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Creating Virtual Engagement for Preservice Teachers in a Science Methods Course in Response to the COVID-19 Pandemic

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ABSTRACT

Due to the COVID-19 pandemic resulting in school closures, shifting to online instruction poses unique challenges for educators. The purpose of the paper is to inform practitioners on how online instruction was facilitated in a science methods course for preservice teachers (PSTs) enrolled in a public university across three campuses. The major challenges were providing constructivist approaches to learning online and PSTs were unable to teach their 5E lesson in field placements. To overcome the first challenge, the instructors developed virtual engagement through iNaturalist and Virtual Engagement (VE) activities on Effective Questioning, Technology, Assessment, and Game-based Learning. To address the second challenge, PSTs integrated what they learned from the VE activities to develop their 5E lesson online which was shared with their field placement teachers and students. The implications of adapting to online instruction during the COVID-19 pandemic are discussed.

Introduction

Globally, it has been suggested that the COVID-19 pandemic has disrupted learning in schools for 70% of students worldwide (United Nations Educational, Scientific, and Cultural Organization, 2019). Due to school closures, shifting to online instruction poses unique challenges and decisions for educators. For example, Gordon et al. (2010) reviewed university websites and surveyed a school of nursing which revealed that not all faculty and staff have the technology solutions, software, and tools to facilitate online learning. To address this issue, educators have developed different solutions to continue teaching science content, such as medical students learning via simulations and videos during the SARS outbreak (Lim et al., 2009). However, the knowledge on how to transition science education instruction during a pandemic is sparse. The purpose of our paper is to provide insights for practitioners on how we facilitated a science methods course for preservice teachers during COVID-19 and prepared them to teach students online.

Context for Course

The context of this course is a science methods course for junior-level preservice teachers (PSTs) studying elementary or secondary education. PSTs were enrolled across three campuses taught by three different instructors associated with a public university in Texas. All eighty-nine PSTs received the same instruction before and after the pandemic. Prior to the COVID-19 lockdown, instruction was face-to-face using constructivist approaches with the 5E Instructional Model (Bybee, 2015) and best practices in science education aligned with the Texas Essential Knowledge and Skills (TEKS; Texas Education Agency, 2020) and Next Generation Science Standards (NGSS) as outlined in the National Research Council (NRC, 2012). The course implemented NGSS core ideas, cross-cutting concepts, and scientific and engineering practices in each lesson (NRC, 2012). PSTs were simultaneously enrolled in field placements in local school districts. One major assignment for this class was the creation of a 5E lesson, with the intention of PSTs practicing a microteach of their lesson in our courses, and then teaching their lesson in their field placements.

The first major difficulty with the COVID-19 pandemic was to continue providing an interactive learning experience to model constructivist approaches for PSTs online. To address this issue, the instructors of this course decided to create short, online instructional videos (20 minutes or less) allowing for immersive learning opportunities that have students construct their own knowledge through student-centered activities. We created a Virtual Engagement (VE) document, in which students explored a series of activities and answered questions in the VE document to demonstrate their learning. The fundamental topics were based on the textbook *Teaching Science Through Inquiry-Based Instruction* by Contant et al. (2018) or the instructors' topics of interest in science education. Examples of VE activities are also described. The second major difficulty with the pandemic was that students were not able to complete their field experience. This meant that they would not have the opportunity to teach their 5E lesson in our class and then subsequently, in their field placements as originally intended. We describe below how we addressed this issue with students creating their 5E lesson as a video. Ultimately, we decided to use asynchronous learning, recognizing the new adjustments PSTs may experience when working at home and experiencing other obstacles we may not have anticipated.

Virtual Engagement (VE) Activities

iNaturalist

iNaturalist is a free citizen scientist website and application where users around the world can upload pictures of any organisms, obtain assistance from users on identifications, and learn about organisms (https://www.inaturalist.org).The rationale for the assignment is that iNaturalist can be used to facilitate engagement in outdoor learning (Ruggles et al., 2015; Unger et al., 2020). The iNaturalist assignment was assigned prior to the pandemic, but an unintended benefit was that virtual engagement could occur online after the COVID-19 lockdown. An iNaturalist page was created for all users across the three campuses. PSTs were asked to make observations of three organisms during spring break and post them to iNaturalist, pose questions to any three posts from their peers, and respond to three questions that were asked on their posts. Students added posts from different locations in Texas and the United States, depending on where they traveled during spring break. Students contributed to an online discussion board about what they learned and how they could apply iNaturalist to their classroom. PSTs valued this assignment as they learned more about the biodiversity and distribution of organisms. For instance, one PST stated:

> Katherine [Pseudonym]: I love that you were able to get photos while in Colorado as they were all different and not what I get to see in Texas. I think this activity was a great experience as it made us take time to not only see what's around us, but actually stopped to enjoy it and take a picture.

The benefit of iNaturalist is that it allows users to have agency in deciding what they want to observe in nature, and also allow other users to learn more about organisms that they may not typically see in their own environment. An additional benefit of using iNaturalist during the pandemic is that students were still able to engage with nature and connect with others virtually.

Effective Questioning

The short instructional video that the instructors made discussed the use of effective questioning. The video focused on the use of open-eneded, equitable, and productive questions to access prior knowledge, promote discourse, and facilitate conceptual understanding (Contant et al., 2018). Following the video, the purpose of the VE was to embed questions throughout a heritable traits investigation to help PSTs understand genetics with questions focused on topics such as describing a gene, alleles, and predicting outcomes from a Punnett square. For the activity, a Google spreadsheet was shared across the three campuses to allow students to inventory traits they inherited such as widow's peak vs. no widow's peak, red hair vs. non red hair, or six fingers vs. five fingers. Students were first asked to create an initial claim about the frequency of dominant and recessive traits. The data collected from this activity helped address the common misconception that dominant traits are more common in the population, as they were able to engage in argumentation with data, and some PSTs were even surprised to challenge their initial claims. After completing the activity, PSTs reflected on the questions present in the document to determine the role of effective questioning, such as considering if questions were subject-centered or person-centered and if they were written in a language that was equitable.

Technology

The instructional video also discussed the use of technology tools and resources to gather scientific information, data collection and analysis, creating and using models for scientific phenomena, and communication (Contant et al. 2018). The purpose of the VE activities were to help PSTs understand how technology tools could support scientific practices in the classroom. One activity consisted of PSTs from all three campuses contributing to a community Padlet (Figure 1). There they shared ideas of technology tools that could be used to support the creation of a virtual 5E lesson.

Two additional activities consisted of virtual field trips, such as through Google Poly, a website where anyone can browse 3D scenes from places uploaded by users (Google Poly, 2019). Students also attended a virtual field trip of their choosing, such as the Smithsonian National Museum of Natural History (Smithsonian, n.d). Students took screenshots of their virtual experience to demonstrate evidence that they virtually attended, described how they could engage their future elementary or secondary students in the NGSS Scientific and Engineering Practices within the virtual experience, and connected their virtual field trip with two other subject areas. Below is an example of a student's virtual trip to Yellowstone National Park and her response in the VE (Figure 2).

Figure 1

PSTs Padlet ideas for Technology Tools and Resources to Implement in a 5E Lesson

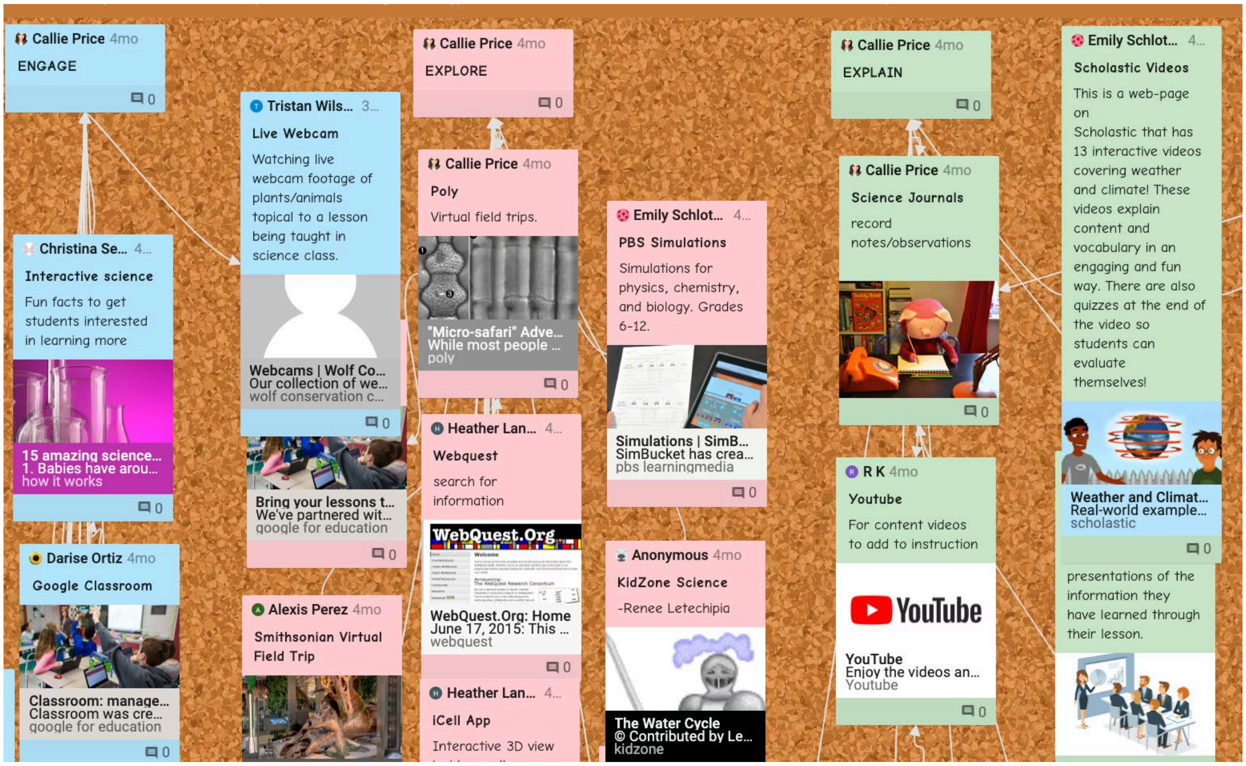

Figure 2

Geyser at Yellowstone National Park

Christina [pseudonym]: What causes geysers to explode? This would address asking questions in scientific and engineering practices and focusing on explaining the physical and natural world.

This example demonstrates that Christina is beginning to think about how to integrate technology tools with scientific practices in her future classroom.

Assessment

The lesson focused on the purpose of assessment and evaluation, the different types of assessments, creating summative assessments, and general guidelines for test administration. Authentic assessment and rubrics were addressed earlier in the semester to amplify the PSTs' agency in creating their own rubrics for the course. The purpose of the VE was for PSTs to apply what they learned about assessments to critique an example of a poorly constructed assessment, which included minimal instructions, deficient questions, and irrelevant information in the test. PSTs identified problematic areas, offered suggested improvements, and identified each exam question as a selected response, constructed response, extended constructed response, or performance task. Once they dissected the exam, the PSTs were asked to evaluate the overall design of the exam such as language used in the directions, determining if the questions aligned with the content, and analyzed the cognitive complexity of the questions.

Game-Based Learning

This content was based on game-based learning (GBL) in science education (Brendzel, 2004). Prior to this lesson, the PSTs read three different articles regarding GBL that addressed different types of GBL and how gaming is used in 5E lessons (Bayir, 2019; Brendzel, 2004; Martin et al., 2018). The lesson itself addressed the elements of GBL, the different types of GBL, how to effectively integrate GBL into a lesson, and possible obstacles with GBL. The instructors also shared games they had created for the EC-12 classroom. For the VE, PSTs reflected on how they could incorporate games into their instruction. They created an example of how they could use *Minute to Win it*, modeled after the game show in which a challenge is completed in sixty seconds; PSTs modified *Minute to Win it* science games to teach a conceptual idea. Lastly, they played an online game about the water cycle from Project Water Education for Teachers (Project WET) which allowed them to create an action poster at the end to think about ways to use and conserve water.

Online 5E Model Instructional Video

As COVID-19 disrupted PSTs ability to teach their 5E lesson during class and in their field placements, students were asked to create their 5E lesson in the format of a 20 minute online video. The purpose of transitioning their lesson online would allow their video to be shared with their cooperating mentor teachers and disseminated to the EC-12 students. Another benefit was that this video would be broadcasted on YouTube to allow other users on the internet to browse their lesson, assisting with learning at home. A rubric was created to guide students on elements for inclusion in their video, such as clearly outlining the E's in the 5E Model as they progressed through the lesson, three Universal Design for Learning (UDL) principles and three technology tools to ensure that their instruction accommodated a variety of learners.

In a lesson summaries assignment, students watched five videos from their peers, summarized the videos, and critiqued each video. First, they looked for pedagogical aspects of the video such as how each "E" in the 5E model occurred and selected any pedagogical strategy of choosing that they learned this semester, describing how it occurred in the lesson. Second, they looked for science content in the video, writing down the NGSS core idea, concepts, and key conceptual ideas they learned. Lastly, they critiqued each video for positive elements and possible areas for improvement. To encourage self-reflection, students considered what portions of their lesson could be improved upon and what modifications they would make if they taught this lesson in the future.

Discussion

COVID-19 challenged schools and universities to transition to online education. As educators of future teachers, we aimed to model best practices in an online environment through VE activities to ensure course objectives were met. One limitation was that some of the VE activities did not directly teach scientific inquiry. We also recognize that a virtual inquiry may not be the same as a tangible scientific investigation as Jeschofnig (2004) noted that simulations do not provide the means for students to learn how to use laboratory equipment and encounter measurement error. To address this, we would consider the use of simple, affordable materials for PSTs to conduct inquiry investigations at home such as experimenting with fermentation of yeast with different types of sugars. Providing PSTs with multiple, hands-on investigations could provide more authentic science experiences.

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