 170-183). SAGE Publications Ltd.

Shaughnessy, M., & Boerst, T. (2018). Designing simulations to learn about pre-service teachers' capabilities with eliciting and interpreting student thinking. In Stylianides, G., & Hino, K. (Eds.). *Research advances in the mathematical education of pre-service elementary teachers* (pp. 125-140). Springer, Cham. https://doi.org/10.1007/978-3-319-68342-3_9

Shulman, L. S. (2005). Signature pedagogies in the professions. *Daedalus*, *134*(3), 52-59. https://doi.org/10.1162/0011526054622015 simSchool. (2022). *simSchool.* https://www.simschool.org/home/simschool/

Straub, C. (2018). *Best in class leadership development: How virtual reality and avatars are changing the learning landscape* [White paper]. Mursion, Inc. https://www.denasamuels.com/wp-content/uploads/2020/03/How-Virtual-Reality-and-Avatars-are-Changing-the-Learning-Landscape.pdf

Straub, C., Dieker, L., Hynes, M., & Hughes, C. (2014). Using virtual rehearsal in TLE TeachLivE™ mixed reality classroom simulator to determine the effects on the performance of mathematics teachers. *2014 TeachLivE™ National Research Project: Year 1 Findings,* 1-50.

Straub, C., Dieker, L., Hynes, M., & Hughes, C. (2015, June). Using virtual rehearsal in TLE TeachLivE™ mixed reality classroom simulator to determine the effects on the performance of science teachers: A follow-up study (Year 2). In Bousfield, T., Hynes, M., Hughes, C., Straub, C., Dieker, L. & Ingrahm, K. (Eds.), *Proceedings of 3rd National TLE TeachLivE™ Conference 2015: Dissecting Education* (pp. 49-109). University of Central Florida.

Talespin. (2021). *Talespin – Enterprise VR, AR & AI.* https://www.talespin.com/

TeachingWorks. (2019). High-Leverage teaching practices. https://library.teachingworks.org/curriculum-resources/high-leverage-practices/

Walters, S. M., Hirsch, S. E., McKown, G., Carlson, A., & Allen, A. A. (2021). Mixed-reality simulation with preservice teacher candidates: A conceptual replication. *Teacher Education and Special Education*. https://doi.org/10.1177/08884064211001453

Table 1

Sample Characteristics

Characteristics		Teacher Educators (n=8) n (%)	Preservice Teachers (n=102) n (%)
Gender	Male	2 (25%)	4 (4%)
	Female	6 (75%)	98 (96%)
Ethnicity[a]	Hispanic/Latino	0 (0%)	31 (30%)
	Black or African American	0 (0%)	32 (31%)
	Asian or Asian American	1 (13%)	5 (5%)
	White	6 (75%)	39 (38%)
	Other	0 (0%)	3 (3%)
Institution Type	Public	6 (75%)	84 (82%)
	Private	2 (25%)	18 (18%)
Course Focus	Elementary Mathematics Methods	4 (50%)	53 (52%)
	Elementary Science Methods	4 (50%)	49 (48%)
Course Format	Online Only	3 (38%)	44 (43%)
	Face-to-Face Only	0 (0%)	0 (0%)
	Hybrid	5 (63%)	58 (57%)
Course Structure	Synchronous Only	6 (75%)	74 (73%)
	Asynchronous Only	1 (13%)	17 (17%)
	Hybrid	1 (13%)	11 (11%)
Prior Experience Using Simulations	Yes	3 (38%)	17 (17%)
	No	5 (63%)	85 (83%)

[a]One teacher educator did not respond to this question. Totals do not add to 100% because each participant could make one or more selections for ethnicity.

Table 2

Coding for Pedagogical Activities Used by the Teacher Educator (TE)

Code	Description
Modeling	The TE models how to engage in a specific teaching practice or a component skill related to a teaching practice.
Using Videos for Collective Reflection	The TE engages the preservice teachers (PSTs) in observing and/or discussing video records of practice in a collective (small or whole group) setting. This activity may or may not include systematic/focused analysis of the video(s).
Using Videos for Individual Reflection	The TE engages the PSTs in observing and/or discussing video records of practice by themselves. This activity may or may not include systematic/focused analysis of the video(s).
Using Videos as Exemplars	The TE engages the PSTs in observing and/or discussing video records of practice **and** is using the video(s) with clear intent that it be an example of something.
Examining Written Cases	The TE engages the PSTs in reading, discussion, and/or analyzing written cases of teaching episodes.
Individual Planning	The TE provides the PSTs with an opportunity to plan part of or a full lesson.
Collaborative Planning	The TE engages the PSTs in lesson planning with one or more of their peers.
Peer Teaching/Rehearsal	The TE engages the PSTs in peer teaching where other PSTs or the TE act as K-12 students while one PST practices an aspect of instruction (e.g., practices facilitating a discussion; practices eliciting students' ideas).
Transcript Analysis	The TE engages the PSTs in analyzing transcripts from video or audio records of practice (could be the PSTs' own transcripts or others' transcripts).
Reflection Writing	The TE engages the PSTs in reflecting on their own or other's instructional practice via writing.
Reflection Discussion	The TE engages the PSTs in reflecting on their own or other's instructional practice via discussion in pairs, small groups or whole class.

Examining Student Work	The TE engages the PSTs in observing, discussing, and/or analyzing written student work samples related to the performance task.
Doing the Work of the Students	The TE engages the PSTs in doing the work that K-12 students might do as part of their classwork (e.g., completing a science investigation; solving a mathematical problem; etc.) related to the content of the performance task.
Direct Instruction	The TE's instruction focuses on conveying information to the PSTs, which may include a class lecture or reading assignment.
None	The TE does not use any of the above pedagogies during this instructional activity.
Unclear/Vague	The pedagogical activity cannot be inferred from the summary description, observational notes, and/or class artifacts.
Other	The TE uses other pedagogies during the preparation and/or debrief to support PST engagement/learning.

Table 3

Coding for Pedagogical Purpose of Activities Used to Support Preservice Teachers (PSTs)

Code	Description for Purpose of Pedagogical Activity
Argumentation Knowledge	To support PSTs in better understanding what argumentation is and/or entails (its key features and/or characteristics)
Argumentation Teaching Strategies	To support PSTs in developing their knowledge about teaching strategies/moves they and others can use to engage students in argumentation
Discussion Knowledge	To support PSTs in better understanding what discussion is and/or entails (its key features and/or characteristics)
Discussion Teaching Strategies	To support PSTs in developing their knowledge about teaching strategies/moves (e.g., eliciting student thinking) they and others can use to engage students in discussion
Content Knowledge	To support PSTs in developing their knowledge about mathematics or science content related to the performance task
Content Teaching Strategies	To support PSTs in developing their knowledge about how to teach specific mathematics or science content to K-12 students
Application to Lesson Planning	To support PSTs in learning how to apply specific teaching strategies/moves to lesson planning
Focused Self-Evaluation	To support PSTs in developing their ability to self-evaluate
Simulation Familiarity	To familiarize the PSTs with the components of the simulated teaching session and help the PSTs understand the simulation logistics (e.g., how it works)
Unclear/Vague	The purpose of the pedagogical activity cannot be inferred from the summary description, observational notes, and/or class artifacts.
Other	The purpose of the pedagogical activity is not captured by the above codes.

Table 4

Coding for Perceptions of Value for Using Simulated Teaching Experiences

Value Using Simulated Teaching Experiences	Code	Description
Yes	Learning/Practice	Describes the simulated discussion as an opportunity or experience to learn/practice.
	Connection to Students/Classroom	Describes the simulated discussion as being connected to what would happen in a real-life classroom, which may include an opportunity to learn about students, their behavior, and/or how they interact or how to interact with them.
	Low Stakes Environment	Describes the simulated discussion as a safe/more comfortable/less stressful environment to practice for beginning teachers.
	Reflection	Describes the simulated discussion as an opportunity to reflect on their teaching skills/abilities.
	Technology/Virtual	Describes the importance of having experience and knowledge using technology (i.e., virtual simulation) to teach.
	Practicum Substitution	Describes using the simulated discussion in place of student teaching or another practicum experience that was not available due to the COVID-19 pandemic.
	Multiple Sessions	Describes a need/want for more than one simulated discussion session and/or describes how additional sessions would be helpful.
	Fun/Engaging	Describes the simulated discussion as a fun and/or engaging experience.
	Knowledge & Skills Application	Describes the simulated discussion as an opportunity to apply the skills/knowledge learned in their courses.
	Consistency	Describes the simulated discussion as consistent across PST sessions, which allows for comparison across different PST performances.

	Vague	Describes a reason for recommendation that is too vague to categorize.
	Other	Describes a different reason for recommendation that is not one of the previous codes.
No	Prefer Alternative Environment	Describes a preference for a different way for PSTs to learn, which may include real-life experiences, more hands-on experiences, and/or other alternatives over the simulated classroom environment.
	Negative Emotion/Feeling	Describes a negative feeling or emotion that is due to the simulated discussion (e.g., discomfort, nervousness).
	Inauthentic	Describes a characteristic of the simulated discussion that is not representative of a real-life classroom.
	Vague	Describes a reason for not recommending the simulated discussion that is too vague to categorize.
	Other	Describes a different reason that they would not recommend the simulated discussion that is not one of the previous codes.

Table 5

Pedagogical Activities Used by Teacher Educators (TEs) by Site and Cycle Component

Pedagogical Activity	Elementary Science Method Courses								Elementary Mathematics Method Courses								Total	
	Site 1		Site 2		Site 3		Site 8		Site 4		Site 5		Site 6		Site 7			
	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After
Modeling	X																1	0
Using Videos for Collective Reflection**	X	X			X		X						X	X	X		5	2
Using Videos for Individual Reflection**					X		X		X		X			X			4	1
Using Videos as Exemplars	X				X		X		X				X	X	X		6	1
Examining Written Cases															X		1	0
Individual Planning*	X		X	X	X		X				X					X	5	2
Collaborative Planning			X		X												2	0
Peer Teaching / Microteaching	X												X				2	0
Transcript Analysis											X						1	0
Reflection Writing				X		X			X	X	X	X	X			X	3	5
Reflection Discussion*	X	X		X		X	X	X		X			X	X	X	X	4	7
Examining Student Work*	X						X		X		X		X				5	0
Doing the Work of the Students*	X		X		X						X		X		X		6	0
Direct Instruction*	X	X	X	X	X		X		X				X		X		7	2

Other	X																1	0
Total	10	3	4	4	7	2	7	1	5	2	6	1	8	4	6	3		

Note. Prior to the simulated teaching experience includes any activities that the TE used to prepare the preservice teachers (PSTs) for the simulated teaching session. After the simulated teaching experience includes any activities that the TE used to support the PSTs in debriefing and learning from their simulated teaching session. An X in each cell indicates that the TE used that pedagogical activity at least one time during the preparation or debrief component of the simulated teaching experience while a blank cell indicates that the TE did not use that pedagogical activity during the preparation or debrief component.

* Pedagogies of practice that were generated in our analysis.
**Pedagogies of practice from McDonald et al.'s (2013) framework that we refined based on our analysis.

Table 6

Pedagogical Purpose of Activities Used by Teacher Educators (TEs) by Site and Cycle Component

Pedagogical Purpose	Elementary Science Method Courses								Elementary Mathematics Method Courses								Total	
	Site 1		Site 2		Site 3		Site 8		Site 4		Site 5		Site 6		Site 7			
	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After	Prior	After
Argumentation Knowledge	X												X				2	0
Argumentation Teaching Strategies	X				X	X	X		X	X	X	X			X		6	3
Discussion Knowledge					X						X						2	0
Discussion Teaching Strategies	X		X	X	X	X	X	X	X	X	X	X	X	X	X		8	6
Content Knowledge	X		X		X		X				X		X		X		7	0
Content Teaching Strategies							X			X	X	X		X	X		3	3
Application to Lesson Planning	X		X	X	X		X		X		X		X		X		8	1
Focused Self-Evaluation		X		X		X		X		X				X		X	0	7
Simulation Familiarity									X				X		X		3	0
Other		X	X	X										X		X	1	4
Total	5	2	4	4	5	3	5	2	4	4	6	3	5	4	6	2		

Note. Prior to the simulated teaching experience includes any activities that the TE used to prepare the preservice teachers (PSTs) for the simulated teaching session. After the simulated teaching experience includes any activities that the TE used to support the PSTs in debriefing and learning from their simulated teaching session. An X in each cell indicates that the TE used that pedagogical activity at least one time during the preparation or debrief component of the simulated teaching experience while a blank cell indicates that the TE did not use that pedagogical activity during the preparation or debrief component.

Table 7

Types of Pedagogical Activities Used by Pedagogical Purpose Across the Teacher Educators (n=8)

Pedagogical Activity	*Pedagogical Purpose*									
	Argumentation Knowledge	Argumentation Teaching Strategies	Discussion Knowledge	Discussion Teaching Strategies	Content Knowledge	Content Teaching Strategies	Application to Lesson Planning	Focused Self-Evaluation	Simulation Familiarity	Other
Modeling	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Using Videos for Collective Reflection**	1 (13%)	4 (50%)	1 (13%)	4 (50%)	1 (13%)	1 (13%)	2 (25%)	2 (25%)	1 (13%)	0 (0%)
Using Videos for Individual Reflection**	0 (0%)	3 (38%)	1 (13%)	2 (25%)	1 (13%)	1 (13%)	1 (13%)	1 (13%)	0 (0%)	0 (0%)
Using Videos as Exemplars	1 (13%)	5 (63%)	0 (0%)	5 (63%)	1 (13%)	1 (13%)	3 (38%)	0 (0%)	1 (13%)	0 (0%)
Examining Written Cases	0 (0%)	1 (13%)	0 (0%)	1 (13%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Individual Planning*	0 (0%)	1 (13%)	1 (13%)	3 (38%)	1 (13%)	1 (13%)	5 (63%)	0 (0%)	0 (0%)	1 (13%)
Collaborative Planning	0 (0%)	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)
Peer Teaching / Microteaching	1 (13%)	1 (13%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Transcript Analysis	0 (0%)	1 (13%)	1 (13%)	1 (13%)	1 (13%)	1 (13%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)
Reflection Writing	0 (0%)	3 (38%)	1 (13%)	4 (50%)	1 (13%)	2 (25%)	1 (13%)	2 (25%)	0 (0%)	0 (0%)
Reflection Discussion*	1 (13%)	3 (38%)	0 (0%)	3 (38%)	1 (13%)	2 (25%)	2 (25%)	7 (88%)	1 (13%)	2 (25%)
Examining Student Work*	1 (13%)	2 (25%)	1 (13%)	3 (38%)	4 (50%)	2 (25%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)
Doing the Work of the Students*	2 (25%)	1 (13%)	1 (13%)	2 (25%)	6 (75%)	1 (13%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)
Direct Instruction*	1 (13%)	4 (50%)	1 (13%)	5 (63%)	2 (25%)	1 (13%)	4 (50%)	0 (0%)	3 (38%)	2 (25%)
Other	1 (13%)	1 (13%)	0 (0%)	0 (0%)	1 (13%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

Note. The total n in each cell represents the number of teacher educators in this study who engaged their preservice teachers in each of these pedagogical activities for the specified purpose. The percentage in each cell is the percentage of teacher educators, out of a total of eight teacher educators, who engaged their preservice teachers in each of these pedagogical activities for the specified purpose.

Table 8

Perceptions of Value Using Simulated Teaching Experiences by Teacher Educators (TEs) and Preservice Teachers (PSTs)

Value Using Simulated Teaching Experiences	TEs (n=8) n (%)	PSTs (n=102) n (%)	Code	All TEs (n=8) n (%)	All PSTs (n=102) n (%)
Yes	8 (100%)	91 (89%)	Learning/Practice	4 (50%)	54 (53%)
			Connection to Students/Classroom	1 (13%)	15 (15%)
			Low Stakes Environment	2 (25%)	12 (12%)
			Reflection	3 (38%)	9 (9%)
			Technology/Virtual	0 (0%)	9 (9%)
			Practicum Substitution	0 (0%)	7 (7%)
			Multiple Sessions	1 (13%)	5 (5%)
			Fun/Engaging	0 (0%)	3 (3%)
			Knowledge & Skills Application	3 (38%)	2 (2%)
			Consistency	2 (25%)	0 (0%)
			Vague	1 (13%)	10 (10%)
			Other	0 (0%)	6 (6%)
			Did Not Provide Explanation	0 (0%)	7 (7%)
No	0 (0%)	11 (11%)	Prefer Alternative Environment	0 (0%)	6 (6%)
			Negative Emotion/Feeling	0 (0%)	4 (4%)
			Inauthentic	0 (0%)	2 (2%)
			Vague	0 (0%)	1 (1%)
			Other	0 (0%)	1 (1%)
			Did Not Provide Explanation	0 (0%)	1 (1%)

Figure 1

Elementary Student Avatars by Mursion®

Appendix A

Rater Agreement for Coding TE Perceptions of Value for Using Simulated Teaching Experiences – Yes

Code	Response Number							
	1	2	3	4	5	6	7	8
Consistency	Y	Y	Y	Y	Y	Y	Y	Y
Practicum Substitution	Y	Y	Y	Y	Y	Y	Y	Y
Low Stakes Environment	Y	N	Y	Y	Y	Y	N	Y
Technology/Virtual	Y	Y	Y	Y	Y	Y	Y	Y
Learning/Practice	Y	Y	Y	Y	Y	Y	Y	Y
Multiple Sessions	Y	Y	Y	Y	Y	Y	Y	Y
Fun/Engaging	Y	Y	Y	Y	Y	Y	Y	Y
Reflection	Y	N	Y	Y	Y	Y	Y	Y
Knowledge & Skills Application	Y	Y	Y	Y	N	N	Y	Y
Connection to Students/Classroom	N	Y	Y	Y	N	Y	Y	Y
Vague	Y	Y	Y	Y	Y	Y	Y	Y
Other	Y	Y	Y	Y	Y	Y	Y	Y

Note. Y denotes, "Yes, the raters had agreement on whether that code should or should not be applied to the response." N denotes, "No, the raters disagreed on whether that code should or should not be applied to the response." Any disagreements were reconciled between the two raters.

Appendix B

Rater Agreement for Coding PST Perceptions of Value for Using Simulated Teaching Experiences – Yes

Code	Response Number																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Practicum Substitution	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Low Stakes Environment	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y
Technology/Virtual	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
General Learning Practice	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Multiple Sessions	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Vague	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	N	N

Note. Y denotes, "Yes, the raters had agreement on whether that code should or should not be applied to the response." N denotes, "No, the raters disagreed on whether that code should or should not be applied to the response." Any disagreements were reconciled between the two raters.

Appendix C

Rater Agreement for Coding PST Perceptions of Value for Using Simulated Teaching Experiences – No

Code	Response Number									
	1	2	3	4	5	6	7	8	9	10
Prefer Alternative Environment	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Inauthentic	Y	Y	Y	Y	N	Y	Y	N	Y	Y
Negative Emotion/Feeling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Better Alternatives[α]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other	Y	Y	N	Y	Y	N	N	Y	Y	Y

Note. Y denotes, "Yes, the raters had agreement on whether that code should or should not be applied to the response." N denotes, "No, the raters disagreed on whether that code should or should not be applied to the response." Any disagreements were reconciled between the two raters.

[α]After both coders met to reconcile the disagreement, it was determined that the "Better Alternatives" code was no longer needed, therefore the code was removed during final coding. During this time, it was also determined that a "Vague" code was needed, therefore the code was added during final coding.

Appendix D

Rater Agreement for Coding Pedagogical Activities Used by the Teacher Educator (TE) – Activity

Code	Response Number																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Modeling	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Using Videos for Collective Reflection	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Using Videos for Individual Reflection	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Using Videos as Exemplars	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y
Examining Written Cases	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Individual Planning	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Collaborative Planning	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Peer Teaching/Rehearsal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Transcript Analysis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reflection Writing	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Reflection Discussion	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y	Y
Examining Student Work	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Doing the Work of the Students	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Direct Instruction	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
None	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Unclear/Vague	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y

Note. Y denotes, "Yes, the raters had agreement on whether that code should or should not be applied to the response." N denotes, "No, the raters disagreed on whether that code should or should not be applied to the response." Any disagreements were reconciled between the two raters.

Appendix E

Rater Agreement for Coding Pedagogical Activities Used by the Teacher Educator (TE) – Purpose

Code	Response Number																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Argumentation Knowledge	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Argumentation Teaching Strategies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Discussion Knowledge	N	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Discussion Teaching Strategies	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Content Teaching Strategies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y
Content Knowledge	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Application to Lesson Planning	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y
Focused Self-Evaluation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Simulation Logistics/Familiarity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Unclear/Vague	N	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other	N	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N

Note. Y denotes, "Yes, the raters had agreement on whether that code should or should not be applied to the response." N denotes, "No, the raters disagreed on whether that code should or should not be applied to the response." Any disagreements were reconciled between the two raters.