Using Online Simulations to Develop Teachers' Ability to Engage in Science Teaching Practices

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Learning how to engage in core science teaching practices is one of the most important and difficult challenges that science teachers face (Kloser, 2014). These teaching practices include eliciting and interpreting students' ideas and experiences; selecting scientific investigations, models, and representations for instructional use; and facilitating science discussions. Being able to apply one's knowledge, skills, and understandings to engage in such teaching practices is critical to ensuring that teachers are poised to help students meet the goals set forth in the K–12 science framework (National Research Council, 2011). Yet, learning how to engage in these science teaching practices requires scaffolded and structured learning opportunities for both novice and experienced teachers alike.

During the last decade, science teacher educators and professional development facilitators have used a variety of approaches to design substantive learning opportunities for preservice and inservice science teachers to learn how to engage in core teaching practices. This work has involved different learning activities, such as having teachers: (a) analyze video records of their own or others' teaching practices to learn how to elicit student thinking, (b) interpret and respond to written case studies of science teachers' instruction to learn how to respond to student ideas, and (c) engage in peer rehearsals with each other to learn how to facilitate science discussions (Benedict-Chambers et al., 2020; Davis et al., 2017; Masters, 2020; Roth et al., 2018; Wenner & Kittleson, 2018). More recently, online simulated classrooms have been developed and used to support teachers in learning how to engage in critical aspects of the work of teaching content, including science content (Lee et al., 2018; Mikeska & Howell, 2019; Straub et al., 2015). To successfully address the three-dimensional student learning standards in the *Next Generation Science Standards* (NGSS Lead States, 2013), teachers need targeted professional learning opportunities to learn how to successfully engage students in a variety of science and engineering practices, such as learning how to engage students in productive scientific argumentation; this is where the online simulated classroom and the use of performance tasks can come into play.

In online simulated classroom environments, like the Mursion upper elementary classroom shown in Figure 1, the teacher interacts with a set of student avatars in real time. The student avatars are controlled by a person behind the scenes called a simulation specialist who uses specialized technology to respond as the five student avatars during the online simulation, which is meant to represent authentic interactions between the teacher and students as they practice engaging in core teaching practices. The simulation specialist undergoes extensive training to learn how to respond like upper elementary students with

differing backgrounds, experiences, and personalities. This upper elementary simulated classroom was designed with funding from the National Science Foundation (NSF) on the NSF Go Discuss project (Grant #1621344) and has been used by over 80 teacher education programs across the United States.

Figure 1

Preservice Teacher Interacting with Upper Elementary Student Avatars. Photograph Courtesy of Mursion, Inc.

For the last few years, researchers in the Go Discuss project have been designing performance tasks and using them within online simulated classroom environments to support preservice teachers in learning how to engage in one core science teaching practice: facilitating discussions that engage students in argumentation. Each performance task includes two components. The first component is a written document given to preservice teachers for use as they prepare for their discussion; the second component is a set of materials used to train the simulation specialist to provide a standardized discussion experience no matter which preservice teacher facilitates the discussion. The preservice teacher-facing document helps to set the stage for the science discussion that the preservice teacher will facilitate in the simulated classroom with five student avatars. This document provides the preservice teacher with information about the student learning goal for the discussion that they will facilitate in the simulated classroom and previous class activities and investigations that the students completed prior to the discussion. The preservice teacher is also given access to students' written work for them to use as they prepare for facilitating the science discussion in the simulated classroom. Each performance task is designed to serve as a formative assessment that can provide teacher educators and their preservice teachers with information about their strengths and areas for potential growth in this core teaching practice. In addition to the performance tasks, there is also a compilation of scoring materials, including an in-depth scoring rubric, training materials, video exemplars, and

formative feedback templates designed and accessible for use and adaptation. All the science performance tasks and related scoring materials can be accessed for free at https://data.qdr.syr.edu/dataverse/go-discuss.

For example, the Mystery Powder science task is one of four previously developed science tasks (Mikeska, Howell, Ciofalo, et al., 2021a; 2021b). The goal of the discussion is for the preservice teacher to use evidence and reasoning to help the five student avatars come to a consensus on the identity of the unknown mystery powder and to determine which properties are most helpful to identifying an unknown powder. Prior to the Mystery Powder discussion, the preservice teachers are provided with access to copies of the students' work where they have already generated evidence-based claims about the mystery powder's identity and which properties were most useful for identifying it. The preservice teachers also see the data table that the students generated in class when they observed and tested different properties (e.g., color, texture, or reaction with vinegar) of several known powders (e.g., salt, sugar, or baking soda). The science discussion in the simulated classroom is video recorded, and both the preservice teacher and their teacher educator are provided with a downloadable copy of the video for use in subsequent reflection.

Research findings from the Go Discuss project identified many affordances of using online simulations to develop and measure preservice teachers' learning of this core teaching practice (Mikeska & Howell, 2021a; 2021b). First, both preservice teachers and teacher educators found the performance tasks to be authentic in nature and found that such experiences provided robust opportunities to practice facilitating argumentation-focused science discussions. Second, teacher educators and preservice teachers perceived the online simulations to be valuable for supporting teaching learning and for addressing perennial challenges in science teacher education, namely, how to help preservice teachers learn to connect what they are learning about in their methods courses to the work of teaching science. More recently, the online simulations served as a critical solution during the ongoing pandemic, providing many preservice teachers with their only opportunity to tryout and engage in the work of teaching science due to the closure or elimination of field placement components within teacher education programs. Finally, and most importantly, studies using simulated teaching experiences result in improvement in preservice teachers' ability to engage in core teaching practices and support teacher educators in knowing how best to target the limited time they have with the preservice teachers.

Online simulations can be used to provide rich, targeted, and scaffolded learning opportunities for teachers to learn how to engage in core science teaching practices. These simulations allow preservice and inservice teachers to try novel instructional practices without risk of harm to real students and can receive targeted feedback to help them build toward improvement (Mikeska, Howell, Dieker, et al., 2021). They also provide a way for teacher educators to observe firsthand how teachers are applying what they are learning to the work of teaching science. Additionally, when standardized, simulations support teacher educators in identifying patterns across a group of teachers for subsequent instructional

focus (Howell & Mikeska, 2021). Online simulations can serve as another important resource that science teacher educators can use to provide preservice and inservice teachers with opportunities to learn how to engage in the complex work of teaching science.

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