Science Education during the COVID-19 Pandemic: Tales from the Front Lines

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INTRODUCTION

Certainly the year 2020 will be one for the history books, as COVID-19 made its impact globally beginning in that year. While it did not hit the United States substantially until about March of 2020, other countries felt the effects sooner. Eventually it seemed that the globe essentially was shut down due to the COVID-19 outbreak. As Cesljarev noted in her chapter, similar to a natural disaster, the COVID-19 pandemic set off a series of adverse events. For example, a high-magnitude earthquake initially exposes one to destructive quakes and aftershocks but subsequent *secondary stressors* can also be debilitating as survivors grapple with losing their homes, insurance difficulties, and stalled rebuilding efforts. For instance, unmet mental health needs after a disaster were found to be of major disturbance for university staff persisting to fulfill academic, teaching, clinical and administrative roles after one such earthquake (Bell, et al., 2016).

This type of shutdown was challenging for education and educators. How could we pivot to online forums and teaching methods? Would our students still learn? It was especially concerning for science teachers and science educators who were accustomed to teaching using mostly hands-on inquiry instruction. How could students manipulate materials in these virtual settings?

The science educators who have contributed to this book decided to conduct research to determine answers to some of these questions. The book is divided into three sections related to science teaching-- COVID-19 science teaching research that involved K-12 teachers, research that explored university science content courses, and research that explored preservice science teacher education. Following each section we include a summary of the outcomes and recommendations. We end the book with conclusions and recommendations from a synthesis of the studies included.

We find three chapters in the first section that includes research on K-12 teachers. Asim and

Hollenbecks's chapter focused on exploring how K-12 teachers quickly shifted to online and remote teaching and learning. Their chapter concludes with recommendations for teachers who may, in the future, find themselves quickly moving to remote teaching. Bilican, Senler, and Aydeniz explored elementary teachers' transition to online teaching and learning, and found that it was very difficult, if not impossible, to maintain inquiry teaching. In a study of middle school science teachers, Avsar Erumit, Yuksel, Tanis Ozcelik, and Tekbiyik explored middle school teachers' adaptations to online teaching. The middle school teachers struggled to find ways to motivate their students, and explored various strategies to improve the effectiveness of online teaching.

The second section on university science content teaching contains two chapters. These chapters by Zhong, Ariyaratne, Yang, Rahman, and Akerson, and Rahman and Buck, were self-studies into teaching the same introduction to scientific literacy course. The instructors were both doctoral students in science education and were students of the professor who coordinated the course. Zhong was teaching it for the third time, but had to pivot quickly to hybrid teaching. She struggled with building relationships with her students and building trust, where this did not previously exist. Rahman had similar struggles regarding students, and also indicated that it was much more difficult to teach using scientific inquiry.

The third section includes two chapters on elementary methods teaching and one on secondary science teaching. The two elementary methods chapters focused on describing how the instructors developed asynchronous online methods instruction (Carter, Akerson & Cesljarev) and rotation hybrid (Akerson, Carter, & Cesljarev) when they had previously been in person courses. The instructors shared their struggles and insights into this kind of switch. In Cesljarev et al.'s chapter on secondary science methods, she shares how much she enjoyed teaching secondary methods, and yet she struggled with moving everything online, and how problems with technology and being remote made things more difficult in teaching and learning.

We hope these chapters provide you with insights into emergency online teaching and how it affected teaching K-16, as well as the ways these instructors persevered to serve their students the best they could during the COVID-19 pandemic. The instructors struggled, but also learned through their experiences, and hopefully their experiences can provide insights to others who may face some kind of emergency science teaching situation. Enjoy!

Reference

Bell, C., Carter, F., Boden, J., Wilkinson, T., McKenzie, J., & Ali, A. (2016). Psychological impacts of the Canterbury earthquakes on the university staff. *New Zealand Medical Association, 129*(1430), 18-28.

Citation

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SECTION I - TEACHING K-12 STUDENTS DURING COVID-19

Chapter 1 - Lessons Learned from Facilitating Inquiry-Based Science Online Teaching: Challenges and Opportunities to Enhance Student Experiences

Dr. Sumreen Asim, Dr. James E. Hollenbeck

Chapter Highlights

- This chapter addresses the changed dynamics of traditional in-class instruction to online instruction at all levels of education during the 2020-2021 academic year.
- The sudden demand for E-learning, which emerged as a result of the COVID-19 pandemic, created apprehension among educators.
- We present and discuss data collected from educators in the Midwest and share their experiences with the transition to online learning.
- We examine the transition fears about teaching inquiry-based science content.
- We identify online learning/E-learning teaching strategies and explain how they may be implemented for classroom success.
- We offer recommendations based on data collected for online science teaching.

Introduction

Among the rush of frightening headlines in the early days of the COVID-19 pandemic, one of the very few positives to emerge was the immediate attention to how to sustain K-12 and higher education during this trying period. As with most educators, our unplanned foray into full-time emergency online teaching began in March 2020 and continued into the next academic year. Seemingly overnight, our campus was forced to convert to an *emergency remote teaching and learning (ERTL*) institution (Hodges et al., 2020) along-side many other classrooms within schools, colleges, and universities.

Before 2020, most traditional instruction (K-12) was within traditional classroom walls, lab spaces, with in person face-to-face interactions (Hollenbeck, 2021). After the COVID-19 pandemic emerged in spring 2020, schools shifted their teaching models quite rapidly. There were three major ways instruction took place during the Spring 2020 and during the 2020-2021 school year: 1) online learning; 2) hybrid; or 3) face-to-face with social distancing. The education community defines online learning (also known as E-learning) as students working online at home while the teacher assigns work and checks in digitally (National Science Teaching Association (NSTA) 2016; Hollenbeck, 2021; Sekulich, 2020; Stauffer 2020; Trust & Whalen, 2020). All E-learning is facilitated by electronic devices such as computers, tablets, or smart phones (Wang & Wang, 2021) as well as in most instances the internet. A hybrid model, which combines face-to-face and online instruction, has two modes: asynchronous and synchronous (Giesbers et al., 2014, Hollenbeck, 2021). Face-to-Face (F2F) traditional, however modified for COVID-19, needed to be met with innovation and change. There were challenges to moving from a traditional classroom versus online teaching that need multiple layers of support.

Some educators, such in online universities or alternative schools, had already been teaching online before the pandemic arose. These teachers proved to have the easiest time transitioning and, as experts, were best equipped to help others with their transition (Barbour, 2014). However, some online courses were static electronic courses reminiscent of a correspondence course: readings were posted, there were written discussion threads, and assignments to be independently completed were issued. The suddenness of building closures in March 2020, however, left teachers and school leaders with little time to prepare for the remote learning

that would follow. It was clear that COVID-19 would demand something considerably more nuanced.

As the Spring 2020 semester wore on, conversations sprang up across academia on how best to meet the new needs created by COVID-19 (Green, 2020); particularly in STEM (Science, Technology, Engineering, and Math) courses. Although there were many who upheld best institutional practices and extended desperately needed support in this dire time, we understood that these stories were not traditional research narratives, where researchers methodically plan their approach, obtain the approval of their human subjects, and then collect and analyze data (Ferdig et al., 2020; Hollenbeck, 2021). In this unusual circumstance, the" research" in question was action-research project to inform changes and needs during the pandemic. Action research is constructed on inquiry-based practices as well as reflective-practitioner traditions (Cochran-Smith & Lytle, 1993). This type of research intends to empower educators by offering guidance and improving pedagogical practice; ultimately being a powerful tool to advancing inquiry-driven meaningful practices.

Within the School of Education at Indiana University Southeast, the reigning task was to improve the student experience in science education coursework in Fall 2020, even with pandemic conditions persisting. We as teacher educators believe that all students need, and deserve, courses that are rich with interactivity and engaging content. One of the central inquiry-based techniques we use is Bybee's *Learning Cycle* (Bybee, 2014) at the university-level in methods courses. Our mission, then, was to overcome the barriers imposed by ERTL and to deliver high-quality online science learning that included the learning cycle. There were new additions to the way we taught science which included the Zoom, video conference platform, and the set-up document cameras and multiple screens. Remote teaching changed the way we taught, and we also envisioned that the same was happening in K-12 schools and we were intrigued to hear and learn more from counterparts, and fellow science P-12 educators.

We believe that locally, nationally, and globally, the paradigm for education will never be the same again. Educators overall will have to develop the capacity to cope with teaching face-to-face, fully online, or in a hybrid model. The shift is already clear, but its future impact is still unravelling. The pandemic incited a dramatic increase in the use of online tools such as video conferencing, learning management systems, and digital content (Hollenbeck, 2021)

and there will be more decisions made as the dust settles post-pandemic after the 2020-2021 ends. Already by April 2020, more than 71 percent of schools in the United States were in alternative teaching modalities (Roberts et al., 2021). Some of the alternate modalities included options, such as: socially distant classrooms with limited room capacities with designated six-feet apart markers for seating, Hyflex where students had the option of attending or "zooming-in", distance/remote learning: synchronous and asynchronous as well as blended learning or the hybrid model. This chapter undertakes one aspect of this complex change by capturing how some K-12 science educators made the transition and by investigating the challenges and opportunities of teaching science content "online."

Research Questions

This study was guided to inform science inquiry-based teaching practices, provide new insights, and broaden and deepen perspectives. The study embodied the following questions:

RQ1: What challenges did science teachers identify as they shifted instruction to emergency remote teaching and learning?

RQ2: How did science instructional practices shift during emergency remote teaching?

Method

Because we are vested in responding to our local schools needing information and trying to assist them in best meeting the changing needs of our local schools, we deployed a questionnaire through social media. We wanted to understand how Indiana teachers were approaching and navigating initial E-Learning experiences. We created a short survey and shared it with fellow teacher preparation faculty to establish face validity. We piloted the survey with a small group of teachers before creating the Qualtrics electronic version and posting it on social media allowing for pre-validated survey items. The Qualtrics questionnaire was shared with an open-access link on Facebook in November. An anonymous survey of ten questions designed by science education faculty consisted of seven objective close-ended questions and three open-ended questions were posted on Facebook from November 2, 2020, to November 20, 2020, to solicit responses from educators in the United States (n=30). Any survey responses that were not identified as being from an educator were not considered as part of the data cleaning before analysis. The exploratory study hoped to understand the immediate and complex process of the changes occurring in

the field. Data analysis was done in several stages. The data was downloaded and recorded and stored on an independent file accessible only to the co-investigators. Initially, the researchers familiarized themselves with the data and began open coding as described by Saldaña (2013) to get to know the data in the first iteration. In the second iteration, the researchers searched for themes that emerged independently. Next, both researchers independently coded the data and look for themes, this led to collaboratively comparing coding results for inter-rater reliability. Lastly, the researchers synthesized the generated themes (Braun & Clark, 2006). The tables list responses offered by the participants of this study. All data is anonymous and will be erased in 2025 by the researchers.

Results

In this research study, we aimed to gain a better understanding and reflect on instructional needs and practices for teaching during ERTL. Table 1 below shares information related to the demographics of the participants and the specific survey questions. The table shares aggregate responses for each question. The four participants that identified as post-secondary were not included in the next stage of data analysis since the study was designed to best understand the changes within schools not higher education institution communities.

Table 1. Survey Questions and Results (n=30 Actual Raw Numbers Listed)

Survey Questions				
How long have you been an educator?	*< 5 years* *6*	*6-10 years* *5*	*11-19 years* *6*	*> 20 years* *13*
Which describes your institution?	*Public K-12* *22*	*Public Charter* *5*	*Private K-12* *0*	*Post-Secondary* *3*
Which describes your community?	*Rural* *12*	*Suburban* *13*	*Urban* *5*	
Describe your teaching level.	*Elementary* *4*	*Secondary* *22*	*Post-Secondary* *4*	

Before January 2020 how much experience did you have with online instruction?	*None* *14*	*A little experience (tried it once for a snow day)* *6*	*Some experience (tried it for multiple days or weeks)* *5*	*A good amount of experience (have taught at least one course)* *5*
Before January 2020 how much experience did you have remote learning?	*None* *15*	*A little experience (tried it once for a snow day)* *4*	*Some experience (tried it for multiple days or weeks)* *6*	*A good amount of experience (have taught at least one course)* *5*
Before January 2020 how much experience did you have of blended or hybrid teaching?	*None* *17*	*A little experience (tried it once for a snow day)* *6*	*Some experience (tried it for multiple days or weeks)* *3*	*A good amount of experience (have taught at least one course)* *4*

As Table 1 indicates, the typical respondent was an experienced (>10 years of experience) public secondary educator in a suburb, with little experience with e-learning. The shift to e-learning was perceived as unexpected. The majority of the respondents (46.7%) had no experience with online instruction. Only 16.67% had taught one online course before 2020. The numbers for remote learning were slightly better. The question "Before January 2020 how much experience did you have of blended or hybrid teaching?" yielded over 67% of educators having no experience in hybrid teaching, which combines traditional classroom experiences with digital course delivery. Table 1 reveals that educators had little experience in any of the alternative teaching and learning delivery modes.

Data analysis beyond the demographic data occurred in several stages. The 4 respondents at the post-secondary level were excluded during this stage therefore the n=26 from this stage forward. The "new normal" required educators to fundamentally change how they taught. Participant's responses and reflections to the questions had no word limit. The next stage of data analysis revealed that the roles of science educators were dynamically changing. Science content area teachers and their real-time responses allowed to better understand contemporary instructional moves to the "new" needs. Table 2 offers a thematic analysis of the following codes: (1) unprepared, 32%, (2) student access, 28%, (3) planning, 24%, and (4) science-friendly, 16%.

Table 2. Emergency Online Teaching Challenges

Code	*Explanation*	*Examples*
(1) *Unprepared (U)*	*Instructors did not feel prepared for remote and online teaching.*	• *Given no training, guidance, or a clue to what to do.* • *Learning the nuances of Zoom and all of its applications.* • *Not enough preparation time to teach over four different preps online.* • *The amount of time it takes to convert from in-class instruction to online (3 hours per course per day).*
(2) Student Access (SA)	*Enabling access for all. communication, materials, language barrier, sharing documents and materials. Even devices such as Chromebooks and iPads.*	• *The biggest issue was on the student end of not having access.* • *How to gauge attendance and engagement.* • *Getting material to students* • *Getting students to log in and do their work* • *How to reach the most significantly disabled students. Those who attended school primarily for*

		behavior issues/education.
(3) Planning (P)	*Establishing communication and protocols. Routines and support for teachers and students.*	• *Formatting Lessons for online.* • *Amount of Time it takes to convert from in-class instruction to online.* • *Adapting my curriculum to online and getting rid of paper.* • *Lack of access to internet access that could support video meetings. As an educator working from home my internet access was not strong enough just as students learning from home also did not have adequate internet access*
(4) Science Friendly (SF)	*Pre-lab instruction, short demo labs, dry-lab, and virtual simulations.*	• *Adapting my curriculum* • *Finding ways to make science-friendly* • *Learning new software and finding a lot of bugs*

The iterative analysis of data revealed affective as well as instructional practice information. In the survey instrumentation, we posed the question "What were the two most important things you learned from emergency remote teaching?" Our prompt elicited several interesting dynamic changes that were occurring. In this iteration of data analysis, we uncovered an additional four themes.

Table 3 offers an analysis of the following codes: (1) labor-intensive, 22.2%, (2) keep it simple, 14.8%, (3) student engagement, 37.0%, and (4) communications 25.9%. The participants desire to share both the connections to instructional practice, proficiency in their own creation of lesson for ERTL, concern for students as well as emerging concern of communication at all levels and stakeholders was thought-provoking. Therefore, educators teaching inquiry-based lesson had an additional layer of social-emotional concern due to experiences that were not being initially voiced strongly prior to the pandemic. Enacting

science lessons embodied more than subject-matter expertise and pedagogical knowledge it requires the fundamental aspect of being there for students in these unique circumstances.

Table 3. Important Things Learned from Emergency Instruction

Code	Explanation	Examples
Labor Intensive (LI)	Online instruction requires more time and logistics. Preparation and responding to student questions	• Have to be more prepared. Online much more difficult • I can learn technology and be somewhat successful in teaching online. Doing the Hybrid teaching for several semesters helps prepare for fully online teaching. • Once I was able to get an internet upgrade I learned how to host Google meets and how to use Google extensions to be able to write on the Chromebook screen as a way to show students diagrams. • A hybrid model can work just as well as full-time instruction. Fully virtual requires more difficult work to build.
Keep it Simple (KS)	Focus on essential tools. Revisiting learning objectives and tools. Prioritizing and adapting to online teaching.	• Simplicity is key • Keep it simple and be gracious • Make directions super easy and give examples • You still need to keep your lessons engaging because

		students have more distractions and less motivation at home.
Student Engagement (SE)	Increasing and varying strategies including spiderweb discussions, using Padlet and Jamboard, Think-Pair-Zoom, Peer-Critiquing, etc.	● The majority of students don't show up for E-Learning unless it is mandatory. ● Poor student do worse ● I also learned that excuses and empathy only stretch so far but at the end of the day we aren't doing these kids any favors by giving them so much slack. There is a fine line between being reasonable and taking advantage of the situation. ● It is easy for students to adapt to online learning and they do not find much motivation working from home.
Communication (Ç)	Having the contact information of instructors and availability. Having guest speakers. Robust feedback and clear expectations. Creative announcements.	● Don't be afraid to ask for help. ● Communication and boundaries ● I learned in the fall that we needed to have higher standards and clear expectations going into this, and that needed to be communicated to the students and community.

		Unfortunately, it was not made clear due to a lack of leadership at the school. ● Make directions super easy and give examples of expectations

The compared coding results synthesized individual coding into themes. These are identified in Table 4. They are expressed as follows: (1) teacher support, 28.4%, (2) student support, 18.3%, (3) planning, 22.1%, and (4) communications, 31.2%. These codes provide evidence to better understand what teachers learned during ERTL, some statements surrounded the barriers related to logistics, curriculum, and pedagogical strategies.

Table 4. Advice for Future Emergency Remote Teachers

Code	Explanation	Examples
(1) Teacher Support (TS)	Provide instructional support to educators	● Have clear expectations and don't implement too many different programs at once. Slowly introduce them in person if you can. Don't reinvent the wheel. Collaborate if possible, even if just to exchange ideas. Cut yourself some slack. You are doing great and most likely are getting underpaid, to begin with. You've got this. ● Insist that schools provide professional development in it. ● Create an asynchronous experience where your students can work as independently as possible. Don't complain, teachers need other positive teachers, talk about what is working, talk about how you are succeeding. ● Work together. Support each other. Delegate and collaborate as much as you can.

(2) Student Support (SS)t	Allow for more intervention services and collaboration	• Be forgiving to your kids. • This is crazy for us adults, so imagine what it's like for kids. • Communicate with parents and never assign any work to students that don't actively help them. • Trying to remember learning for some kids is harder online. A procrastinator and not disciplined student won't do well. Kids that are motivated and overachievers tend to do better. Some kids learn better from their peers and the students that know how to teach themselves tend to do better. I noticed it's very important to do breakout sessions for social students.
(3) Logistics (L)	Implement training	• Make it part of your pre-service teaching courses, and offer non-credit professional development. • Get help from experts who have worked with students • Better professional development and training. • Simple is best use resources that have already been made • Try to find new and engaging ways to interact with students.
(4) Communi cations	Communicatio n on all fronts that is transparent.	• Remember that every student has a different home situation. That is true in regular in-person teaching, but it can be exacerbated when the students can't leave the home. • Focus on relationships, everything else is secondary • Relax and understand it's not going to be perfect. Even so, don't throw away your plans.

	Have expectations, though they may be different than usual, and make them clear. Many students will feel comfort in knowing you have faith in their ability to apply themselves in some way rather than feeling you've given up on them. • It's going to be frustrating for both sides, be willing for it to be slower-paced and also be willing to explain everything 3 to 4 times more with remote learning.

The thematic analysis of data collected during COVID-19 uncovered new information. Overall changing modalities is complex and meeting the demands of diverse learners across context without proper communication, planning and can be difficult.

Limitations

There were many stories, anecdotal information, sharing of information that we heard about and was happening during the pandemic from Spring 2020-Fall 2020 that was of importance to be communicated with a broader audience of educators. A quick survey deemed cost-effective and allowed for real-time data. However, there are limitations in this study that we bear in mind while presenting the findings: 1) As stated before, we had a voluntary convenience sample. Studying responses from a survey announced on social media was challenging since we were dependent on participants' engagement on the social media platform and possible participants seeing the request to participate. Therefore, we had a small sample size; however, posting through social media allowed the survey to reach a diverse set of teachers that varied in grade-level taught, number of years' experience in teaching as well as the context they taught in. The data was cleaned; all responses that were screened, if the responses did originate from a current P12 educator, were used as part of this data analysis. 2) Time was a factor in collecting the data, as we wanted to compile, analyze the information to return it to the community of educators: such as administrators, departmental leaders and program faculty 3) The data is limited to the survey instrumentation; the hope is to inform researchers and educators with information that would better prepare us for similar situations

that may arise or E-learning in general in the science content area. 4) The survey did not inquire about the learning management system that could have given insight on applications that may have been used. 5) The response rate and the number of survey respondents were limited. The data collection and response rate could have been strengthened by sending out emails to partnering school corporations; however, we did not want to over-burden any stakeholders in the process with another item that would be requested to be done. Despite the limitations, the results will help inform the field about the needs of educators in ERTL that can also better prepare for future teaching in cross-contextual situations beyond COVID-19.

Discussion

When teachers transitioned to off-campus learning, the process was met with a wave of concerns. According to our survey results most teachers were not prepared to teach in an online learning context despite being seasoned and veteran teachers. Other immediate concerns shared were a) concerns about preparedness of teachers to teach in a new context; b) access of many students to devices and/or internet services; c) logistics and planning for inquiry-based hands-on lessons to mimic traditional face-to-face instruction. Throughout the current study, there were concerns from educators regarding students and establishing a good learning environment that was conducive to needs to actively participate; concerns about internet bandwidth and reliability of service were a major concern no matter the subject matter taught, and this impacted instructional decisions. Some school districts were able to procure "hotspots" for students, and other cable suppliers did step up to provide limited services (Indiana Broadband, n.d.). Additionally, teachers were concerned both about technology support for students as well as themselves because of the new modality to teach along with the logistical concerns related to conducting an online teaching and learning. For example, maintaining proper class procedures, developing relationships and a classroom rapport, keeping, and maintaining active student engagement.

From excerpts of the responses, teachers responding to the survey disclosed parents' concerns, such as: "[c]communication with families is key," and "[c]communicate with parents and never assign any work to students that doesn't actively help them." Very few parents lacked the understanding of how best to meet the new demands of ERTL. Several parents and the majority of students conceived of learning to be within classroom spaces with face-to-face dynamic activities where both teachers and students share in the co-creation of

knowledge and learning (Hollenbeck, 2021). In a very limited time frame, schools attempted to prepare all stakeholders to best embrace and adjust to ERTL which was the "new norm" and a COVID-19 paradigm shift for education. The science educators in this study pre-pandemic predominately just focused on inquiry-based teaching and learning; however, now due to ERTL were challenged to master new educational technology in the form of devices, learning management systems, software, and apps. According to the respondents, teachers were sharing a difficulty in adjusting. These are some of their responses: a) "Given no training, guidance or even a clue to what to do," b) "Learning all apps to programs you plan to use. Watch videos and go to free training or PDs. Ask for assistance from technology experts at your schools," and "discover how to integrate their lesson plans into the computer." Many lessons that used to take teachers only minutes to plan now took hours which was a common theme that emerged. Teachers surveyed reported that "It is very labor intensive", "I am inadequately prepared" for this change in pedagogy. In a similar fashion, the inherent challenge of preparing inclusive lessons to serve all learning needs as required by federal equity laws further escalated demand for new teaching methodologies. These newly emerged needs and particular protocols for classroom instructional design further exasperated the situation. The teachers' views were general and not addressing the potential of its impact of inquiry-based methods such as the learning cycle, hands-on labs, simulations, or modeling.

Beyond these justified and explicable concerns lay an array of obstacles and opportunities that further complicated the picture related to teaching science content during the pandemic. In the following section, we will describe and deconstruct some of the issues associated with science teaching and learning. An emphasis needs to be given to being more mindful of instructional design, curriculum choices, context needs and state standards.

Paradigm: Good Face-to-Face Instructors Make Good Online Instructors

First, there is an assumption that faculty are pedagogically sound for all forms of teaching. However, teaching online requires a different toolbox, mindset, and pedagogical style for implementation. For successful online science teaching and learning, there needs to be an emphasis on inquiry, discovery and application of knowledge, as well as students' active engagement in the instruction (Hollenbeck, 2021). Loucks-Horsley et al. (1996) suggested that in developing online learning activities, instruction must include active modeling, and scaffolding which is like teaching in a classroom; however, our findings in the survey

indicate that our teachers did not feel prepared to mimic similar practices online because of the lack of professional development.

Instruction in an online format requires that educators to re-think the traditional methods they use to teach within a classroom space and now transfer the replication in an online learning environment (Asim et al, 2019). *ePedagogy*, online teaching, digital pedagogy requires careful instructional design (Mehanna, 2004). Online teaching needs to be more carefully thought of in advance; it is virtually impossible to spontaneously improvise online (Miller, 2008). Over a third of the educators' surveys (Table 2) expressed frustration with not being trained to plan online learning or with lacking the time to develop lessons for online teaching. Some of the participants voiced that "adapting curriculum" for science was a barrier. Equipment and tools that were readily available in classroom context were now not available to utilize due to remote teaching. Some educators did find alternatives online such as simulations and virtual dissections, but these also had their own limitations. In Darrah et al. (2014) research study using a virtual lab for an introductory physics course shared that using innovative software can be utilized for some lab concepts however there is no substitute for some physical concepts to be done online.

Additionally, much of our communication experiences in a physical classroom is related to physical presence, proximity, demeanor, and interpretation of nonverbal communication. To overcome this paradigm, training needs to be developed for new practices to bridge the communication gap in online learning spaces. Educators moved to using YouTube, screen recordings, Loom and other platforms to assist with creating an inviting, meaningful and good classroom climate; however, in the same vein these avenues required more time and preparation for educators. A significant number of teachers (33%) surveyed (Table 4) wanted opportunities to learn how to teach online and professional development sessions to improve E-Learning for all students. Some respondents were further queried, and they shared they learned to utilize visualizations, such as images, graphics and other written communication like infographics that assisted them in implementing activities.

Paradigm: Online Delivery Is the Same as Correspondence Coursework

Today's online course model evolved from the traditional correspondence course that is rooted during the 18th century (Moore & Diehl, 2019). Correspondence courses in the 1960's

had a format where students would respond to lessons sent from the university by mail, complete them, and return them for assessment (Miller, 2008; Roberts et. al, 2020). In sharp contrast to some initial perceptions, online courses are designed to stimulate active teaching and dynamics interactions (Meyers, 2008). An online course is developed to create in-depth feedback with instructor comments and clear rubrics, peer-to-peer discussions in discussion boards, peer-to-instructor communication, as well as the possibility of synchronous video conferencing via such as Zoom, Microsoft Teams, and/or Google Meet depending on the institutional guidelines and accepted practices (Angelone et al., 2020; Hollenbeck, 2021).

Teaching online is different from teaching face-to-face, and instructors who teach online should receive training in online communications and course facilitation (Kleiman, 2005; Meyers 2008). Researchers do acknowledge that "face-to-face pedagogy can and should be used to inform online pedagogy" (Roberts et al., 2020 p.78). Nevertheless, the nuances of online instruction indicate the need for *ePedagogy* to cultivate the online classroom (Li & Akins, 2005; Mehanna, 2004; Sekulich, 2020; Hollenbeck, 2021). *ePedagogy* is best broadly defined as learning design that incorporates educational quality, values and effectiveness of teaching, learning and assessment activities supported by technology (Mehanna, 2004). The move to online education has brought this to the forefront and some schools of education are incorporating it into their methodology courses. Mehanna (2004) describes pedagogies that are connected with students' learning and outcomes and have been widely accepted for epistemological and empirical reasons. With the COVID-19 situation, the issue of integrating E-learning into the pedagogical system has recently emerged as an important and pressing focus for research on student learning and retention.

Using interactive programs like Google Classroom, Microsoft Teams, or Canvas, the instructor may establish discussion groups, breakout rooms or Jamboard to facilitate content understanding. Often breakout sessions can be formed during the class to facilitate group work, cooperative learning, or inquiry-based lesson with specific role responsibilities. Additionally, some advantages to ERTL included students can use the chat function to communicate to the whole class or to initiate private chats with individual classmates or with the instructor. In this manner, assessment can be more individualized and can provide the instructor with a deeper understanding of the students, as reflected in more-interactive, discussion-based, on-campus classrooms. Table 4, in communications, indicated that 18% of the teachers considered the student needs to provide direction and support to maximize

student learning and form the foundation for the learning community. Creating a community of learners within an online environment, in short, takes dedication and skill but is manageable if the instructor gives guidance to creating team-based groups or leverages social media avenues such as Facebook, Twitter or other platforms. Asim (2020) suggests using a scaffolded technique to invite educators to utilize platforms such as Twitter to create a professional learning network in order to have a support system beyond classroom spaces.

Paradigm: Inquiry Teaching Strategies Cannot Be Modeled Online

Sekulich (2020) states that an online learning community needs to be developed in an interactive model that has responsibilities in the areas of collaboration and interaction, organization and communication, technology, learning-style differentiation, critical thinking, and feedback. This not only has been shared in research but also is part of the Quality Matters (QM) standards for online teaching. Although, the QM standards may be a long stretch for ERTL the Constructivist Learning Model (CLM), described by Yager (1991) and Kimble et al. (2006); may be a steppingstone to achieving some part is in an online inquiry-based classroom. The CLM, is the foundation for inquiry-based science teaching like the learning cycle, which allows students to draw from their previous experiences and actively add to their learning experience (Miller, 2008).

The surveyed teachers offered strategies for teachers forced to undertake ERTL in the future (Table 4). They offered the following advice for educators: provide support to teachers, give teachers more time to prepare lessons, and make it interesting with multiple strategies and also share ways to meet the demands of diverse topics. Additionally, provide clear expectations or lesson planners/instructors and don't implement too many different programs at once. For synchronous teaching, slowly introduce the curriculum and teaching in person if you can (Kamenetz, 2020; Stauffer, 2021). Encourage collaboration among learners and teachers developing online curriculum, and co-construct knowledge by exchanging ideas. Insist that your school provide professional development that is on a needs assessment by the teachers in the building. Finally give yourself some grace and forgiveness. As teachers entering ERTL is not in their own prior experiences, so this "new" paradigm requires a steep learning curve for many science educators. Providing digital support groups to encourage dialogue and sounding boards for ideas, asking questions, and addressing concerns for online teaching should be part of the solution moving forward. Again, leveraging social media

allows for more for on-demand learning for teachers may be great avenue to encourage by administrators and other national organizations.

Student support is also just as important in the development of online learning environments. Protocols for all educators no matter the discipline they teach should be communicating with parents and not assigning work to students that does not enhance their learning. Some educators in our study suggest to not assign "busy work", make all learning meaningful, maintain open communications with home, and have established times that parents can reach you within established boundaries. Based on research from the surveys, anecdotal information from teachers, and research, online learning for some students is more difficult than being in a structured classroom (Kamenetz, 2020; Sekulich, 2020). For example, a procrastinator and student with poor self-discipline will have problems completing homework on time. The traditional classroom provides structure and rules of decorum gained and reinforced on a consistent basis. The online environment is not as structured and demands self-discipline that many students have not developed for self-paced learning. Teachers in the survey reported that "[l]earners who are motivated and overachievers tend to do better. Some kids learn better from their peers and the students that know how to teach themselves tend to do better. I noticed it's very important to do breakout sessions for social students (Hollenbeck, 2021, p. 6)."

Teachers in our study shared that they observed that their online courses provided social role-modeling of appropriate online behavior- netiquette- and assisted students in becoming better students because some students found that online learning was less distracting. During learning experiences, instructors guide the students' learning to understanding scientific concepts but also are bringing in several other non-content specific aspects to teaching science such as roles and responsibilities in a classroom context. Additionally, teachers still need to facilitate inquiry-based lessons by asking probing questions to the students about their responses, having them summarize main themes, and linking them to activities and assignments similar to a traditional guide-by-the side in classroom who may probe further about readings, written responses, and independent and group projects in a science lab. The logistics and communications of the online course will determine the success of constructivist inquiry teaching strategies (Asim et al, 2019). With planning, communication, and the abilities of students, active problem-solving within learning can occur; therefore, action research should be further encouraged to inform instructional practices.

Paradigm: Interactions are Limited in Online Delivery Formats

Students in an online format should not be allowed to sit back and let others discuss and lead discussions. The instructor must act as an active mediator guiding the flow and direction of the interaction. To encourage collaboration, it is important to value the discussions, and it should be reflected in the course grade. Using resources such Quality Matters (www.qualitymatters.org) as well as the Universal Design for Learning (https://udlguidelines.cast.org/) are resources that all educators should use when teaching online. Research has also shown that many students tend to do only what is required in online learning environments (Sekulich, 2020); therefore, students should be encouraged to show their images on the screen in synchronous sessions. This strategy of sharing screens allows of more interactive course interactions therefore immediately improving the learning environment and promoting interpersonal skills (Sekulich, 2020). An additional tip is to assist students who are shy about their backgrounds, instruct these students on the first day on how to use virtual backgrounds.

It is important to note that as of June 2021, there are no legal requirements for students to show their images on the screen. Local schools and universities' policies differ from school to school; therefore, it is important to know your school's policy. Many institutions encouraged instructors to respect the wishes of the student. Valuing collegial interaction with peers and the instructor will certainly enhance the discussions and the learning experience; however, an instructor cannot make screen sharing during a synchronous a requirement. This was a barrier that was stated by some in the survey response.

In designing the online courses, and courses that are being broadcasted publicly, one must keep in mind that in the United States, the Family Educational Rights and Privacy Act (FERPA) (20 U.S.C. § 1232g; 34 CFR Part 99) is a federal law that protects the privacy of student education records. The law applies to all schools that receive funds under an applicable program of the U.S. Department of Education. The guidelines regarding online education and E-Learning are generous and protect the learners and teachers. These regulations protect the social and emotional well-being of all parties. However, during the pandemic the social aspect tended to vanish in the "new" learning environment. In March 2020, the United States Department of Education's Student Privacy Policy Office issued a

memorandum addressing online education. The FERPA guidelines as described by Cornell University (n.d.) clarify the protocols for virtual instruction:

- Course content that does not involve any identifiable student information does not implicate FERPA. Asynchronous lectures depicting only the faculty member, whether generated by Zoom, Kaltura, Loom, YouTube, Instagram or Facebook, would all be compliant and can be distributed through any learning management platform (e.g., Canvas, Google Classroom), assuming there are no independent reasons for restricting access such as copyright concerns addressed in other materials.

- If students are included in the recordings, either through questions or interactions, then the platform used for your classroom sessions must be FERPA-compliant. The primary restriction is that the material can only be distributed only within the course, and reasonable precautions must be taken to prevent any broader release. Further, personal information such as grades should be restricted to individual students only.

- The presumption is that you will not have students appearing in your lectures, but rather only as ancillary participants through questions or active teaching. It is not "illegal" to capture student presentations or comments in a class and to share recordings with members of that same class. However, such sessions should not be posted publicly on platforms such as YouTube, Instagram, or similar social media sites.

Approved applications like Canvas and Zoom, with sessions initiated within Canvas and recordings made to the Zoom cloud and accessible only to the class members. Other programs used by the students must be FERPA compliant and, again, restricted to class members only. YouTube is not FERPA compliant if there is any student involvement in the session and is, therefore, not allowed for recordings that include students. In order to stay within the bounds of "fair use," access to lectures incorporating unlicensed third-party content such as photographic images and sound recordings should be limited to members of the class and not posted on public platforms. Specific policies differ with each institution. Several of the FERPA related key points are important to remember as science educators since there may be times when we ask students to do labs in kitchen spaces or even go outdoors to find items in nature to supplement online lectures and activities. The guidelines

are not to be viewed as an impediment rather they should be valued and respected for the protection of all stakeholders.

Conclusion

In this study, we examined how science instructors adapted during teaching science in an online learning environment. The findings of this study suggest science teachers do engage in a process when preparing to teach and the process of instructional adaptations require further support from various key stakeholder such as department chairs and school administrators. The theoretical framework for lesson design should be informed by current research and contextual needs. Students may be intellectually engaged by a lecture; however, a firsthand experience can help allow them to solidify the construct. Whatever the mode of instruction, research suggests that students need multiple exposures and that said exposures need to be tied to prior knowledge and framed in a relevant context (Bransford et al., 2000). One of the problems that we discovered is the effectiveness of learning science is at risk. Science students need to be engaged and challenged and have hands-on learning experiences. They are missing the excitement of experiencing science in action.

Some students are thriving in the online environment. There are some anecdotes of children who are thriving with remote learning. “There's [approximately] 10% of people for whom it works better” according to Reich (2021, p. 22); additionally, Kamenetz (2020) states school “districts are trying to recreate classroom teaching routines online with varying levels of success (p.4).” Reich reports that 10% of children are thriving in this better version of school. However, these students may have had various forms of school anxiety stemming from bullying, discrimination or have sensory issues and enjoy having more control of their learning environment (Reich, 2021, p. 5). Our survey of educators confirmed his observations. The success of online learning is dependent on peer coaching, dedicated IT staff, and teachers willing to put forth long hours and learning as they go. Teaching is based on personal relationships, trust, and mentoring at all levels. School districts for years to come will be compiling and analyzing data to determine the effectiveness of student learning. We can only hope that all students were put first in all considerations in designing these programs to accommodate "new needs" during COVID19.

Recommendations

As the imperative for effective online education grows, providers of K-12 and higher education will need to acquire appropriate internet-based learning. The federal call to integrate technology in teacher preparation (South, 2017) demands those who can design courses and teach those courses. It appears that the quality of course content and design, and the nature of the interactions with the instructor are more important determinants of learning than whether the course is taught face-to-face, online, or some other blend of both (Miller, 2008). The scope and sequence of science instruction is critical for teaching science as suggested by frameworks such as the *Constructivist Learning Model* (Yager, 1991) and *Learning Cycle* (Bybee, 2014). Therefore, educators need to introduce facts, terms, and concepts in a meaningful way and help students to invent accurate understanding by pulling their own knowledge and experiences. Trying to teach online without getting to know your students will be a hindrance; therefore, rather than trying to just teach science concepts, science educators need to take the time to understand the needs of the context, students, and plan as effectively as they would in a traditional classroom setting.

As faculty members and schools continue to convert their traditional teaching to online learning, there will be other paradigms to dispel. The application of E-Learning/online learning has become a permanent and accepted fixture of education. The advantages of availing online learning to remote, distant locations and at student convenience will survive long after the pandemic. The following is a list of action items that instructors can implement right away:

- Establish Routines: While not all classroom routines, procedures, norms are discussed in this chapter, we do have a solid starting point to build with. The traditional classroom has well established classroom rules, customs, and norms as part of the classroom climate. Because we are not all in the same "room", we must establish a "netiquette" for the online classroom environment and teaching space; this may be as simple to start with having students renaming themselves with their preferred name in the Zoom participant list. Another example, specific to science teaching, may be using a set of safety protocols for "kitchen" science experiments, documentation in shared spaces such as Google documents or use of the same web browser for uniformity. The paradigm of E-Learning, the discussion etiquette is fairly like what you would expect in

a classroom, perhaps creating an infographic would be a good place to start. This norm change was observed in several of the teachers' surveys and the author in classes (Hollenbeck, 2021).

- Collaborate: Build an effective community of support between academia, parents, and the community (Asim, 2020; Lave & Wenger, 1990). This will provide a leverage for the time and effort of heterogenous group of individuals to come together and build a firm foundation for online education and build a sense of belonging and community. If some of your students have more experience than others using online discussion forums—and perhaps more experience than you—encourage them to be advocates, discussion leaders, and co-instructors for the day. This will not only give them a boost of confidence, but it will also help bring other students up to speed (Peratt, 2020) as well as address the issue of student access to some degree which was a voiced concern of respondents.

- Innovation: We stress the importance of examining the particularities and the needs of the context to apply proper instructional techniques. As the COVID-19 pandemic escalated and became part of our lives, educational technology companies sped up their development and release of new products to a receptive community of educators and stakeholders; however, researchers and the education community should take in consideration context, content, grade-level and other pertinent factors such as teacher needs. The unintended consequence of the development of E-Learning is the improvement of the quality of instruction, democratization of education, and accessibility for diverse learners. More people than ever will have access to education at all levels due to the internet, devices and the infrastructures for connectivity since the online learning environment is not free of bias, power and prejudice. Educators need to consider the positive aspects of digital tools but also call to action app developers, companies and administrators who make the choices of what technology can be used my teachers in school districts.

Future Research

As the threat of COVID-19 recedes, we should not simply return to the teaching and learning practices we had before the virus and discard all that has since been discovered about online

learning and E-Learning. The pandemic has impacted all parts of our communities and it took center stage. This time begins a journey of reflection and looking at affordances that inform teaching. One necessary part of the solution to resilience is to make *ePedagogy* part of a faculty member's skill set, as well as providing on-going professional development programming for any personnel involved in the instructional mission of school, colleges, and universities (South, J. 2017; Hodges et al., 2020; Hollenbeck, 2021). In this regard, our educators will be best prepared to plunge into multi-platform schooling and advance the democratic possibilities that the pandemic has opened.

Through online learning, students with limited time or with learning challenges that impede F2F learning can be better accommodated. Through online learning, individual campuses can offer their best to develop cutting-edge programs. The field needs to capitalize on this pause and reflect and begin dialogue to take elements of best practices and implement them meaningfully. Even as we embrace this brave new world of online instruction, we are humbled by just how little we still know. Research on the dynamics of online education between the individuals is still in its infancy as the pandemic has uncovered. Likewise scarce is any comparative investigation between the online teaching environment and traditional classroom practice. One valuable source of insight can be found in suggestions from peer educators that are important to other teachers developing and teaching online, such as those procured for our study.

The importance of home connectivity was an issue that many educators voiced in the survey. Learning does not stop at the end of the school day, and access to digital learning resources should not either. In a 2017 report by the Department of Education, a report from the Council of Economic Advisers, approximately 55 percent of low-income children under the age of 10 in the United States lack internet access at home. Educational leaders need to work to ensure learners have access to connectivity and devices when they leave school grounds so that they are not limited in their ability to experience high-quality connected learning fully. To support schools in this effort, private companies with partnerships with schools need to focus on providing quality Internet access to low-income households in rural and urban areas (South, 2017). Access to the internet will only act to promote learning and economic opportunities for all residents in economically challenged neighborhoods and rural areas.

The threat of COVID-19 has presented a unique challenge for all levels of education. Students, faculty, and staff were asked to do extraordinary things with course delivery and learning—things never managed on this scale. Institutions will emerge with an opportunity to evaluate how well they were able to implement online and E-Learning to maintain continuity of instruction. With careful planning, officials at every campus can assess their efforts and allow those involved to highlight strengths and identify weaknesses to be better prepared for this future area. That way, we can further democratize and expand education in unprecedented ways and, from such a dire situation, salvage something rich and enduring practices.

No matter what the next academic year may hold, such as self-isolation, masking, and other social-distancing guidelines, we should take the time to pause, reflect and consult others to best meet the needs of our diverse students, teachers, and school communities. Teacher, teacher educators, administrators and educational leaders need to work collectively to help the educational field thrive and not just survive. The inequities have been uncovered in the last 18 months and it's the collective action that will help harness, navigate, and manage this deep societal issue that not only impacts science teaching and learning but the profession at-large. Making high-quality resources available across the board can help alleviate some of the strain for our educators. Promoting innovation and contemporary practices should be encouraged and supported. Our stance as authors of this study is to help engage the field and advocate for the needs of our teachers and help capitalize the good we have learned during COVID-19.

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Chapter 2 - Adaptation to Online Science Teaching: Experiences of Turkish Middle School Science Teachers

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Chapter Highlights

- Middle school science teachers used various methods and approaches to increase students' motivation and interest in online education during the COVID-19 pandemic.
- Middle school science teachers used various strategies to increase the effectiveness of online science education.
- Teachers found some subjects and concepts more appropriate for online education.
- Synchronous online science lessons yield to interesting incidents teachers face.

Introduction

With the emergence of the COVID-19 pandemic, the course of our lives has changed, and globally we have sought to go through this new process smoothly and effectively. On the one hand, efforts have been made to prevent the spread of the COVID-19 outbreak, on the other hand, efforts to continue daily life within the scope of "new normal" led people to change their routines. In this context, preserving social distance or physical distance is among the measures recommended by the World Health Organization. Many countries seriously started to implement this first. Along with the strict regulations such as working from home, closing restaurants and café shops as well as shopping centers, teaching K-12 and higher education students online became mandatory in many countries all around the world (Aliyyah, et al., 2020; Giovannella et al., 2020; Nambiar, 2020; Paudel, 2021).

Educational institutions and especially teachers, were caught unprepared for the sudden and rapid transition to online education. This paradigm shift in education caused by the COVID-19 pandemic was not easy for teachers to overcome the difficulties and limitations of not teaching face to face [f2f] (Giovannella et al., 2020; Zaharah & Kirilova, 2020). Therefore, the process of reorganizing the teaching and learning process within the scope of the new normal and transitioning to online education has been reported to be challenging for both teachers and students (Avsar Erumit et al., 2021; Bataineh et al., 2020; Guangul, Suhail, Khalit, & Khidhir, 2020; Unger & Meiran, 2020). Within this new normal, the sustainability of education was the priority. Therefore, teachers are expected to carry out teaching/learning activities on online platforms, which means using digital tools and resources to deliver learning objectives and problem-solving, and using new pedagogical approaches to maintain effective teaching and learning (Eickelmann & Gerick 2020). In addition to all these, teachers are also expected to keep in touch with their students and to maintain social relations (König et al., 2020).

Although the current literature gives a mixed result about the efficiency of online learning (e.g., Anderson, 2020; Bates, 2020; Hebebci et al., 2020; Thelwall & Levitt, 2020), students, teachers, and families seem to have concerns about how to continue education in this process. Especially science teaching, which involves activities that need physical presence such as conducting experiments, applications, internships, etc., has been argued to be the most affected by this transition (al Darayseh, 2020; Guangul et al., 2020). Researchers found that

students' performance in science was adversely affected with the beginning of online learning (Sintema, 2020). Therefore, teachers' and students' adaptation to the online teaching and learning process is necessary to increase the efficiency of lessons when considering the online education will continue to be part of the future educational system. Science teachers' attitudes toward online teaching and their choice of online teaching approach could determine students' performances and motivations (al Darayseh, 2020; Duraku & Hoxha, 2020).

Science Teachers' Experiences in Online Teaching

Although such dramatic events are seen as unfortunate for human beings, these events sometimes become a factor that accelerates change which can take education to the next level (Giovannella et al., 2020). Previous researchers who studied technological pedagogical content knowledge (TPACK) argue that K-12 teachers' adaptation to technology in the new era has not reached the desired level yet (Mishra & Koehler, 2006; Poitras et al., 2017). However, this mandatory transition laid the groundwork for teachers to use more technology in their online classes. Especially science teachers should integrate technology into their science courses, use technology to assess their students, provide interactive learning environments, conduct experiments, and more (Yildirim & Sensoy, 2018). Such an enriched use of technology has been proven to contribute to students' participation in science classes as well as their success (Oktay & Cakir, 2013). It is also argued that digital technologies can create new opportunities for teaching and learning (Chauhan, 2017).

Current literature examining teachers' points of view about science teaching during the case of emergency reported that teachers agree that their workload increased (Giovannella et. al., 2020; Marek, Chew, & Wu, 2021). Additionally, teachers commonly believe that some subjects or topics are not well suited to online teaching (Gratz & Looney, 2020; Joshi, Vinay, & Bhaskar, 2020b). These subjects are generally the ones that are procedural and require extensive applications. Further analysis of difficulties cited by teachers indicate external distractions, networking problems (Joshi et al., 2020a); lack of interaction, low participation rate (Arora & Srinivasan, 2020), and lack of training and technical support (Almaiah et al., 2020; Joshi et al., 2020a; Sudevan, 2020). Another challenge for teachers was reported as managing students during online teaching. Punit and Qz.com (2020) argued that many students may sabotage online classes by making noise, eating in front of the camera, playing music or using fake accounts to post improper comments.

The study conducted by Trust and colleagues (2020) showed that teachers used Twitter hashtags to establish academic and emotional support. In that way, they were able to share their knowledge as well as teaching strategies with their colleagues. The researchers claimed that teachers demonstrated a participatory and sharing behavior in such an unusual situation. On the other hand, Persico and colleagues (2020) found out that teachers often skip the part to communicate with each other or exchange their experiences.

The compulsory online education also draws attention to web-based tools that facilitate teaching and learning activities. Research conducted during the COVID-19 Pandemic period showed that teachers have started to see web-based tools more and more as auxiliary materials for online science teaching (al Darayseh, 2020; Radha et al., 2020). Besides web-based tools, teachers also reported using media such as Youtube (Almurashi, 2016).

Strategies such as classroom discussions (Townsend et al., 2002; Twigg, 2005), conducting collaborative activities (Niess & Gillow-Wiles, 2013), asking challenging questions during synchronous classes (Smith & Diaz, 2004), and speaking gently to students (Bao, 2020; Mahmood, 2021) have also been included by the teachers in the online education process. Moreover, teachers are suggested to be patient and give more flexibility to their students to complete their work since students may encounter infrastructure problems (Waqar, 2020). Joshi, Vinay, and Bhaskar (2020a) suggested that for effective online teaching, teachers also need some external motivation such as “best online teaching award”, as they need in traditional teaching settings. Their exemplary efforts for improving their skills to help students’ learning should not be ignored.

A report released by UNESCO (2020) revealed that as of April 2020, 92% of the students’ educational life had been impacted by the COVID-19 all around. This is a severe issue when considering that the process has lasted longer than expected. Therefore, educators and stakeholders worldwide are in search of making the distance teaching and learning process more effective and uneventful. Moreover, it is still investigated what measures should be taken to prevent students from breaking away from school and lessons and what kind of pedagogical approach and teaching strategies should be applied. In light of these developments, we believe it is essential to examine what methods and strategies teachers think positively affect students' participation and motivation and how courses they think online education works more effectively.

This study aimed to explore middle school science teachers' experiences of online science teaching and the strategies that they develop to increase the effectiveness of science teaching and learning processes during the COVID-19 pandemic. In line with these purposes, the following research questions guided this study:

1. What methods or approaches do middle school science teachers use to increase their students' motivation?
2. How do middle school science teachers carry out experiments in online lessons?
3. What strategies do middle school science teachers use to enhance the effectiveness of online science teaching?
4. What content areas do middle school science teachers have difficulty with during online science teaching?

Methodology

Once schools switched to online education in Turkey with the spread of COVID-19, we developed an online questionnaire through google forms. We shared it with middle school science teachers to grasp their experiences about teaching science online, methods, and strategies they utilize to deal with the drawbacks of online science education. The questionnaire was shared with teachers through personal emails and professional social media groups. Below, we described the context, participants, and qualitative methods of the study in more detail.

Context: K-12 Science Education in Turkey

Science courses in Turkey begin at 3rd grade and are taught by elementary teachers in 3rd and 4th grades. Middle school science teachers teach science courses starting from the 5th grade till 8th grade. In high school, science courses are offered as individual natural science disciplines such as physics, chemistry, and biology, which are taught by teachers who are specialized in these specific disciplines.

Science courses in middle school consist of four major content domains: Earth science, life science, physical science, and matter and its nature. All these domains take part in all grades due to the spiral nature of the curriculum. Among these domains, earth science takes place

one time in each grade level, whereas other fields occur two times, both in the fall and spring semesters. For example, in 5th grade, while the measurement of force occurs in the fall semester, simple electric circuits take place in the spring semester for the physical science domain.

In sixth grade, while combined force takes place in the fall semester, the conductivity of electricity takes place in the spring semester. Due to the spiral nature of the curriculum and the presence of all content domains in each grade level, the teachers need to have dynamic content knowledge to respond to this level of content. Different from the US school system, teachers offer science courses to more than one grade level in one semester. That means one teacher could teach science in 5th to 8th grade in the same semester.

Students who want to enter exams could take a national exam at the end of 8th grade to be placed in qualified high schools that are considered to be in the ten percent of all the high schools. In these exams, science and math scores are important factors determining the students' test scores. For this reason, science teachers also take the responsibility of preparing students for these exams. Therefore, teachers have to maintain the effectiveness of science education during the COVID-19 conditions similar to face-to-face instruction.

Online Teaching Context after COVID-19 Lockdown

On March 11, 2020, with the first cases of COVID-19 occurring on March 23, 2020, the Ministry of Education had decided to move K-12 and higher education to online in Turkey. Teachers have taught their classes online (synchronous) since May 2020. For this purpose, three different national broadcasting channels, TRT EBA-TV, were established for primary school, middle school, and high school to help students access and follow their courses. In the following days, teachers were encouraged to use the Educational Informatics Network (EBA) platform more effectively, which the Ministry of National Education developed and started to broadcast in 2011.

In EBA, students, teachers, and parents can access textbooks, learning materials, animated films, and documentaries. Teachers can assign assessment tasks to their students through EBA, and students can participate in online lessons prepared by teachers. The EBA platform uses the infrastructure of the Zoom video conference application for live lessons. In the

meantime, students also have the opportunity to access all the lessons through TV channels simultaneously at TRT EBA-TV. In EBA, one class hour is equal to 30 minutes of compulsory class time in live lectures. Another feature of EBA is that the school administrations can monitor all the teaching and learning activities.

Participants

Thirty-seven middle school science teachers (25 Female, 12 Male) voluntarily participated in this study from different regions of Turkey. We used a convenience-sampling method to reach and invite the middle school science teachers to the study. Almost half of the participants (N: 18) had bachelor's degrees, while 19 middle school science teachers had either master's degrees or are students in master's or doctoral programs in science education. We also gathered demographic information about middle school science teachers such as years of experience in teaching, grade levels they teach, number of hours they teach in online education, and average number of students in their classes. We provided this information in Table 1.

As shown in Table 1 below, most science teachers had 6 to 10 years of teaching experience. The majority of the teachers either teach at all grade levels (5, 6, 7, and 8) or two different grade levels. Middle school science teachers in Turkey are responsible for teaching grades 5th to 8th in their schools. Depending on the number of students and number of middle school science teachers in a school, teachers could be assigned to one or multiple grade levels by the school principal.

The participants in this study were responsible for teaching various grade levels. Turkey has a national science curriculum; thus teachers in these different grade levels in different regions of Turkey teach the same concepts approximately at the same time. The majority of teachers (N:26) teach more than 20 hours a week in online education. Teachers in Turkey have mandatory teaching hours in compensation for their salary. For middle school teachers, the minimum number of hours they are required to teach for their pay is 15 hours per week; when it is more than 15 hours, they receive additional fees on top of their basic salary. The average number of students that most participants had in their classes varied from 11 to 20 students.

Table 1. Demographic Information about Participants

		Number of participants
Education degree	Bachelors	18
	Master's degree	5
	Master's student	12
	Doctoral student	2
Years of experience	1-5	7
	6-10	18
	11-15	7
	16-20	2
	20-30	3
Grade levels they teach	All grades (5th, 6th, 7th, and 8th)	14
	3 different grades (5th to 8th)	5
	2 different grades (5th to 8th)	11
	Only one grade (7th or 8th)	7
Number of hours per week they teach in online education	< 15	2
	16-20	9
	21-25	16
	26-30	10
Average number of students in their classes	5-10	5
	11-20	21
	21-30	10
	30-40	1

When we coded the participant data, we labeled middle school science teachers as T1, T2, etc., to maintain confidentiality.

Data Collection

For data collection, we used an online open-ended questionnaire through Google Forms that are discussed as being a useful method and enable reaching out to the geographically distant participants by different researchers (Lefever et al., 2007; Lobe et al., 2020). We sent out the questionnaire to the middle school science teachers via email and social media groups. We gave enough time for teachers to access the questionnaire without a strict time limitation.

The questions we asked in the questionnaire could be grouped into two parts: one related to information about the participants' demographics, and the other one is related to their experiences in online science education. The questions related to their experiences included questions about teachers' implementation to increase student engagement and motivation, how they conducted hands-on activities and experiments that students should participate, their strategies and methods of making the online science education more effective, the

difficulties they had in different subjects within science, and interesting incidents they encountered during online science education.

Data Analysis

For the analysis of written responses, inductive content analysis was used (Elo & Kyngäs, 2008). All the responses middle school science teachers wrote were first translated into English by three researchers. Then, all four researchers read the answers multiple times and began the analysis based on the questions in the questionnaire during research meetings through the Google Meet platform. As we read the responses, we did open coding of the quotes from each teacher. We collected the assigned codes and controlled the differences and similarities between these assigned codes (Strauss & Corbin, 1990).

After open coding, we combined similar codes and grouped them into subcategories, and subcategories were grouped into categories (Elo & Kyngäs, 2008). For example, we have the category of *Strategies to increase the effectiveness of online science education*, and under this category, we have the following subcategories: *1. Conducting experiments 2. Interactive tools. 3. Face to face strategies 4. Frequent assessment 5. Fun ways to keep students engaged, and 6. None.* Under the *Conducting experiments* subcategory, for example, we have three codes related to experiments: *1.Experiments at home with the help of parents. 2. Simple experiments that can be done at online lessons,* and *3. Have students be prepared before the lesson (sending videos related to the next class, sending material lists that will be used during the lesson*. In short, the codes, categories, and subcategories were all obtained from the analysis of raw data from the middle school science teachers' written responses, and therefore emerged from the data.

In a qualitative study, it is essential to provide the trustworthiness of each phase of the research, from planning to data collection, analysis, and reporting of the findings. The credibility of qualitative research depends on whether the research findings display a reliable interpretation of the original data. In this study, careful research design, detailed descriptions of each section of the research process, and extensive discussion of results were conducted to try to ensure credibility (Elo et al. 2014; Kyngäs, 2020; Kyngäs et al., 2020). For the transferability of the research, we provided a detailed description of context and participants, and the stages of data collection and analysis. For the dependability of the research, a

repeating analysis of the data was conducted to check the consistency of the results by four researchers. Through providing different citations to show the connection between the results and data, we tried to support the authenticity of the study (Elo et al. 2014; Kyngäs, 2020; Kyngäs et al., 2020).

Results

We obtained four main categories after analyzing teachers' ideas on their experiences of online science education. These categories are: Approaches/methods to increase students' motivation, Science experiments in online education, Strategies to increase the effectiveness of online science education, Evaluation of topics/units and their appropriateness to online teaching, and Interesting incidents during synchronous lessons. In this section, we will present our findings by these main categories.

Approaches and Methods to Increase Students' Motivation

Teachers addressed various strategies that they used to increase students' motivation in online education. We have compiled these strategies into four sub-categories that include:

1. Interactive tools
2. Hands-on and minds-on activities
3. Seeking fun ways to keep students engaged
4. Promoting social interaction

The most common approach that the teachers addressed to increase students' motivation was integrating interactive tools into lessons such as web 2.0 tools, virtual labs, interactive games, and videos that are related to the topic. Also, some teachers stated that they actively used online learning platforms such as Educational Informatics Network (EBA). As mentioned previously, the EBA platform is run by Turkish Ministry of National Education and includes many supporting materials such as videos, simulations, and allows teachers to assign tasks, form groups, schedule and run online lessons. Below we give teachers' statements as examples to this category:

> "I use concept cartoons applications. Students love voicing the characters. I also use Wordwall application. It is a random wheel used for expressing ideas" (T17).

> "I use Web 2.0 tools (Quizizz app for test-taking, Wordwall or LearningApps for playing games." (T8).

> "I use activities on the EBA platform for active engagement" (T2).

The second most common approach used by teachers was finding creative ways to keep students engaged within the learning process. Using stories or songs in lessons, giving students positive reinforcements in online classes, and using competitions were such strategies addressed by the teachers:

> "I send emojis when there is active participation in the lessons or students give correct answers to difficult questions with good explanations. Students are happy when they have emojis" (T28).

Another approach used to increase students' motivation was finding ways to promote social interaction. Small group activities and having students open cameras during the lessons were ways that teachers thought maintained social interaction during distance learning:

> "I created science clubs at EBA based on science concepts such as astronomy, living organisms. Students can conduct research, exchange scientific information, and share the research results on this platform. In the past, I spent a lot of time giving feedback on tasks, but now the system runs on its own. Students enjoy doing scientific research. Their communication improves with information sharing. I have three sections of 5th-grade newcomers to our school this year. It is a good opportunity for them to socialize" (T14).

> "Turning on cameras makes them more active. Asking them questions suddenly by calling their name keeps them active and alert" (T32).

Using both hands-on and minds-on activities is another approach used primarily by teachers to increase students' motivation. Some teachers said they leave more time for discussions, and question-and-answer sessions during online lessons to keep students mentally engaged:

> "Allowing them to speak, making them watch entertaining videos related to the topic, make the course out of monotonous" (T32).

Science Experiments in Online Education

Shifting from traditional face-to-face experimenting to online experimenting was new for all participant teachers. Some of them managed to transfer experiments and hands-on activities to an online environment, while some others were more challenged in carrying practical aspects of science lessons into online lessons. The main sub-categories that appeared in this category were 1) virtual experiments and simulations, 2) home/kitchen experiments conducted by students with or without the engagement of parents, 3) doing synchronous experiments 4) demonstration or watching experiments videos, and 5) none. Using home/kitchen experiments was the most common approach utilized to carry out experiments. Many teachers said that they assigned home/kitchen experiments to actively carry out the experiments with simple materials. Some teachers said that parents are also involved in the experiments that make the experiments more entertaining. Some teachers wanted students to explain the experiment and video record it, and send it back to engage students mentally within hands-on activities:

> "If it is not possible to do it in front of the screen, I explain how to do it [the experiment]. I want them to do the experiment with their families after the lesson and send their videos or photos" (T11).

> "I assign them to do experiments and performance tasks that can be done in the home environment. I ask them to upload their pictures to Google Classroom and give feedback and corrections" (T14).

Some teachers preferred to carry out the experiments during lessons. They addressed that they guided students to follow the steps and do the experiments simultaneously:

> "I want them to prepare their materials before the lesson, I want the students to open their cameras during lessons so that we can experiment all together step by step" (T8).

Using simulations, animations, and digital applications for the more complicated experiments was commonly utilized by teachers:

> "I want students to do simple experiments during the online lesson and show them to the camera. For more complicated ones, I use animation and simulations" (T31).

Some students were not as lucky as others to engage during experiments in online education. A few teachers stated that they could not conduct experiments either because they did not force students who had internet problems or did not have appropriate technological devices to attend lessons or did not feel confident to conduct online experiments:

> "I can't conduct experiments..." (T12).

> "I don't know if they have the opportunity to do online education; thus, I do not force anyone, only send the course link" (T5).

Strategies to Increase Effectiveness of Online Science Education

We asked teachers what strategies they utilized to increase the effectiveness of online science education. The principal codes that appeared in this category were:

1. Conducting experiments.
2. Integrating interactive tools.
3. Using similar strategies that are used in face-to-face lessons.
4. Using frequent assessment.
5. Seeking fun ways to keep students engaged.
6. Not using any specific strategy (none).

Some of these codes overlap with the codes that appeared in the first two categories mentioned above.

Trying to do simple experiments that can be done during or after online lessons is one strategy that teachers taught that increased the effectiveness of their online science lessons. Also, integrating interactive both digital and homemade tools such as web 2.0 tools, virtual labs, online games, augmented reality applications. Simple homemade tools were believed to

increase both students' motivation and interest and in turn the effectiveness of lessons. The excerpts below are examples of the mentioned code:

> "I use Orff studies, Zoom, simultaneous games, Acrostic and web 2.0 tools" (T22).

> "I increase the effectiveness of the lesson through making my online lessons more interactive, such as through preliminary preparation for the lesson with my students. Before one of my lessons, we prepared element cards, and they learned the names of the elements through these cards, their symbols, atomic numbers and their area of usage" (T36).

Some teachers carried out the strategies and materials used in face-to-face instruction to the online environments. Some teachers stated that they bought blackboards and used them in their online lessons:

> "To create the classroom environment, I bought a blackboard in my house, and I do the examples on the blackboard" (T21).

Using frequent assessment to check for students' understanding was also a common strategy used by many teachers:

> "After the lecture, I prepare Wordwall matching games, LearningApss puzzles for reinforcement, and I use quizizz competitions. For 8th graders, I make online trial exams by using Google forms" (T8).

Teachers tried to use fun ways to increase the effectiveness of the lessons. Using songs or stories, using praises such as sending emojis, or integrating humor in lessons are some strategies mentioned by teachers:

> "I search for songs about the subject beforehand and use them during the lesson, and they both have fun and learn. I enable them to be active during the lesson via questions and answers from time to time" (T21).

> "While working on the skeletal system in the sixth grade, bringing home the skeleton model from the school and meeting a skeleton instead of me during the live lesson attracted a lot of attention and increased students' motivation. When I realize that they are bored from time to time, saying "Let's energize each other" and sending emojis from the screen makes my students happy. (T21)

In contrast to teachers who sought ways to increase the effectiveness of online science education, some teachers stated that they did online education because they had to and therefore did not endeavor to any specific strategies:

> "Distance education is done for force majeure. It is done as it should be. I only use question-answers and traditional instructional method" (T5).

Evaluation of Topics/Units and their Appropriateness to Online Teaching

We wanted teachers to evaluate the appropriateness of science topics and units in online teaching. They stated that they had difficulties in different content areas or topics due to various reasons. Teachers' statements showed that they had the most difficulty in teaching topics that; 1) are application-oriented and require experiments and investigations, 2) are abstract such as astronomy concepts and some physics topics, 3) involve drawing and writing, 4) include procedural and high-level problems:

> "I had difficulty in the force and motion unit because in the experiments in this topic, we need a dynamometer; thus we couldn't do the experiments. I used to teach the topic of speed by doing activities at the schoolyard. It was more entertaining and efficient. I had difficulty in teaching this topic" (T21).

> "I had difficulty teaching crossbreeding topics in the DNA and heredity unit in 8th grade. In addition, I had difficulty in teaching mitosis and meiosis in the cell division unit in 7th grade. The reason I had difficulty was due to the necessity of drawing figures in these topics" (T3).

> "I had difficulty in teaching seasons and climate topics. After all, these concepts appear to be quite abstract for these students. Students who did not develop three-dimensional

thinking skills already had difficulty in understanding. I find teaching these topics even more difficult and boring during online teaching" (T8).

A few teachers mentioned that they did not have difficulty teaching any science subjects. Conversely, some teachers said that they had trouble teaching online regardless of the subject:

"The emotional aspects are very few as if there is none. We cannot see students' behaviors. We cannot see and analyze students' body language. I think synchronous lessons are one-sided education" (T12).

Interesting Experiences during Online Lessons

We asked teachers if they had experienced any funny/interesting incidents during online science lessons. Although teachers tended to carry out safe experiments that can be done using simple household materials, some teachers still indicated that students sometimes had minor accidents, some of which turned out to be funny memories:

"When I was teaching potential energy, I wanted students to fill up a container with water for the experiment. Then, I wanted them to throw ping-pong balls or coins into the water from different heights. One student dropped the ball, and it spilled everywhere. He shouted, "sank!, sank!" He cleaned the house during the whole lesson. Then, everybody better understood the concept of energy. We still laugh together when we remember that day" (T28).

"We were experimenting with air pressure, and I asked students to burn a small piece of paper in one glass and flip it over and place it on another glass and wait until the flame goes out to show how two glasses stick each other. One of the students was almost having a fire" (T33).

Some teachers mentioned that students shared interesting things on the topics being covered using household materials as a resource:

"When I was teaching the concept of energy transformation, one of my students came by holding a big LED light bulb in his hand and said, 'I transmit energy to the light

> bulb, and it lights up, see it glows. We always do it with my brother whenever the electricity goes out. Then, another student said, 'Then, electricity is genetically transmitted- everybody in his family can light a light bulb up' We all laughed" (T1).

Another interesting incident teachers faced during online teaching was to hear parents' talking behind or parents' and siblings' involvement in the lesson when students turned on their microphones:

> "When I was talking about the human spine and showing on a skeleton model, a student's mom came and showed it to his son, saying, " Look, it is right there, behind you" (T6).

> "The younger siblings' requests to answer the questions of their brothers or sisters' give us funny moments" (T36).

Discussion and Conclusion

This study aimed to examine middle school science teachers' experiences with online science teaching during the COVID-19 process. We were specifically concerned about how they dealt with the drawbacks of online science education and the strategies that teachers utilized to increase students' motivation and effectiveness of online teaching and learning. The results showed that most teachers endeavored to keep up with changes that the COVID-19 pandemic brought to the education system. We know from recent studies that students had lack of motivation and concentration during online learning (Bataineh et al., 2020; Croft et al., 2020; Gonçalves et al., 2020; Ozdogan & Berkant, 2020). Teachers in our study mentioned that they used various strategies to increase students' motivation and interests and the effectiveness of online science education. Using interactive online tools and materials, including web 2.0 tools and simulations, were commonly used strategies by most teachers.

Actually, integrating technology more into our lessons has been one of the benefits of compulsory online education (al Darayseh, 2020; Radha, Mahalakshmi, Kumar, & Saravanakumar, 2020). Studies before the COVID-19 pandemic argued that many instructors had little or no intention to integrate these technologies into their lessons (e.g., An and Williams, 2010; Barak, 2017). When used effectively, these technologies bring various

benefits to teaching and learning. For example, web 2.0 tools can increase interaction and collaboration between teacher and students, allow sharing resources, can improve students' technological literacy, and provide an atmosphere for learning while having fun (An & Williams, 2010; Kamalodeen et al., 2017). Virtual laboratories can reduce the need for physical space, equipment, and staff, can be accessed from anywhere and anytime, allow students to progress at their own pace, can be safer for dangerous experiments, allow recording to watch later, change parameters that cannot be changed in real lives, and can transform abstract things into its tangible representations (Bhargava et al., 2006; Darrah et al., 2014; Gorghiu et al., 2009; Heradio et al., 2016; Olympiou et al., 2013). In light of the aforementioned benefits from our study results, we suggest integrating these technologies more often into online science teaching.

Previous research showed that many science teachers are concerned about providing laboratory experiences for students during online lessons (Bakioğlu & Çevik, 2020; Chadwick & McLoughlin, 2020; Sarioglan et al., 2020; Unal & Bulunuz, 2020). Nevertheless, most teachers in our study continued to carry out experiments that were suitable for online education. Simple kitchen experiments were the widely used experiment type, among others. Although kitchen experiments possess many advantages indicated by teachers, such as giving opportunity for students to plan and carry out their own experiments and share it with their classmates, and enabling the involvement of parents, there are also potential drawbacks of such experiments including safety issues as argued in previous research (Chadwick & McLoughlin, 2020). A teacher in our study indicated that one of her students was almost having a fire when they were doing an experiment about air pressure during a synchronous lesson. Therefore, teachers, parents, and students should be trained about the safety of home experiments. Also, teachers can notify parents to supervise their children before conducting specific experiments.

Lloyd, Byrne, and McCoy (2012) argued that to facilitate an effective online education, pedagogical and material support need to be supplied to teachers during the process. Departing from all the results of online education studies, we can conclude that program leaders and educators have started to design the courses and programs with alternative tools and pedagogy for online education. However, within all of these modifications and efforts to improve online learning, it is an indisputable fact that giving professional training to teachers

should be prioritized for teachers to keep up with this new education process (Hebebci et al., 2020).

Humor, songs, games, and interesting stories have also been used by our participant teachers to keep students engaged with the online science courses. Many researchers highlighted that teachers have to be creative to motivate their students to participate in the online learning process (Dwijuliani et al.,). Therefore, it is expected that teachers should develop innovative and attractive learning materials which help to arouse students' interests (Aslan et al., 2020).

Teachers find some subjects and concepts challenging to teach in online education (Gratz & Looney, 2020; Joshi et al., 2020b). Many teachers found it a barrier to teach concepts that had numerics and/or abstract topics in online education in our study. This might be the issue because of the lack of educational and technological tools to teach numeric-based subjects. The teachers are used to solving problems or writing down the equations on a traditional whiteboard. Particularly the teachers who are less knowledgeable about the different features of learning management systems (LMS) or are not compatible with using technological devices may have negative ideas on online teaching of these concepts or subjects. Therefore, training future teachers with TPACK as well as improving digital infrastructure appeared to be necessary for possible blended configuration (online + f2f learning) for the future educational systems.

Despite teachers' individual efforts to adopt their teaching strategies during this emergency, there is still room for optimization of online courses in terms of students' participation and effective teaching (Giovannella et al., 2020). Besides the challenges of online education, the recent literature discusses the economic burden of the pandemic for teachers and parents, increased workload, distracted home environment, lack of tools and a poor internet connection, and lack of administrative support, which also may affect teachers' motivations (Almaiah et al., 2020; Bakioğlu & Çevik, 2020; Giovannella et. al., 2020; Joshi et al., 2020a; Marek et al., 2021; Okebukola et al., 2020; Sudevan, 2020). In parallel to these arguments, some studies highlight that providing appropriate incentives positively affects teachers designing and delivering science classes online (Hoyt & Oviatt, 2013). Since the uncertainty and fear of the pandemic process reduce the motivation of teachers (Marek et al., 2021), a reward system can be introduced for teachers who try innovations in the online

education process, design and use effective course materials, and keep students' interest in the lesson alive.

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Appendix

		Number of participants
Education degree	Bachelors	18
	Master's degree	5
	Masters student	12
	Doctoral student	2
Years of experience	1-5	7
	6-10	18
	11-15	7
	16-20	2
	20-30	3
Grade levels they teach	all grades (5th, 6th, 7th, and 8th)	14
	3 different grades (5th to 8th)	5
	2 different grades (5th to 8th)	11
	Only one grade (7th or 8th)	7
Number of hours per week they teach in online education	< 15	2
	16-20	9
	21-25	16
	26-30	10
Average number of students in their classes	5-10	5
	11-20	21
	21-30	10
	30-40	1

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Chapter 3 - Facilitating Inquiry-Based Learning during COVID-19 Pandemic: Experiences of Turkish Elementary Science Teachers

Kader Bilican, Burcu Senler, Mehmet Aydeniz

Chapter Highlights

- This chapter explored elementary school science teachers' experiences with designing and facilitating online inquiry-based learning activities in Turkey during COVID-19.
- This chapter embraced an inquiry-based learning framework for distinguishing teachers' instructional practices.
- The results of the study revealed that teachers' efforts to implement inquiry-based instruction faded away due to the managerial tasks, in addition to naive conceptual and practical views of inquiry-based teaching.
- The chapter stated that teaching science through online mediums is not only a pedagogical knowledge and skills issue, it involves teachers to develop curriculum design skills.
- Teachers have been facing unique challenges when attempting to teach science through inquiry. The sources of these challenges are diverse and include conceptual and practical concerns.

Introduction

The global COVID-19 pandemic has changed many aspects of our social and economic lives in unimaginable ways. One sector that has been hardly hit by the pandemic is education. Despite promising vaccine production and administration at scale the future is still not predictable for education. While many schools have adapted to the new normal, we do not know much about how the new normal has impacted teacher practice and student learning. Meanwhile, there is a growing interest in and push by policymakers due to the pandemic for teachers to teach their lessons online. In some countries and contexts, teachers are required to deliver online classes.

Technology can support student learning of science in many ways: by making the microscopic aspects of scientific concepts visible to the students, by helping students model the structure and behavior of scientific concepts and processes, offering interactive domain–related applications (e.g. online laboratories), and tools that support students' effective engagement with data, models and with each other (Edelson, Gordin, & Pea, 1999; Feldman & Capobianco, 2008; Linn, Freda, Husic, Slota, & Tinker, 2006). Some examples of these technologies and tools include, the Web-based Inquiry Science Environment (WISE) curriculum, PHET simulations, and the GoLab learning ecosystems. These technological ecosystems and technology-based curricula have been designed so that teachers can adopt and facilitate students' learning of science concepts and practices through technology. The assumption is that because these technological ecosystems are so rich in content and attend to many aspects of inquiry such as hypothesis formation, data collection, organization and analysis, students will automatically learn science concepts and practices. However, designing and implementing online or digital learning material is a demanding task for teachers who have no training in teaching online, limited experience with digital material development and limited pedagogical tools to design lessons for online teaching. STEM teachers who are used to delivering hands-on inquiry-based learning activities in person are especially struggling to teach science in an online learning environment (Cober, Tan, Slotta, So, & Könings, 2015; Varma, Husic, & Linn, 2008).

Students' meaningful engagement with learning is considered one of the driving forces behind acquisition of deep conceptual understanding and acquisition of core scientific and engineering skills (Beymer, Rosenberg, & Schmidt, 2020). Engaged learning can be achieved

by different forms of instruction, such as problem–based learning, inquiry-based learning, collaborative learning, modeling, and argumentation (Ainley, 2006; Ben-Eliyahu, Moore, Dorph, & Schunn, 2018). Inquiry-based learning is the core of science education reform rhetoric and engaged learning (Bansal & Ramnarain, 2021; Nhlengethwa, Govender & Sibanda, 2021). Science education reform literature defines inquiry-based learning as learning opportunities where students make careful observations, engage in designing and performing scientific investigations, asking research questions, analyzing data, developing evidence based scientific explanations (Driver, Newton, & Osborne, 2000; National Research Council [NRC], 1996; 2000). However, for most teachers, inquiry-based learning refers to students performing scientific investigations through hands–on laboratories. The hands-on laboratory experiences constitute the core of inquiry-based learning that takes place in science classrooms. However, with the pandemic this type of teaching and learning has been interrupted. Instead, teachers are expected to design the same experiences in online learning environments (de Jong et al., 2020). Moreover, they have been asked to emulate inquiry in online teaching environments without necessary training.

Designing online learning tasks that promote students' curiosity, ensures students' effective engagement with the material and with each other, keeps them motivated to invest cognitive effort during the learning process, and results in acquisition of deep conceptual knowledge and acquisition of scientific inquiry skills is the ultimate goal of an effective science teacher (de Jong et al., 2020). Online learning activities achieve real instructional value only when they can be designed and scaffolded effectively by the teacher. For instance, instructional designs require multiple forms of expertise, ranging from content knowledge, pedagogical knowledge, technological expertise and resources called TPCK ([Technological Pedagogical Content Knowledge] Mishra & Koehler, 2006). Yet, most teachers lack the necessary TPCK for designing or effectively using inquiry-based learning activities (de Jong et al., 2020; Yan, Chai, & So, 2018). Consequently, they need support to translate abstract theoretical assumptions of the designers about the goals and affordances of these technological ecosystems into their teaching plans. By technological systems, we mean online learning environments such as GOLABZ, WISE and PHET simulations that afford opportunities for students to engage in learning science through inquiry.

Significant factors impacting how teachers design engaging and impactful learning experiences are the teachers' belief systems related to teaching and learning, teachers'

content knowledge and teachers' pedagogical technological content knowledge. In countries or regions of countries where students lack technological resources to engage with the designed learning activities and complete assignments, teachers wanting to implement inquiry-based teaching face additional challenges. For instance, a recent survey revealed that participation of students living in rural parts of Turkey, especially those living in eastern part of Turkey remained below 50% (Egitim-Sen, 2021). Moreover, those who were able to access the class material reported frequent interruptions due to unstable network issues (Egitim-Sen, 2021). Similarly, there is a huge divide between how established private schools train their teachers, support them with tools and resources to teach science through inquiry and the public schools. Collectively the theoretical assumptions about what good online teaching should look like, differences in in-service training of teachers between public and private schools, and the challenges related to student participation in online learning highlights the need for and importance of bringing science teachers' instructional practices under scrutiny. In this study, we explore 6 elementary school science teachers' experiences with designing and facilitating online inquiry-based learning activities in Turkey.

Theoretical Framework: Inquiry-Based Learning

We used the National Science Education Standards (NSES) Inquiry-Based Learning Framework (NRC, 996) for distinguishing teachers' instructional practices to guide this study. Inquiry-based learning can be classified into different forms ranging from structured inquiry, guided inquiry to open inquiry (Abrams, Southerland, & Silva, 2008). Inquiry-based learning refers to the type of learning in which students pursue their curiosity to observe and make sense of the natural world through questioning, data gathering, data analysis, modeling, argumentation and sense making (Donohue, Buck, & Akerson, 2020; Driver et al., 2000; Eti & Sigirtmac, 2021; Feyzioglu, 2019; NRC, 2000). In this form of learning students investigate an important scientific problem, collect and organize and refine data, identify and look at patterns in the data, and construct and communicate models and evidence-based explanations. In the process of learning and teaching through inquiry, teachers extend their role from that of knowledge transmitters to one that makes them learning facilitators. As facilitators, teachers create a stimulating learning context so that students are intellectually curious and motivated to learn, help students to formulate learning goals, provide a framework for students to effectively engage in intellectual activities, formulate inquiry questions, design their investigations, and support them when students are implementing their

investigations (Bansal & Ramnarain, 2021; NRC, 1996; NRC, 2000; Wirkala & Kuhn, 2011).

Structured inquiry is the most basic form of inquiry implemented in the classroom. In structured inquiry-based learning environments, the students simply follow teacher directions to engage in learning (Abrams et al., 2008; NRC, 1996). The teacher provides the question for students to investigate, outlines the procedures for the students to follow in their investigations based on a specific order, a structure for data collection and organization and a format for writing the results of their investigations. In this form of inquiry, students have ownership neither over the question nor the process of investigation. As a result, there is little intellectual involvement of the students in the inquiry experience.

In ***guided inquiry,*** the teacher helps students develop questions and design their investigations. Learner selects among questions provided by the teacher, or guided by the teacher to formulate new investigable questions (Abrams et al., 2008; NRC, 2000; NRC, 2013). The teacher assists the student or the group of students to design their investigations through ongoing scaffolding. Learners are instructed to collect and analyze certain data by giving the students a data table template. Finally, the learner is guided in the process of drawing conclusions and formulating explanations from their data typically through a template or a set of questions given by the teacher.

Open inquiry can be defined as a student-centered approach that begins with a student asking an investigable research question based on his/her interest, followed by designing and conducting an investigation or experiment, analyzing data and communicating results to the learning community through models, evidence-based explanations and defending the results through persuasive arguments (NRC, 1996; NRC, 2013; Windschitl, 2003). Having students ask the questions that guide their own investigations, and giving them the opportunity to design their investigations is the key to open inquiry. This is the most sophisticated form of learning as it most closely mirrors the science that takes place in authentic scientific laboratories. Students engage in the epistemic and social practices of science as they design, conduct and report the results of their investigations. This framework helped us to analyze and interpret teachers' instructional practices and the quality of inquiry-based learning opportunities provided to their students.

Method

A case study research has been defined by Creswell (2007) as *the "study of an issue explored through one or more cases within a bounded system (i.e., setting, a context)"* (p.73). In the current research, we aimed to explore inquiry-based teaching practices of six teachers in the COVID-19 pandemic. The teachers were selected based on their past history with teaching science through inquiry. The context is bounded by the number of teachers and teaching in the pandemic. Therefore, the current study was a multi case study (Merriam, 1998) exploring elementary science teachers' implementation of the inquiry- based strategies during COVID-19 pandemic. The research questions leading the study were:

- How did elementary teachers adapt their inquiry-based teaching during the COVID-19 pandemic?
- What are the challenges that they encountered during implementation of online inquiry-based teaching?

Participants

Participants of the study were six elementary teachers: three working in a private school, and three working at a public school. Two of the participants are currently pursuing a Ph.D. degree in science education and are in the process of dissertation writing. One of the participants holds a Master of Science degree in teaching science. All of the participants were experienced teachers, that is, their teaching experience varied from 8 to 25 years of teaching science. The teachers' grade band varied form the fifth-grade to eight-grade. Currently, all of them were teaching online either via Zoom or the special online teaching platform provided by schools themselves. All of the teachers were highly motivated to teach science by means of inquiry. All of them expressed their efforts and commitment to teaching science through inquiry-based instruction. All of the participants stated that they had attended face to face professional development programs in STEM and inquiry-based learning before the pandemic in the past.

Data Reduction and Analysis

Data were collected by means of semi-structured interviews. While forming the interview

questions, the authors used literature and help of expert ideas. The interview questions were mostly created based on the authors' previous published research regarding the development of the scientific inquiry scale (Aydeniz, Bilican, & Senler, 2021) consistent with the NSES framework (NRC, 1996). Development of the aforementioned questionnaire items included writing interview questions, getting feedback from experts on the questions and piloting these questions via a face to face set of short interviews. Then, the process included revision of the interview questions. These revised interview questions were piloted before they were revised and finalized. The open-ended questions consisted of questions related to the science teaching goals, description of an inquiry-based teaching, description of an online inquiry-based teaching, strategies to adapt inquiry-based teaching during the pandemic, adaptation of the assessment strategies, the teaching related challenges they have been experiencing during the pandemic. The interviews took about 45 to 60 minutes and were conducted through Zoom. All interviews were audio-recorded to be transcribed. First, we transcribed all audio recorded interview data. The interview transcription was conducted in Turkish and translation was made during the writing phase of the study. Analyses were done through writing reflective notes, drafting summary sheets, creating patterns and themes, relating categories and making contrasts and comparisons (Miles & Huberman, 1994). The analysis of the interviews was done by the first and the third authors of the current study. Differences in interpretations were resolved by re-analyzing the raw data and category adjustment until consensus was reached (Patton, 2002). Additionally, the second author independently did the coding with the four participants of the study and the coding overlapped with an %95 agreement (Creswell, 2007).

Results

This case study explores the inquiry-based teaching experience of six in-service elementary science teachers during COVID-19 pandemic. The main aim of the study was to explore how COVID-19 pandemic influenced elementary science teachers' inquiry-based teaching goals, their implementation of inquiry-based teaching, and how and to what extent their teaching goals and practice related to inquiry shifted during the pandemic. The results are organized by the following subtitles reflecting the themes that emerged from the analysis of the data:

- Conceptual challenges for teaching science by inquiry
- Methodological challenges for teaching science by inquiry
- Administrative challenges for teaching science by inquiry

Conceptual Challenges for Teaching by Inquiry

Under this heading, we explored teachers' understanding of teaching science, definition of inquiry teaching and transformation of these understandings and goals due to the pandemic. The participants of the study had claimed they applied inquiry-based teaching in their practices. In order to understand how their practices of inquiry-based teaching are compatible with the actual inquiry-based teaching framework promoted in science education reform documents, we asked them to describe the primary goals of science teaching in general and if their goals have been adjusted due to the COVID-19 pandemic. As expected, all the teachers stated that their main goal in teaching science is to prepare scientifically literate citizens in society. The participants mostly focused on students' meaningful understanding of natural phenomena, and students' exploration of the concepts, stimulating student curiosity towards nature, acquiring science process skills, and application of scientific knowledge to daily problems encountered. One teacher stated:

> *My ultimate goal in teaching is to develop citizens who can make science-informed decisions. I want to make their science learning experiences meaningful for them so they stop asking me "Where am I going to use these concepts in my life?" I want them to be inquisitive and productive members of society. (Umay)*

Another teacher said:

> *My main goals are increasing students' curiosity towards nature, giving them a sense of joy through discovery, and help[ing] them to develop scientific observations and questioning skills. (Elif)*

Yet another participant stated the goal of science education as:

> *The main goal of science education is understanding nature. I want my students to follow their curiosity and explore the nature using methods and means of science. (Ahmet)*

While most participants did not provide elaborate answers, the common goal across all their answers is an attempt to help students understand the natural phenomena through methods of

science and preparing informed scientifically literate citizens.

Evolution of Teaching Goals During the Pandemic

Regarding the influence of the pandemic on science teaching goals, the majority of the teachers stated that they had not changed their goal of scientific literacy. They expressed that they adjusted the tools based on the online-learning environment to achieve their pedagogical goals. One teacher said:

> *My goals did not really change. The only thing that changed is the teaching tools I use to achieve my instructional goals. I am still doing the same thing I used to do but this time doing it online. I am still trying to promote student curiosity, still trying to help them make sense of scientific phenomena. That has not changed for me. (Elif)*

Only one of the teachers stated that he shifted his science teaching goals, focusing more on teaching conceptual content as opposed to teaching them scientific inquiry skills. He blamed students' lack of resources to engage in inquiry at home as the justification for focusing more on conceptual themes rather than inquiry.

> *It is really hard for me to teach science through inquiry online. I have reduced my goals to student well-being, creating opportunities for them to like science, to develop positive attitudes towards science and learning key concepts of scientific phenomena. (Ahmet)*

Practices Related to Teaching Science through Inquiry

In this section, we explored participants' transformation of the inquiry-based teaching and assessment practices and factors impacting their planning, instruction and assessment. First, we tried to decide if the participants held an acceptable definition of the inquiry-based teaching within the framework of the current research. By acceptable we mean, teachers were at least engaging their students in guided inquiry as opposed to the ideal open inquiry. This means instruction focused on students' engagement with science process skills such as observing a phenomena, conducting scientific investigations and drawing conclusion based on the investigations through data analysis. Keeping in mind that the participants were chosen

voluntarily based on the claim that they were using inquiry-based teaching in their actual teaching practices. We explored the transformation of inquiry-based teaching due to the pandemic by detecting the definition of inquiry-based teaching, and transformation of the actual practices and assessment strategies used. First, we asked their definition of inquiry-based teaching to be able to understand if they have an adequate understanding of inquiry-based teaching conceptions.

Regarding teachers' definitions of scientific inquiry, it was revealed that, the participants' definition of the scientific inquiry overlapped with their science teaching goal. Most of the participants defined scientific inquiry as exploration of scientific concepts through students' questioning and curiosity and discovery, a method in which students are responsible for their own learning, use of science process skills such as questioning, identifying variables, controlling variables, testing, experimenting, questioning, inferencing. One teacher said the following regarding inquiry-based teaching.

> *Inquiry to me is the type of teaching where students are exploring concepts and constructing knowledge on their own. The teacher's role should be limited to guiding student inquiry not controlling student thinking. Students can explore concepts on their own, together with their friends, either through experiments, or through brainstorming. The important thing is that they are the ones in control of their exploration and inquiry. I see my role as scaffolding their experiences as they engage in these explorations. (Umay)*

Another teacher shared the following in response to our question related to inquiry-based teaching.

> *Inquiry to me is students asking questions, designing controlled experiments, deciding on and understanding dependent and independent variables, developing arguments or reaching conclusions by comparing weaknesses and strength of alternative arguments. I believe we will be able to align our practice with authentic science only if we engage our students in all of these things. (Ahmet)*

Another teacher stated the following regarding inquiry:

> *Inquiry to me is… like you are not giving students the answers directly, but through questions. You gather students' questions first and then build on these questions to drive your instruction. You can enrich this experience by creating a laboratory environment, where students can conduct investigations, collaborate with their peers to collect data and arrive at conclusions based on the patterns observed in the data. Students start with a hypothesis or a question and then engage in other practices such as data collection and analysis to arrive at a conclusion. (Hande)*

Although two of the teachers did not provide a detailed explanation of the inquiry-based teaching, they had an understanding of inquiry-based teaching as students' own exploration. For instance, one of the teachers defined inquiry-based teaching as questioning, which involved developing explanations for the "why" questions. Additionally, she defined science teaching as relating daily life and making interpretations in which the definition included the components of inquiry-based teaching:

> *Inquiry to me is… Ummm… I think students answering the why questions. They should be able to answer the why of their observations… They should know why they are doing everything they do. So learning through questioning and justification. They should ask the why question, in everything they do, everything they observe in daily live[s]. They need to understand that science is in everything they encounter outside of the classroom. (Ayşe)*

The other teacher defined inquiry-based teaching as the exploration of the concepts through questioning. Moreover, she expressed her way of science teaching involving students in the exploration of the concepts by guiding them through the scientific process:

> *Inquiry-based learning to me is … arriving at knowledge by asking questions, exploring, discovering. I think the most important part of inquiry-based learning is exploring answers to the questions by asking the right questions. I try to reflect this in my teaching. Consistent with this belief, I focus on improving their observation skills, their questioning skills, and try to help them understand the features of quality scientific research. (Elif)*

Teaching Inquiry in the Pandemic

Once we ensured that all of the teachers had a basic understanding of inquiry-based teaching and adopted this approach in their teaching practice, we aimed to understand how they adapted their teaching in the COVID-19 pandemic. When we asked how they adapted their teaching strategies while teaching online, none of them mentioned inquiry. Although they insisted that they tried to teach through inquiry, the nature of the activities did not match inquiry-based instruction. They referred to hands-on learning, minds-on learning, use of models in teaching science to make their teaching effective in online environments. They admitted however students' lack of access to the laboratory settings and resources made teaching science through inquiry a challenging endeavor.

> *I try to demonstrate the process of inquiry through hands-on activities using household materials. I have used items ranging from soccer balls to springs… Sometimes the use of different items comes to my mind while I am teaching so I go grab them and explain the scientific principles and concepts to my students. I try to teach through examples using household items…(Bora)*

> *Since I cannot engage my students in lab-based learning experiences, I engage them in hands-on activities at home. For instance, I recently engaged them in a hands-on activity which required students to prove to me the conservation of matter using household items. I give each student a couple minutes to explain their models and the scientific process they went through. Sometimes we do such activities collectively as a class. We did that in the cell structure model and the construction of a telescope projects. They just follow me as they go through the construction process. (Umay)*

> *I am asking them to do labs and show me the proof of their labs through photos. I spent one day a week teaching lab-based activities. For instance, I recently asked them to design a model of the respiratory system and share their models with me. (Ayşe)*

Moreover, one of the participants pointed out the reduced time of science classes which was shortened 15 minutes per class hour as another obstacle for conducted inquiry-based teaching and as a solution he revised the content of the homework. He gave assignment mostly focused on skills like manipulating variables, and modelling:

> *..... but because the lessons were shortened to 30 minutes, I ended up giving my students homework assignments that would engage them in inquiry. For instance, my students construct a cell model and they share the photos of their models with me. I can give them feedback that way. I have them use digital notebooks, they ask questions and I review them. I like that they are asking questions. I like the flow of the introductions of concepts, it gives the students opportunities to learn concepts by trying, by manipulating variables, the modules are interactive. We can do a lot of things through digital notebooks. I share my screen with my students and we go over the concepts with them, I share examples from real life, I can ask questions… and require them to answer my questions. We have a very interactive and dynamic learning environment. (Bora)*

Participants reported other methods through which they achieve inquiry-based instruction in their teaching. Participants said that a lack of effective inquiry-based online teaching tools forced them to use online videos as a means to teach their students the concepts and practices of science. One teacher said, he typically has his students watch science videos maybe once a week but since the start of the pandemic, he has them watch online videos of science concepts almost every day.

> *I send them videos and ask them to analyze the videos by providing scaffolding questions and asking them to respond to these questions. I sometimes ask them to develop concept maps and try to help them develop conceptual understanding that way. (Ahmet)*

Another teacher pointed out lack of access to quality online teaching tools. She said:

> *In normal times, I ask students to bring activity materials with them to the classroom. We do a lot of hands-on activities but I cannot now because of the pandemic restrictions so they end up using household items to complete the activities I assign to them. (Elif)*

One of the teachers mentioned the failure of the online learning environments for students to experience the skills such as observation, variable testing and inferences which were the major parts of inquiry-based teaching:

> *Online learning does not provide an opportunity for students to experience inquiry… Therefore, online learning is not a good modality for teaching science. We were able to play with variables to test the effects of different variables on the behavior of the systems, we are not able to make observations. Online learning is not suitable for inquiry-based science teaching. (Ahmet)*

Another teacher shared his struggles with teaching science through inquiry. He said:

> *The major challenge for science teachers is not being able to do labs, to engage students in collaborative learning. I still try to do inquiry but it is hard to plan inquiry-based activities while you are teaching online. (Bora)*

Only one teacher shared that she switched to flipped teaching method to be able to teach science through inquiry and create collaborative learning opportunities for her students and to allow her students to ask questions.

> *The changes I made…Hmm.. I switched to flipped learning model. I send them a video about the content we plan to cover and ask them to come up with questions about the concepts covered in the video and together we answer these questions. I send them a Google form and ask them to submit their questions through that form. That way I gauge their weaknesses and strengths related to the content of the lesson. Students' questions drive my instruction. I use these questions to engage students in whole class discussions. One other thing I am doing is creating opportunities for students to socialize. They don't get a chance to socialize because of the pandemic. I want to make sure they are still connected with their friends so I create such opportunities for them. (Elif)*

Additionally, participants cited extensive workload tasks as an obstacle to teaching science through inquiry. This extensive workload was stated due to more preparation time for teaching online. Regarding the extra preparation, the majority of participants said they are spending more time searching for and choosing online programs, finding engaging videos, and adapting some of the activities to teach content online. One teacher said:

> *I search for online content. Let's say I found a video, I have to watch it by myself first*

> *to see if the video content is really relevant, engaging and effective. I have to create worksheets or activity materials. I have to load my PowerPoints on Google Drive, organize them, and then open them during class. This takes a lot of time. (Umay).*

Ahmet also shared his experiences related to doing extra work to plan for his lessons and to keep his students engaged outside of classroom hours.

> *The students send me a video related to the rotation of the earth for instance. I have to answer their questions related to the video. I find myself constantly responding to my students' questions. I have to do this because that is the only way I can keep my students engaged. (Ahmet)*

In short, these findings reveal that teachers held instructional beliefs consistent with inquiry-based learning but they felt that they were limited with reduced class time and students' access to learning materials required for them to do hands-on inquiry. They maintained their goals of engaging their students in inquiry through questioning, however, even that became problematic because they did not have time to engage their students in meaningful and reflective learning experiences consistent with premises of inquiry-based learning.

Changes in Teachers' Assessment Practices

In order to understand how teachers' assessment practices changed due to the pandemic, we asked the participants to describe how they adapted or changed their assessment practices in online learning environments. In their responses, despite the pressure regarding the students' performance in paper-pencil national exams, most of them stated that they used diverse assessment methods in their instruction. Their assessments focused on both students' conceptual understanding and higher order thinking skills. For instance, one of the teachers designed assessments to promote students' performance skills in group settings. She wanted her students to develop argumentation/discussion skills in group activities. She used peer assessments to promote students' acquisition of science related performance skills. One teacher said:

> *I have performance-based assessments… I want to see if my student is active, is he/she relying on peers to complete the learning tasks, or is she/he completing tasks*

independently at the individual level. At the group level I am looking to see if they are collaborating, if they are discussing ideas, if they are brainstorming as a group. I monitor how they participate in these activities both formally and informally. I grade them based on how they perform on these skills. (Umay)

Two of the teachers highlighted their focus on measuring students' higher order skills through performance revealed in project assignments or the experiments they engaged their students in online tasks. They drew attention to the questioning and modelling skills, and the ability to analyze information as seen in the following quotes:

I am looking to see if my kids are learning the standards at the fundamental level, checking to see if they have constructed that understanding. Are they able to develop researchable questions? Are they able to apply their understanding when conducting experiments? I had expectations about the end of semester. I wanted to see if they have developed a set of skills and certain type of understanding. Now, I am assessing their ability to think creatively, their skepticism, their ability to question and to inquire. I now look for these things in the questions they ask, while they are discussing in groups or in class discussions. I take notes about their conceptual understanding and performance skills when they are engaged in group work. (Elif)

Another teacher stated:

For instance, a student had created an innovative product. No one else had come up with this idea. We had a cooler project, I looked to see if the students came up with an innovative idea? Is he /she using novel material? Are they coming up with a novel model? Then there is this…. Are they actively engaged in group projects? Are they making contributions in group projects? Are they able to apply their knowledge and skills in projects? I look for these things. (Bora)

One of the teachers stated that her assessment strategies changed based on the grade level she taught. Her assessment strategies primarily focused on model construction and design skills, whereas for upper grades, she focused on measuring students' problem-solving skills. For instance, because 8th graders need to take the national standardized exam at the end of the school year she focused on problem solving with this group of students.

The teachers' assessment strategies mostly shifted towards measuring students' acquisition of conceptual knowledge during COVID-19 pandemic. During the pandemic, teachers abandoned performance-based assessment in favor of traditional paper-pencil tests due to external factors impacting their planning and teaching. These factors include the pressure to teach the content standards within a short period of time, pressure from the administration related to the expectations for student performance on the national exams, and parents' expectations related to the students' performance on the national exam.

One teacher stated:

> *My assessments have been reduced to measuring students' conceptual understanding. Measuring students' advanced skills such as their analytical skills, cause and effect have become my secondary goals. (Ahmet)*

Another teacher said she is mostly focusing on students' content acquisition and problem-solving skills.

> *We go by the standards. I am trying to see if they remember content from last year, have they built on what they already knew. Are they able to solve problems related to content I teach? For instance, do they know the differences between metals and non-metals? These are the things I focus on in my assessments. The national exams and school-wide exams continue to take place. (Hande)*

Administrative Challenges for Teaching by Inquiry

This part aimed to explore the challenges that the teachers experienced apart from the conceptual and methodological issues related to inquiry-based teaching. Teachers found themselves dealing with such issues as administration's demand from teachers, challenges with parents and the student attendance. Consequently, the goal of teaching through inquiry-based learning faded away since the majority of the teachers had to put more effort to deal with these administrative challenges instead of focusing on planning for inquiry-based teaching. Among the reasons why the teachers shifted their inquiry-based teaching towards more teacher centered teaching instruction was the time limitation, focusing on keeping students' presence in online classes, getting used to online teaching resources, lack of

students' access to laboratory equipment and the toll COVID-19 pandemic had on their psychology and responsibilities at home. For example, regarding students' absences, one of the teachers pointed out the lack of student motivation for attending online classes. Further, she highlighted how the socioeconomic status of some students prevented students from participating in online classes.

For instance, one teacher said:

> *I have some students who cannot be present because of lack of access to a computer at home or access to the internet. Unfortunately, I cannot do anything for them. I lose them. I have attendance issues. In a class of 42, typical number of present students is around 37-38. Students have low motivation to be present for online classes. Some days they are mentally present but most days they are not present mentally. (Umay)*

Another teacher participant expressed similar concerns by saying:

> *When we are talking about a science class, you want to do experiments, hands-on activities… When I assign inquiry-based activities, I can only get 5 or 6 students out of the whole class (n=23) to do the activity. When I am teaching in person, I can get everyone engaged in the activity. I will have one or two students playing around but I am mostly successful in getting everyone to engage in the activity. However, it is hard to monitor students in an online environment. There is access to the materials problem and teacher monitoring and support problem. (Hande)*

Teachers stated other reasons for not being able to teach science through inquiry during the pandemic. Teachers stated that they needed more prep time for designing effective inquiry-based online lessons. They blamed lack of prep time and shorter class times as the reasons why they did not teach science through inquiry.

One teacher said:

> *It takes longer to prepare lessons. I find myself spending at least 10 hours in front of the computer getting ready for my teaching. (Elif)*

Other teachers expressed different concerns that made it harder for them to teach science through inquiry:

> *Class time was reduced to 30 minutes. Creating engaging lessons for 30 minutes became a real challenge. I had a hard time using time effectively. That's why instead of doing inquiry-based lessons, I present the content first, and then teach through questioning, showing them visualizations and helping them to establish relationships between relevant concepts. I try to approximate inquiry-based learning but it is really hard. For instance, I know that students have questions but I have to shut the student down because I have to implement my plan. I have to limit class discussions to 1 minute. I can see students are interested, they have questions and ideas, they raise their hands to make contributions to the class discussion but I have to shut them down. (Ahmet)*

Bora also expressed concerns about the shortened class time. He said:

> *The class time is really short. Also, my camera cannot be moved around to show them everything. For instance, I am doing a lesson on the science behind insulation but I cannot do it through inquiry. This lesson can be done more effectively at school. We measure the temperature using the thermometers, record data, compare measurements etc… We can't do that in online environment. The class time should be extended. If class time is extended, I can answer every students' question, I can build on their questions to explain concepts. I can do more engaging activities but… (Bora)*

Elif, another participant, expressed similar concerns about rush to cover the standards and how it impacted her ability to teach science through inquiry:

> *I am not able to cover the standards. I find myself rushing and trying to cover all the standards. I need an extra 2-3 classes to be able to effectively teach each of the standards I am covering now but I have to move on. All science teachers need to follow the same pacing guide so I cannot deviate. We all need to be on the same page. The system is the source of problems we are experiencing, not the individual teachers. (Elif)*

Regarding the managerial tasks, teachers stated that these tasks require extra time in addition

to the lesson preparations which has been another obstacle for the inquiry-based instruction. These managerial tasks have been mostly related to the school culture, such as administrators' expectations, needing to attend more meetings, increased frequency of communication with parents and the increasing diversity of problems related to student learning.

Ahmet, a teacher participant, said:

> *I sometimes plan a lesson and think that everything is perfect, but the next day I receive a note from the administrators that I need to change my plans. There are a lot of unplanned decisions that I have to deal with. They ask us to rush the content coverage or do something else. Because I don't feel I have control over the lessons I teach, it is hard to plan for inquiry-based teaching. (Ahmet)*

Other teachers also expressed concerns about the added responsibilities to their to-do-list. The following quote from Bora shows the nature of tasks that the teachers had to do due to the pandemic:

> *I don't remember how many times I had to call the parents regarding student attendance. I found myself talking to other teachers to make sure they are attending other classes as well. I have to make calls to the administration regarding student attendance, regarding students' access to a tablet at home. I found myself making calls to everyone to make sure my students have access to the computers and other tools to participate in learning. (Bora)*

Umay also expressed similar concerns regarding lack of student attendance and how this affected her teaching. She said:

> *I need to make calls to the parents, inform them of their child's absence. I have to call my students in an effort to* convince *them to participate in class activities. I try to understand the reasons behind their lack of participation and engagement. I make calls to school counselors to make sure that they are getting the help they need. So, I find myself pulled in all directions. (Umay)*

Collectively, these findings summarize the experiences and struggles of six elementary school teachers related to inquiry-based teaching. In the next section, we discuss what these findings tell us about teachers' preparation and their implications for education policy and practice.

Discussion and Conclusions

Achieving scientific inquiry in science classrooms starting from elementary school has been a long-held goal of science education reform efforts (NRC, 1996; 2000; 2013; Schwab, 1960). Science educators have achieved a limited level of success after the publication of the National Science Education Standards in 1996 (van Uum, Verhoeff, & Peeters, 2016). While we are still far from witnessing a significant number of teachers effectively implementing inquiry in their classrooms (Correia & Harrison, 2020; Crawford, 2007) some teachers were able to develop beliefs, knowledge and skills to teach science inquiry (Abrams, Southerland, & Evans, 2008; Blanchard, Southerland, & Granger, 2009). In this study we explored how these teachers' practices were impacted by the COVID-19 pandemic.

One goal of inquiry-based instruction is to engage students in practices of science (NRC, 2000; 2013) as they occur in authentic settings. These practices include, ability to ask questions, making systematic observations, collecting and analyzing data, developing evidence-based scientific explanations and communicating these explanations to their peers (Chinn & Malhotra, 2002; NRC, 1996; 2000). The results of our study showed that teachers held developing views of scientific inquiry and ambitious goals for teaching science through inquiry. By developing views, we mean that these teachers understood that the goal of scientific inquiry is to engage students in authentic practices of science, they were able to name different aspects of inquiry, but not able to elaborate on the specific instances of inquiry in the classroom. However, despite these ambitious goals and a developing level of understanding about features of inquiry-based teaching, they struggled to develop a fruitful context and effective strategies to engage their students in inquiry.

The reasons for this struggle varied. Teachers expressed increasing communication workload related to managing student attendance issues, increased planning time for online teaching, reduced instructional time and the impact of the pandemic on their responsibilities at home. While these are all important challenges, the fundamental challenge to implementing inquiry-

based teaching reported by teachers was students' access to learning tools and resources. For instance, teachers mentioned that some students were not able to be present in class because they did not have access to reliable internet or a tablet or a computer as some of them had to share it with their siblings. In addition, teachers shared that they were not able to ask their students to purchase the materials they needed to do inquiry-based activities at home as they would when they are in the classrooms. Instead, they had to form their teaching goals and activities based on the materials they thought their students had access to at home. While this was not a big concern for private school teachers, students' access to learning tools and materials needed for hands-on learning was a big concern for public school teachers.

The teacher acknowledged that planning an inquiry-based lesson for a 30-minute time in an online environment, proved to be a challenging task to undertake. This time issue was reported earlier by a study conducted in Australia (Fitzgerald, Danaia, & McKinnon, 2019). Considering a 30-minute class time being almost half of the regular class time in the Australian study, it makes sense that teachers would struggle. If teachers struggle to teach inquiry in normal times due to short instructional time, time becomes an important barrier to teaching science through inquiry in online environments. Knowing resource and tool deprived that students cannot participate in inquiry-based activities, they limited their efforts to asking questions, encouraging students to ask questions and engaging them in model-building activities. Teachers found engaging students in collaborative problem solving to be not feasible in a 30-minute online class. Getting students' attention, giving them directions for activities and helping them to understand teacher directions will take at least 10 minutes. This shortened time period does not prove to be a good timeframe for conducting inquiry-based lessons. However, we argue that here the real issue is not the time itself, but 1) teachers' perceptions that the whole inquiry cycle should take place in one lesson and 2) the pressure on teachers to follow the pacing guide. If teachers do not follow the pacing guide, their students will not be able to score well on the standardized tests.

The results show that while their goals of helping students to engage in critical thinking and development of scientific process skills did not change, their ability to design and implement such lessons were severely limited partly due to external factors: such as limited instructional time, increasing need to convince students to be present in class and students' lack of access to technological tools and resources to complete inquiry-based activities. For instance, one teacher said that because she knew her students would not be able to have access to the

reliable internet or the computer at home, she modeled inquiry for them. Instead of having students to engage in inquiry she modeled inquiry with them and for them.

One could argue that even if these teachers were asked to collaborate, supported with instructional resources, and professional development (Crawford, 2007; Fitzgerald et al., 2019) they would be able to implement inquiry in a digital learning environment with greater success. The struggle to teach inquiry in an online environment is a hard task for one teacher alone to achieve than in normal times (Linn et al, 2006; Van der Valk & De Jong, 2009). This struggle was further complicated by the decreased instructional time set by central government policy, problems with students' attendance and cognitive presence during the online lessons and home-related COVID-19 issues.

One key challenge to the implementation of inquiry-based teaching in Turkish elementary classrooms is that public school teachers are not being asked to teach science through inquiry. These teachers teach science through inquiry because of their personal commitment to teaching science through inquiry. What motivates them is the learning they have been exposed to in their graduate programs. The authors know these teachers personally and this conclusion has been reached because of our prolonged engagement with this group. Another challenge is that while teachers were able to implement inquiry-based teaching in their physical classrooms, as hands-on activities facilitate the process of scientific inquiry that teachers are familiar with, they struggled to translate their conceptual understanding and pedagogical skills of inquiry in online environments. This challenge has been reported earlier by other scholars (Edelson et al., 1999). Teaching science in an online environment is challenging because teachers found themselves being curriculum developers, teachers and managers of resources. This observation was also made by others in a European studies (de Jong et al., 2020; Sotiriou, Lazoudis, & Bogner, 2020) and a U.S studies (Blanchard et al., 2009; Crawford, 2007). Sotiriou et al. (2020) found that even when teachers are given the scaffolds they need to develop inquiry-based lesson plans, they struggled to teach science through inquiry.

In terms of assessment beliefs and practices, teachers had naive understanding about inquiry related skills. Teachers talked about data collection, questioning and performance skills but they did not go beyond these basic skills. This raises the need for helping teachers to develop robust understandings about inquiry skills and ways to measure them.

Finally, high stakes national examinations at the end of each grade band are very common. Teachers feel pressured by the administrators and families to teach skills tested on these exams. Teaching of inquiry skills are sacrificed in favor of promotion of knowledge and skills tested on the national exam. However, this is only a peripheral concern. The real concern is teachers' limited knowledge of assessment content and practices related to inquiry-based instruction. For instance, when asked how they go about assessing inquiry-based learning outcomes, teachers struggled to provide answers that were aligned with the goals and practices of scientific inquiry. Instead of providing explicit and targeted answers they referred to measurement of higher-order-thinking skills without future studies can explore how teachers can be supported to develop beliefs, knowledge and skills related to inquiry-based teaching.

Recommendations

We provide with the following recommendations based on the results of our study.

- Teachers are facing unique challenges when attempting to teach science through inquiry. The source of these challenges is diverse and includes conceptual and practical concerns. To address these challenges teachers, need to engage in meaningful professional development contextualized in their work assignments (Capps & Crawford, 2013).
- Teaching science through online mediums is not only a pedagogical knowledge and skills issue, it involves teachers to develop curriculum design skills. Teachers need to be provided with rich opportunities to develop and test online curriculum informed by principles of scientific inquiry.
- The responsibilities of school counselors have been placed on teachers due to mismanagement of the process. This has created a challenge for teachers. Instead of spending time on planning for their lessons, they found themselves calling parents and students to make sure they attended the class. There should be better coordination of personnel and resources during emergencies.
- Finally, building a community of teachers who are committed to inquiry-based teaching can take off some of the burden on teachers as they can share resources, and address concerns related to student engagement and collectively find solutions.

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Commentary: Teaching K-12 Students During COVID-19

One could argue that K-12 teaching was impacted more than university education as younger students transitioned to online learning. K-12 educators and students may have experienced multiple shifts throughout the early pandemic period, from moving to remote learning and sometimes returning to in-person learning with social distancing, to then moving back to remote learning. Teachers and young students alike needed to learn how to navigate online learning platforms such as Google Classroom, Zoom, and others, and the authors of the chapters in this section indicated unique challenges with student attendance and participation, resources for them to teach and for students to learn, and seeking ways to align their new teaching modalities with their philosophies and knowledge about best-practices teaching. Asim and Hollenbeck indicated that students' access to technology was a challenge. Indeed, the news in the United States shared how some young students were having to sit outside libraries and other establishments in order to connect to their Wifi because they did not have Internet access at home. Interesting dynamics resulted from learning from home as students' motivation was affected (see, for example, Asim and Hollenbeck). The middle school teachers in Erumit, Yuksel, Ozcelik, and Tekbiyik's study shared how parents and siblings sometimes got involved in the online lesson, which could cause a funny moment. The challenges K-12 educators and students have experienced during the pandemic were unprecedented and required much creative problem solving.

To meet the challenges of online learning, the authors in this section discussed the ways in which teachers in their respective studies used innovative and creative strategies to teach science. Bilican, Senler, and Aydeniz discussed ways in which K-12 educators sought to align their online instruction with their philosophies and values as educators, specifically with regard to inquiry-based teaching. Teachers engaged in demonstrations and asked students to complete investigations with materials they had at home. Furthermore Asim and Hollenbeck and Avsar Erumit et al. shared strategies teachers used to motivate students in the online learning environment, such as sending students emojis and using creative platforms or

applications to engage their thinking. Avsar Erumit et al. also discussed at-home science investigations, but noted that there were moments of risk that resulted in minor accidents. Two teachers mentioned asking students to do the experiment at home when they were not on camera, and then sending a video or photo to the teacher.

One can conclude from the chapters in this section that K-12 teachers made an impressive effort to find ways to engage their students in science learning, and even tried to continue engaging students in scientific modeling, demonstrations and investigations whenever possible. Furthermore, teachers explored a variety of online tools, platforms, and applications to support teaching in ways that aligned with their philosophies. Although this was time consuming to do so (as the teachers in Asim and Hollenbeck and Bilican et al.'s chapters noted), it was clear that teachers were determined to try to provide their students with experiences that would result in critical thinking and active learning. The authors of all three chapters in this section noted that professional development and training is an important factor that can contribute to supporting teachers in facilitating online learning for students. Avsar Erumit et al. notes:

> Actually, integrating technology more into our lessons has been one of the benefits of compulsory online education (al Darayseh, 2020; Radha, Mahalakshmi, Kumar, & Saravanakumar, 2020). Studies before the Covid-19 pandemic argued that many instructors had little or no intention to integrate these technologies into their lessons (e.g., An and Williams, 2010; Barak, 2017). When used effectively, these technologies bring various benefits to teaching and learning (p.13).

In conclusion, despite the challenges that K-12 teachers faced teaching online during the Covid-19 pandemic, many of them made valiant efforts to continue to facilitate quality science learning experiences for their students. These efforts may result in increased innovation and creativity in science teaching and learning even beyond the pandemic.

Citation

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SECTION II - TEACHING UNIVERSITY SCIENCE CONTENT COURSES DURING COVID-19

Chapter 4 - It's Hard to Focus on the Content Knowledge: Understanding a Doctoral Student Instructor's Emotional Challenges of Teaching Science During the COVID-19 Pandemic

Qiu Zhong, Tulana Ariyaratne, Jing Yang, Shukufe Rahman, Valarie Akerson

Chapter Highlights

- The doctoral student instructor being studied encountered many emotional challenges teaching during the pandemic.
- While needing emotional support for herself, the doctoral student instructor was also seeking strategies to support her students' learning and well-being.
- The doctoral student instructor experienced multiple identities, among which her identity as a student resulted in more empathy and compassion for her students.
- The pandemic has amplified the need to build trustworthy relationships with students and offer them emotional support, which masked the curriculum goal to deliver science content knowledge.
- Social injustices impacted both the instructor's emotions and science teaching.

Introduction

According to Farouk's (2012) definition, teacher emotions are "internalized sensations that remain inert within the confines of their bodies but are integral to the ways in which they relate to and interact with their students, colleagues, and parents" (P.491). Teacher emotions have a significant impact on teachers' mental health (Burić et al., 2019), their teaching in the classroom, and their student's learning and well-being (Frenzel et al., 2018). The global pandemic that emerged in 2020 has placed challenges for science teaching, among which emotional challenges are significant. Since spring 2020, most schools around the U.S. abruptly transferred traditional teaching modalities into various remote learnings with limited training for teachers (Adams, 2020). Although many efforts had been made for the new format of teaching and learning, research and news reports showed that teachers and students demonstrated a variety of difficulties and showed a lot of emotional challenges (e.g., Kim et al., 2021; Petrakova et al., 2021). The pandemic caused extra difficulties for graduate students who were both teaching and taking courses at the same time (Alsandor & Trout, 2020). According to the National Center for Education Statistics (NCES), there are more than 3.7 million graduate students in the U.S. in the year 2020. During the COVID-19 pandemic, many graduate students continued their studies and teaching jobs with a lot of constraints and challenges due to the multiple roles they play. For example, besides making efforts to adapt to the new teaching and learning format, many of them had to take care of their own children at home (Bal et al., 2020). A survey study (Blankstein, 2020) showed that while students understood the pandemic institutional policies, they wanted additional support in terms of their physical and mental health. International graduate students showed extra anxieties about their visa status and the loneliness of being isolated from their families (Alsandor & Trout, 2020). Technically graduate student instructors are also students. So they are also experiencing the same hardship that their undergraduate students are experiencing. However, the graduate student instructors were asked to teach the undergraduate students in a different format despite the hardship that they are experiencing.

Existing studies highlighted the importance of offering emotional support for graduate student instructors. However, there is a lack of studies that reveal the emotional challenges they have experienced during the pandemic. Here, the first author conducted a self-study in Spring 2021 when her institute was still in pandemic mode, and the undergraduate-level course she taught was in a hybrid format. The initial purpose of this study was to understand

how she developed an identity as a teacher educator who teaches Nature of Science. However, results have consistently revealed her emotional challenges which became the focus of this chapter. The emotional challenges were discussed based on the first author's intersectional positionalities as a Chinese doctoral student and an instructor in a science education program in a public educational institution in the U.S. The aim of this study is to provide information to science education programs, teacher education programs, and graduate programs more broadly on how to support graduate student instructors during and post COVID-19 pandemic, or for other similar emergent times. The research questions of this self-study are: (1) What emotional challenges did the first author, as an international doctoral student instructor, experience in teaching a science course during the pandemic? (2) How did those emotional challenges influence her teaching during the pandemic?

Method

A self-study approach was used in this study to answer the research questions above since the personal experiences demonstrated in the self-study would help us to understand the complexity and difficulties in teaching that other educators may have experienced as well during the pandemic. As a component of action research (Akerson et al., 2000), a self-study investigates oneself with the purpose to understand how science teacher educators' theoretical notions of teaching are formed/informed by their teaching experience (Buck et al., 2016). A self-study generates knowledge based on personal teaching experience, but the outcomes are shareable public entities that have implications to both self and others to improve one's teaching (Akerson et al., 2000; Feldman, 2003; Hamilton et al., 2008; Laboskey, 2004). The self-study approach does not rely on a single method, and rather, it employs many methods that are commonly adopted in other educational research. These methods allow us to gain a more comprehensive understanding of the research question being investigated (Pithouse et al., 2009). Also, self-study is collaborative as the researcher being studied interacts with multiple sources (e.g., colleagues, students, educational literature, etc.) to reflect on oneself (Pithouse et al., 2009). .

As Berry (2004) summarized, one of the reasons that motivates teachers to embark on self-study is to investigate a particular aspect of practice. In this study, the first author was a doctoral student instructor seeking to improve her teaching practice by investigating her own teaching during the pandemic. In this regard, a self-study is appropriate because this study is

self-initiated with the purpose of seeking improvement. In addition, self-study comprises both emotions and occurrences (Akerson et al., 2000), it offers an ideal lens to understand the research question of interest. More specifically, it allows us to capture the personal emotions in teaching science during the COVID-19 that involve pressures, struggles, and dilemmas. Under the special context of the pandemic, the first author wanted to understand what caused those emotions and how those emotions had influenced her practice of teaching science. The scholarship of this practice would provide information in supporting doctoral student instructors and advancing the field of teacher education about what and how to teach science during difficult times.

Participants

The primary participant in this self-study was a third-year doctoral student in science education. She came from Wuhan, a city in Central China and the first city that was attacked by the COVID-19. Since spring 2020, she has experienced and witnessed how the pandemic influenced her hometown to her family and friends and how it spread into the U.S and globally among which a lot of social issues and injustices were involved (Sheppard, 2020). At the beginning of spring 2021, she was in the second semester of her third year in the program. She was on an appointment as an instructor teaching an undergraduate-level course about scientific inquiry. She had taught this course twice in previous years. While teaching, she was also taking two courses that had transferred fully online in response to COVID-19.

Secondary participants included one science education professor and three doctoral students in the same program with the first author. The professor and the three other doctoral students served as her critical friends in supporting and validating her self-study across the semester through regular meetings. They also participated in data analysis and result validation.

Class Context

The course is a university introductory level course on scientific inquiry that focuses on the nature of science. Before the pandemic, there were usually around 5 sections of this course offered every semester. This course is a requirement for most education majors and is also open to all other majors in the university. The majority of students enrolled in this course are freshmen and sophomores from different education majors. The main goal of this course is to

help students to understand the nature of science, the nature and process of scientific inquiry. Each section of this course used to meet twice a week in a science classroom with a variety of science materials available during the class. The full capacity of the class is 24 students and each section usually had 20-24 students before the pandemic. This course had been instructed with many hands-on activities, indoor and outdoor experiments, intensive discussions, and group work.

In response to COVID-19, the course in spring 2021 used a hybrid modality that included different ways of asynchronous and synchronous teaching for the whole semester. There were a lot of changes both for the content of the course and the way it had been delivered. During the first three weeks when everyone just finished the Christmas and New Year's holiday, all classes were on Zoom. Students met the instructor twice a week through synchronous instruction remotely. After three weeks when all students were required to return on campus, a hybrid modality was used for the rest of the semester. The in-person classes were reduced to once a week and students were required to learn other content of the course asynchronously online during the week.

To maintain social distance, the university used a rotation teaching mode in which the students in the same class were divided into two groups to attend in-person classes in different time slots. In other words, instructors met different groups of students twice a week and repeated the teaching. For example, the first author taught one class of the course in Spring 2021 with 18 students in total. Her students were divided into two groups with one group of 9 that attended on Tuesday and the other 9 attended on Thursday. The same teaching was repeated for the two groups. The classroom moved to a bigger room to accommodate student numbers and maintain social distance. The new classroom was not a science lab, and had no science materials at all, and students had to be seated in their assigned places to keep distance and be tracked. With time, space, and material constraints, a lot of the activities in this course had been excluded and modified. For example, students used to do an independent inquiry as their final project. During the pandemic, students were asked only to do the literature review and research design instead of carrying out the whole inquiry. Other changes included but were not limited to transforming some hands-on activities online, replacing some lab experiments with virtual ones, and designing new activities to accommodate students' situations.

Data Collection

The data sources of the study include the instructor's journals, critical friends meeting recordings, class video recordings, lesson plans, students' work and end-of-semester course evaluation. The main sources of data were instructor's journals and critical friends meeting recordings. The instructor's journals served as the primary data source for identifying emotional challenges she experienced for teaching science during the pandemic, while the critical friends meeting recordings served as the primary data source for understanding the reasons behind those challenges. Other data sources served as supplementary data.

Instructor's Journaling

The instructor maintained a reflective journal over the course to explore her science teaching as well as factors that had influenced the teaching practices. Her emotions were documented throughout every class across the whole semester. She wrote the journal five times a week: one before and after Tuesday and Thursday's classes, and one summary journal reflecting the whole week. There are approximately 75 journal entries for the study.

Critical Friend Meetings

Critical friends meetings occurred once a month through the self-study process. An important focus of the critical friends meeting was discussing the first author's journal entries. Critical friends asked questions to challenge the first author's assumptions and asked her to elaborate on some of the emotional experiences and the reasons for those emotions. Critical friends also shared their similar experiences of emotional struggles and challenges they encountered for teaching during the pandemic. Besides the research purpose, critical friends meetings served as a cohort that supported all participants. As in one of the meetings, all of us agreed that "this makes me feel better that I am not the only one who has such problems." There were four critical friend meetings in total with each lasting around 90 minutes.

Class Video Recordings and Lesson Plans

All the classes had been recorded via Zoom. Due to the need to accommodate students who cannot attend class, these videos had been posted on Canvas for students to view. These class

recordings served as supplementary data for us to see how the first author taught the course, how she interacted with the students and how those teaching and learning activities had been influenced by the COVID-19 related issues. In order to better assist students to learn, the first author also uploaded her lesson plans on Canvas weekly. The lesson plans documented her instructional strategies for each class.

Student Work and Course Evaluation

Student work that was produced across the semester helped us to understand the first author's teaching strategies and responses to student needs during the pandemic. The end-of-semester course evaluation demonstrated how students felt about the course for the whole semester. Both provided additional perspectives in understanding the first author's teaching experience and emotions.

Data Analysis

All authors in this study worked collaboratively for the data analysis. In the first phase, the first, second, and third authors worked individually to go through the instructor's journals using an open coding method that was based on grounded theory (Strauss & Corbin, 1997). Data were coded based on the research questions for understanding the emotional challenges the first author experienced in teaching during the pandemic, and how her teaching had been influenced by those emotional challenges. The themes emerged directly from the data. We met once a week for three weeks to discuss the themes we found from the data. Then, the first author went through the instructor's journaling again to revise the coding based on the discussions. In the second phase, the three authors used the coding system they developed to code the critical friend meeting recordings. In the process, coding was developed and revised again based on new understandings and findings. After all data had been coded, we compiled all the documents and then analyzed them using thematic analysis (Glesne, 2006). Themes were pulled out with data segments for further analysis and description. Lastly, the fourth author and fifth author went through and validated the final results.

Results

We found that the first author's emotional challenges were mainly from three sources: (1)

adapting pandemic teaching modality; (2) dealing with student learning and well-being; (3) pandemic social violence, injustice and racism. We describe the results in categories for the convenience of writing. However, in reality, we found the emotions were intertwined and were connected with each other. While some emotional challenges came from the multiple identities the first author has as a female Chinese doctoral student instructor, some others came from lack of institutional support during the pandemic. The complexity and intersectionality will be discussed. In the next few sections, the emotional challenges are described in detail and are illustrated with quotes.

Emotional Challenges in Adapting COVID-19 Teaching Modality

Feeling Depressed in Zoom Teaching with Student Cameras Off

The first emotional challenge came from the difficulties in communicating and interacting with students. In the first three weeks of Zoom classes, most students did not turn on the cameras. Sometimes, only one or two turned a camera on among 18 students. She described it in the journaling:

> "There was a time when I was the only one turned on my camera and I did not feel good. Initially, I do not think students must turn on their cameras, because I understand how overwhelming it is to take Zoom classes all day, and I do not mind if they lie on a couch or bed while taking my class. However, I think I might change my mind, especially at the beginning of this semester to establish some rules" (Week 2, journaling after Tuesday's class)

She described her dilemma of empathizing with students' situations and her bad feeling of teaching in front of a black screen. She wanted to make policies in terms of using cameras because even though she encouraged students to turn on the cameras, it still did not work. Similar situations happened several times and she shared the struggles with critical friends meeting and explained why she hesitated to make it a requirement. She said that one of her students last semester never turned on the camera during the classes. However, the student turned on the camera during office hour and it was in her bathroom. The girl was sitting on the toilet telling the instructor that this was the only quiet place she had for classes. The first author said to critical friends that "how can I require students to turn on cameras when I don't know what difficulties they have?" So, thinking about invisible difficulties students might

have, the first author chose to take the bad feelings by herself. Even though she thought it was more ethical to do so, she still felt depressed that "I was very frustrated talking by myself especially when no one responded. I felt like I was an idiot."

Feeling Pressured in Finding Alternative Science Activities with Time, Space, and Material Constraints

Using constructivism theory, student learning in the course was embedded with a lot of hands-on activities, indoor and outdoor experiments, the group works, and discussions. During the COVID-19 pandemic, many such activities were excluded or modified. Even for in-person classes, students cannot move freely into groups to work together. The first author expressed the pressure of learning the new ways of teaching and realized that "some activities cannot be done through Zoom which is a bummer! Due to the time constraints, I need to rethink how to conduct those activities." She noticed that different courses have different levels of difficulties in adjusting delivery during the pandemic. She was surprised to hear some other instructors whose course was lecture-based saying that they had less workload. However, for a course like she taught, "it was much difficult to make the changes because alternative online science activities were hard to find and design." She felt a lot of pressure to make changes in such a short time with all the time, space, materials, and communication constraints. In the journal, we found that she had been busy with thinking and finding such alternative instructional strategies. Many emotions came after the try-out of those new learning activities. Here is one example:

> "I felt both glad and frustrated for today's class. Glad: We had some fun observing students' favorite objects. Most of them bring their dogs and cats to make observations. We really liked it! It is also a good opportunity for them to make dynamic observations which are usually hard for ice-ball and flower activities. They all turned their cameras on to show their observations. Frustrated: When we discuss investigable questions and non-investigable questions, I would feel more comfortable if I can write on the white board, and walk around the classroom to join their discussion group by group. We did it in Google Sheets and it went ok. But I felt like students were not that willing to discuss and ask questions compared to in-person class. Plus, I cannot see them when I share my screen. All make me a little frustrated with this online teaching." (Instructor's Journal, Week 2 after Thursday)

In addition, the reduced in-person class time each week made the course schedule very tight. The first author expressed many anxieties and worries about finishing the teaching task on time. While there was not much flexibility on the time schedule, as an instructor, she had to be very flexible to coordinate with everything to make sure the class kept on going smoothly. Whenever unexpected issues happened, she had to find alternative ways which made her very stressed. For example, when there was an urgent need to clean the classroom due to the COVID-19 tracking policy, instructors had to transfer class online in only two hours. Other times, like school Wellness Day, or just bad weather would impact how the classes would be implemented.

The first author showed a lot of anxieties about having to prepare or change everything in a rush. In week 8, she said in the journal that "I cannot postpone the activity two weeks in a row! I am crossing my fingers now and hope the rain will stop during my class time!" In the April critical meeting, she explained that "if they cannot go outside to do the soil experiment, I don't know what else they can do in the classroom. I don't have any ideas yet about a good alternative experiment."

Feeling Frustrated about Low and Unstable Student Attendance

The first author said that it had been very frustrating to see the low and unstable student attendance. Even though she developed some instructional strategies to accommodate different student numbers, when there were only two or three students that showed up, she felt very disappointed. She wrote in week 10's journal that

> "Only three students showed up today. Two of them said they won't be able to make it next two weeks. It has been hard to maintain regular attendance during COVID-19 time. The reduced size of the class makes it worse. The activities were less interesting and less lively because there were only a small number of students there. There were also fewer discussions from them. I felt bad about this. I can tell one student was still sick and not feeling very well. So, I don't blame them. I just felt I wanted the pandemic over soon, so we could go back to normal. The students may also have a lot of overwhelms and tiredness because there was no break for the whole semester. This is bad for their enthusiasm to engage in classes." (Instructor's Journal, Week 10 after Thursday)

Feeling Exhausted in Repeating the Teachings with A Mask On

Teaching during the pandemic had been very labor-intensive. According to the university COVID-19 response policy, instructors and students needed to wear masks when having in person classes. Talking for two hours with a mask on was very uncomfortable. The first author said that it was very tortuous and she needed to take a long nap after the class to recover. In the February critical friend meeting, other participants shared similar experiences and feelings that "it was very suffocating and I have to raise my voice to make me heard all the time. It makes me very tired."

We found that physical exhaustion caused psychological tiredness and the feeling of burnout. While the first author understood the policy of using a rotation teaching mode for safety reasons, she still hated it because "it was so energy consuming and I am so bored to repeat my class several times a week." She said that it was a nightmare last semester when she had to repeat the same class four times a week with a mask on. Such tiredness also affected her teaching, especially in Thursday's classes. The first author admitted that she had less patience for Thursday's class and "sometimes, I even skipped parts and just wanted to have it done." She felt that her physical, psychological, and emotional well-being were not considered in this new teaching modality. As an international doctoral student, she had to rely on this position to sustain her study and living. Such powerless status in the school system made her have no choice. The feeling of being ignored and used as a tool working for the university had permeated across the whole semester during the pandemic.

Emotional Challenges about Student Learning and Well-being

Feeling Helpless in Seeing Student Suffering Due to COVID-19

The first author showed the emotions of distress and helplessness in seeing and knowing students were suffering and struggling. The COVID-19 pandemic caused a variety of physical and psychological loss and difficulties to every individual in this society. Those struggles and suffering had also been reflected in student learning in classrooms. During the semester, the first author's class experienced problems that she never had experienced before such as students got COVID-19 and had to be quarantined, students' family members got sick or died because of COVID-19, students got overwhelmed because there was no break during the whole semester. Those issues lead to low and unstable class attendance, social-emotional

stress among students, and lower quality of student learning. As a teacher, being caring, showing kindness, and having emotions are not only a choice, but also part of the professional identity (Jones & Kessler, 2020). As an instructor, the first author was very willing to support the students, however, she felt helpless because she did not know what and how to do. For example, she realized some students had emotional stress based on her observation and several student emails. So, in week 5 Thursday's class, she tried a social-emotional learning (SEL) activity she had just learned from a webinar one day ago. She described this activity in the journal:

> "The SEL activity went well and students responded actively. However, while I realized that helping students to express their emotions is good, I don't know how I can help/respond to those who expressed that they had troubles. One student who missed a lot of assignments posted on the Zoom that she had been very sick. Another girl who failed my course last semester said she felt overwhelmed. I sent them emails asking whether I could do anything for them, and I am not sure whether my response was appropriate or not. I hope I can learn more about social-emotional learning in education." (Instructor's journaling, week 5 summary)

In this self-study, anxiety, sadness and worry had been found in the first author's journal across the whole semester. In April's critical friend meeting, the first author shared her concerns about the students who had missed many classes. Other participants shared similar emotions that "some of my students never showed up again. I really worry about them, but I cannot do anything." A participant in March's critical friend meeting said that one student in his class lost seven family members during the pandemic. They all agreed that it was very distressing to know such woeful information from students.

The Struggle in Accommodating Students- Showing Trustworthiness vs. Maintaining Class Policies

Teaching during the pandemic needed the instructors to have a lot of flexibility with a variety of ways to accommodate student needs. While the first author believed those strategies were very necessary for helping students, she also felt that those accommodations might have been abused. She demonstrated struggles in showing trustworthiness while still maintaining class policies. She encouraged students to send her emails whenever they had COVID-19 related

problems. However, she found it hard to distinguish who was really in trouble and who just wanted to take advantage of the accommodations. For example, when the weather was not good, she always got student emails saying they cannot come to class because they were sick. Other times, students asked for assignment extensions or other accommodations also saying that they had been sick. In week 10's journal, she said that

> "I felt complicated during this time towards my students. On one hand, I am not happy with what they did such as not attending class, kept their cameras off all the time, and even the complaints and some ridiculous requests to me (like ask an extension of assignment for a whole week, or not attending the lab and asked me where can they get the data for writing the report, etc.). On the other hand, I know the difficulties and emotional stress of online learning for a whole year. If they showed some difficulties or problems, they might really be experiencing a difficult time. I tried to be as compassionate as I can, but I felt it was difficult because I want my classes to go on smoothly as well. So, how to balance by giving understanding and flexibility to students and maintain the standards, policies and learning goals of the classes? (Instructor's Journal, Week 10 Summary)

The first author tried to maintain a policy that students need to send her some documents to prove their situation, but it was not working well. She said in the March critical friend meeting that "I asked them to call the school Health Center if they don't feel well. And ask the center to give them an email or something. So, they can send it to me. However, nobody did that. They just don't come." She complained that the school health system should work together with the instructors to help the teaching in the classrooms.

Things changed in April when the first author realized showing trustworthiness was more important than maintaining class policies during the COVID-19. She got a fever around mid-term and could not finish her course assignment on time. So, she asked her professor for an extension. While writing the email, she resonated with her students that "if my professor replies to me saying that I need to show some proof, I would think he is so mean and does not trust me!" The professor's reply did not ask for proof but showed approval with understanding. "I felt very warm, and appreciated the trustworthiness and understanding." Later, she reflected in the journal that:

> "I tried to avoid my assumption for students, especially during the pandemic. If students showed difficulties in doing or finishing the assignments, I need/should trust and believe that they WERE experiencing some difficulties, even though I don't know exactly what and how. It is always easy to label them as "not working hard," "lazy," "just want to play," "finding excuses," "always wait until the deadline." But these labels cannot solve the problems. Even though a lot of times, showing my concerns like letting them talk and sharing their hard times could not solve the problems directly either. It shows my trust, understanding, and empathy to them and I think this is very important and will make the difference." (Instructor's Journal, Week 11 After Tuesday)

It was the first author's own experience as a student that made her realize that showing empathy and understanding was more important than sticking to class policies during COVID-19.

Uncertainty in Letting Go of Some Content Knowledge---Should I Lower the Standards?

While noticing the importance of showing support and trust to students, the first author was not sure how much content knowledge should be delivered. Learning content knowledge has always been the core of the course goals. However, during the pandemic, the first author realized that it was hard to maintain the same standards. She felt that "everyone is in a survival mode." For most students, things like attending classes on time or finishing the assignments were hard enough. In May's critical friend meeting, the first author was asked whether she lowered grading standards. She admitted that "I was trying very hard not to, but I believe I did. I don't know whether it is appropriate or not." Other participants shared similar experiences and one participant said that she even gave students extra credits for attending all classes in the semester.

We found across the semester, the first author's focus was distracted from how to teach scientific inquiry to "how to support my students to get through everything." She wrote in the journal that "when there were only two persons present in the class, all you thought was not about how to teach the nature of science, but how to make them feel better and let them know that you are with them." She had lots of compassion for students who demonstrated hard work even if the work was not "good" enough. In a journal, she showed the emotions in giving full extra credits to a student's work:

> "This girl went back home for a long time because her grandma died. She took all the opportunities to get the extra credits. She did two presentations and I was the only audience. I am willing to give her the full extra credits even though I know there are some parts missing in her presentations according to my requirements. As long as she showed her efforts, I would make it count. I admit I am a little sentimental." (Instructor's Journal, Week 14 Tuesday)

However, no one told the first author that it was OK if the content knowledge could not be delivered and learned well during the pandemic. She got some support from critical friends knowing that she was not alone, but she still felt very uncertain about the priorities. To her, letting go of the content knowledge was not an option or a strategy, but a result. She wrote in the journal that "when there are so many things happening, it is hard to focus on the content knowledge."

As an instructor, she was supposed to do whatever the course director told her to do, which means that she did not have the power to modify the course goals or standards. She worried that she could not get a good teaching evaluation because the content knowledge was not delivered as well as before the pandemic. She hoped that "it would be very helpful if the course goals and standards were modified accordingly. So that both students and instructors would maintain some confidence and efficacy even in a pandemic learning mode."

Emotional Challenges from Social Racism and Injustices During the COVID-19

The social injustices during COVID-19 caused the first author to have many fears, anxieties, and depressions. While we are writing this article, the latest data from Stop AAPI Hate National Report (2021) shows that nearly 4,000 hate incidents have happened since the pandemic began. Women report hate incidents 2.3 times more than men and Chinese are the largest ethnic group (42.2%) that report experiencing hate. Those hate incidents range from verbal harassment, insults, jokes to violent attacks in schools, businesses, and other public spaces (Jeung et al., 2021). The hate and violent incidents against Asians in America made her worry about her safety all the time. As a person from Wuhan, the situation was even more difficult. She said to friends that she never thought her hometown would be known in this way. Worrying about being judged, biased, and isolated, she hid her identity as a Wuhan-er by telling people that she was from Beijing. She felt a lot of fear and indignities whenever

hear words like "Chinese virus" or "Wuhan Virus" from the media.

We found that social racism and injustice made the first author meditate about the purpose of science education, and what should educators do during or after the COVID-19. She felt she understood more about BLM and empathized with her black students and friends, and other minorities who had been suffering from racism. In March, she participated in the university protest of Stop Asian Hate and wrote in her journal that "it reminds me of many discussions about the purpose of science education. The ultimate goal for science education is to promote a society with more justices, equities, and diversities." In her teaching, she designed some assignments for students to connect pandemic social issues and injustices with scientific inquiry. For example, we found one extra credit assignment she posted on Canvas:

> "You can make a presentation of your investigation/thoughts/observation/critique about COVID-19 related topics… For example, you can talk about the COVID-19 vaccine and how it works based on scientific knowledge and evidence you found; or you can talk about social problems during the pandemic such as BLM and Stop Asian Hate events, and share your thoughts on how you think science could help people doing better, or you can talk about NOS tenets in COVID-19." (Instructor's teaching plan, Week 12)

At May's critical friend meeting, she shared the reason for doing so: "I want my students to connect what they learn in this class to what they have been experiencing during the pandemic. I want them to think about what scientific inquiry and science education can do to improve those social problems." However, because it was an optional assignment only one student did it. The first author was "very disappointed and wished she could have made it a required assignment." She hoped there would be support for Asian, Black, and other minority instructors in terms of social injustices during the pandemic, and the strategies to talk about it to students in class.

Discussion

This self-study revealed the emotional challenges that a doctoral instructor experienced for teaching an undergraduate science course during COVID-19. As a student instructor, she demonstrated pressure and anxiety of learning and adapting to the new teaching modality. In

the meantime, she had to deal with student COVID-19 related issues by showing trust and providing support. Social injustices and racisms aggravated all those challenges during the pandemic.

Multiple Identities

We noticed that many emotional challenges came from her multiple identities. Even before the pandemic, Zhu & Zhang (2015) found that many doctoral students demonstrated stress and difficulties in balancing the multiple roles they have as instructors, students, and scholars. International graduate students often have extra stressors such as adjustment to new cultures, language difficulties, feeling of isolation, and financial stress (Myers-Walls et al., 2011). With the emergent changes in teaching and learning modalities during the pandemic, doctoral student instructors' pressure had been compounded. The competing identities of being a student and an instructor led to many anxieties, pressure, and exhaustion. For example, in week two, the first author felt exhausted and skipped some plans in teaching because she had to finish her coursework. However, multiple identities also had positive influences on the first author's teaching because her identity as a student enabled her to show empathy towards her students. However, even though she found it was more appropriate to choose an empathetic teaching approach (Bozkurt & Sharma, 2020) during the pandemic, she was often uncertain about her choices.

We found that the uncertainties came from her identity of being a *student* instructor who was still developing her professional skills and could not make the decision herself. As she noted in her journal: "I am not free to do whatever I want in this course. I do whatever the course director tells me." Such hindrance directly affects her identity development. A tension was shown between the instructor's agency and the doctoral student's powerless status in making decisions. Research shows that there is a connection between agency and the psychological construct of self-efficacy that is needed in developing teacher identity (Beauchamp & Thomas, 2009). Parkison (2008) argued that as part of teacher identity, teachers have the option of surrendering to outside forces or acting to make a change. In this case, the first author chose to take action on student pandemic needs which was critical for the development of her identity as an educator, however, such agency was not well supported by the institutional system.

Another aspect of emotional challenges came from her identity as a Chinese in the U.S. The constant violence and hate incidents (Jeung et al., 2021) during the pandemic not only led to many feelings of insecurity, fear, and depression, but also damaged the sense of belonging. Being a native Chinese from Wuhan made the first author worried about her family members' safety and health. Despite that, she had to constantly be concerned about her visa situation. According to the existing government's policies, the international students who fully enrolled in online programs were asked or forced to leave the country (Zhang-Wu, 2020). The first author doubted whether she could be a science educator or teaching in the U.S because she is Chinese. She expressed that she had a very complex feeling. On one hand, she was proud of being part of the community that kept working during the pandemic. On the other hand, she felt she was not welcome by the whole society. These negative emotions motivated her to reflect on the goal of science education and address social issues with her students using the content of this course. These are evidence of the formation of the first author's professional identity as a teacher who taught scientific inquiry.

Lacking Institutional Support

We also noticed that many emotional challenges resulted from lacking institutional support (Pedro & Kumar, 2020). The first author expressed many times in the journal that she wanted support for herself and strategies to support her students. The COVID-19 pandemic surfaced out the importance of SEL that long has been ignored (Kim et al., 2021). Teachers need to know strategies not only about how to deal with their own emotions but also ways to support their students (Petrakova et al., 2021). As an essential part of teacher identity, the tendency to care had not changed during the pandemic, even though the teaching modality had changed unexpectedly (Jones & Kessler, 2020). However, there was not enough support for teachers during the COVID-19 pandemic that most teachers felt sad and anxious for themselves while having to provide emotional support for their students (Auger & Formentin, 2021).

We realized that the emergent transition was not simply copying in-person classes online; it needed many modifications such as the course content, goals, assessment, teacher evaluation, etc. Support in policy levels was needed and should be made explicit to teachers and educators, rather than leaving the difficulties to teachers. Besides SEL, the pandemic worked as an amplifier to make a lot of pre-existing social inequities visible. How to support teachers and students in terms of violence and racism should be discussed even after the pandemic.

While writing this article, the first author resonated with Bozkurt & Sharma (2020) that "we should remember, when things go back to normal, people will not remember the educational content delivered, but they will remember how they felt, how we cared for them, and how we supported them" (p. 3). This also applied to graduate programs where many doctoral students are and/or will be educators in the future. The support they received during and post-pandemic will affect their own life well-being and academic success as well as the quality of teaching to their students (Smollin & Arluke, 2014).

Implications

We have learned the first author's emotional feelings that were full of challenges of teaching during the turbulent time. She said that "teaching is not just teaching anymore. It means to be with your students and get through a hard time together." She was glad to know most of the students appreciated the emotional support she showed. In the course evaluation, one student wrote:

> "I really appreciated how understanding she was as an instructor. She did a really great job of acknowledging how difficult this year has been for everyone and making accommodations. She has a clear passion for science and spreads that passion through her work. I think she was a great instructor." (Course evaluation from students)

The purpose of self-study was not limited to showing personal experiences, but also to inform others in similar situations (Pithouse et al., 2009). The pandemic would pass eventually, but what people experienced would not disappear. To better support students, teachers, and teacher educators in the post-pandemic, we need to know what happened during the pandemic.

Even though full of emotional challenges, the first author felt that she became a science educator "who is able to be flexible and empathize with students." We expect that other teachers and teacher educators who had been teaching during the pandemic have similar emotional challenges. It is important to share those stories and think together about what we should do in the post-pandemic for science education specifically and education broadly in all areas.

Conclusion

In adapting the pandemic emergent teaching, teachers and students demonstrated a variety of emotional stress such as sadness, fear, anxiety, worry, and being overwhelmed (Auger & Formentin, 2021). In the semester of spring 2021, the first author did a self-study to investigate her own emotional challenges of teaching an undergraduate science course that used a hybrid modality. Three aspects of emotional challenges were explored. First, in adapting the new hybrid teaching modality, she felt depressed, pressured, frustrated, and exhausted both physically and psychologically. Second, in dealing with student learning and well-being, she felt helpless in seeing students suffering. She also felt conflicted and uncertain about what priorities should be chosen for teaching, and whether it was ethically right to let go of some content knowledge. Third, the social injustices, violence, and racism of Asian Hate in America caused fear, sadness, and indignities to the first author. We found many emotional challenges were from the multiple and competing identities she has as a female, Chinese, doctoral student instructor in the United States. Institutional and systemic support was greatly needed for doctoral student instructors during the pandemic for teaching.

Recommendation

Several recommendations were suggested about how schools should support doctoral student instructors for the post-pandemic time in the future, or in similar emergent situations:

(1) Doctoral student instructors need social-emotional support in terms of how to care about themselves as well as strategies of how to support their students in teaching. This is not only needed for an emergent time, but for all the time.

(2) Under emergent situations like COVID-19, educators, and course directors should work together to modify the course goals, standards, and expected learning outcome to an attainable extent for students and doctoral instructors. An empathetic approach (Bozkurt & Sharma, 2020) should be considered to help the students and doctoral instructors to maintain confidence and efficacy in teaching and learning.

(3) Educators should consider students' and doctoral student instructors' traumas from racism, violence, and poverty during and after the pandemic. Relevant strategies such

as using trauma-informed perspectives of teaching (Cohan, 2020) should be considered.

(4) New ways of evaluating doctoral student instructor's teaching should be considered during the emergent time like COVID-19. As shown in this study, teaching during the pandemic involved a lot of physical and emotional challenges. The evaluation should be part of the supporting system in helping doctoral student instructors to build confidence and efficacy in their current and future careers.

(5) While it is necessary to forgo some content knowledge during the pandemic (Cohan, 2020), it is also necessary to consider how to help students to catch up after the pandemic as well as help doctoral student instructors in learning the post-pandemic teaching strategies.

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Chapter 5 - Navigating the Pandemic as an International Teaching Assistant in Science Education

Shukufe Rahman, Gayle Buck

Chapter Highlights

- This chapter evaluates the impact of the COVID-19 on an international teacher assistant in science teaching.
- This chapter explores the struggles and emotional challenges of the international teacher assistant in science teaching and acculturation process that were created and exacerbated by COVID-19.
- This chapter examines the switch to online teaching and learning while identifying the strengths and weaknesses of the international teacher assistants' teaching approach and strategies.
- This chapter provides evidence of emerging pedagogies and strategies in supporting international teaching assistants and their students in science education.

Introduction

International teaching assistants (ITAs) teach many undergraduate science courses and laboratories in U.S. universities where they play an important role in defining the quality of science teaching (Gardner & Jones, 2011). The teaching assistantships they hold benefit the university by supplying qualified teachers and globalizing the institution (Chiang, 2009); and they benefit the international scholars by providing valuable experience and income (Walsh et al., 2020). The process of becoming an effective ITA, however, is not necessarily an easy one. Avsar Erumit et al. (2020) noted that ITAs face significant challenges as they become immersed in the U.S. higher education system. Among the noted challenges are: tensions from local communities regarding globalization (Montgomery & Fernandez-Cardenas, 2018); language and communication differences (Ravichandran et al., 2018); cultural differences (Vakkai et al., 2020); contextual differences (Adebayo & Allen, 2020); and students that lack understandings of different cultures, contexts and languages (Chiang, 2009). These are examples of significant challenges faced under normal conditions. They are exacerbated by large-scale societal challenges, such as a worldwide pandemic.

The COVID -19 pandemic impacted every aspect of human life, including education. As a result of the educational implications associated with the pandemic; teachers, students, administrators and parents had to think differently about education. This unexpected and unprecedented crisis created a new situation for every individual at the university-level. Many universities worldwide were forced to rapidly transition to on-line delivery whilst concurrently facing the longer-term impacts on educators and students (Barton, 2020; Choi et al., 2020; Crawford et al., 2020; Curie et al., 2021; Humphrey & Wiles, 2021; Johnson et al., 2021; Quezada et al., 2020). The experience was difficult for ITAs because they not only faced challenges in coping with this “new normal” situation; but also, experienced dilemmas and frustrations while they crossed multiple boundaries (e.g., geographic, social, cultural, linguistic, personal, and/or professional) to make a transition from one context to another.

There is a significant number of self-studies exploring the experience of becoming a new science teacher educator, with a particular focus on tensions manifested in harmonizing prior identities and practices with developing identities and practices as teacher assistants. In comparison, there is little research on the challenges, dilemmas, and frustrations that ITAs experience in becoming a new science teacher education; and no research on such

experiences occurring during major educational disruptions such as the COVID-19 pandemic. Such research is needed in order to develop necessary practices for ongoing difficulties and future interruptions. The purpose of this study was to explore the challenges and struggles of an ITA as she taught an inquiry-based science course for undergraduate students during a worldwide pandemic.

Background

International Teaching Assistants' Challenges and Struggles

Increasingly, graduate students relocate for better learning and career opportunities. The U.S. is ranked as a leading destination for graduate students from countries around the world (Adebayo & Allen, 2020; Arshavskaya, 2015; Ravichandran et. al., 2018; Vakkai et al., 2020). A majority of these students become teaching assistants, research assistants, project assistants or tutors as a part of funding packages provided by universities (Arshavskaya, 2015; Adebayo & Allen, 2020; Banu et al., 2020; Gardner & Jones, 2011; Walsh et al., 2020). As these ITAs adapt to these new educational and social environments, they face unique challenges (Vakkai et al., 2020). These challenges are particularly complex for those with cultural and educational backgrounds that differ significantly from those of their students.

Although a substantial number of empirical studies exploring the challenges international students face have been completed (e.g., Vakkai et al., 2020; Ravichandran et. al., 2018; Yan & Pei, 2018), the research base on the challenges of ITAs teaching and identity formation is still very limited. Within this existing research base, linguistic barriers are the most frequently noted challenges for ITAs and their students (Arshavskaya, 2015; Avsar Erumit et al, 2020; Gorsuch, 2012; Ravichandran et. al., 2018). The language barrier restricts not only ITAs' communication with their students; but also, the students' understandings of the instructional process (Avsar Erumit et al, 2020; Chiang, 2009; Ravichandran et. al., 2018) as the ITA and undergraduate students misinterpret each other's intentions and articulation. In addition to these linguistic challenges, ITAs face immense cultural and societal challenges as they strive to understand different norms and experiences. Adebayo & Allen (2020) contend that knowledge competence is one of the most recurring challenges confronted by ITAs in U.S. contexts. ITAs often enter U.S. higher education classrooms with limited knowledge of the educational and cultural experiences of their students. This leads to relational difficulties.

For example, research shows that ITAs were taken aback by certain student behaviors; such as calling instructors by their first names or interacting with them in a friendly manner (Adebayo & Allen 2020; Avsar Erumit et al, 2020; Chiang, 2009). These behaviors made the ITAs feel uncomfortable and disrespected. In addition, ITAs' past K-12 education in their home countries often differs from that of their U.S. college students. They enter the classrooms with their own teaching beliefs and strategies which are grounded in their well-formed propositional knowledge about what they have observed and experienced in their own countries (Gorsuch, 2012). Due to ITAs' lack of knowledge in regard to the academic level of their students, many ITAs encounter major problems to explain discipline specific concepts and vocabulary (Arshavskaya, 2015; Avsar Erumit et al., 2020). As the teaching style and approach of ITAs is inconsistent with U.S. perspectives, the ITA's have difficulties in following and implementing the new U.S. contextual teaching strategies and approaches (Gardner & Jones, 2011). At the same time, ITAs often experience major barriers in grading due their lack of constructive assessment skill as well as grading experience in this new context (Walsh et al., 2020).

Although the number of ITAs in the U.S. universities continues to increase, few studies have examined the challenges related to ITAs' teaching and identity formation. The studies that have been completed demonstrate that the socio-cultural differences between ITAs and their students bring challenges to the teaching and learning processes (Avsar Erumit et al., 2020). This is under normal educational conditions in U.S. institutions of higher education. These challenges are such that a sudden change to the teaching and learning process in an institution, such as those brought about by the COVID-19 pandemic, will result in unique challenges for ITAs in the U.S.

COVID-19 Pandemic Impact on Teaching and Learning

At the onset of the COVID-19 pandemic, the traditional methods of instruction in educational institutions all over the world had to change dramatically and quickly (Auger & Formentin, 2021; Choi et al., 2020; Humphrey & Wiles, 2021; Quezada et al., 2020). Many in higher education systems were unprepared for this sudden change. As a result, instructors and students in higher education institutions faced immense teaching and learning challenges. Most institutions of higher education worldwide sent their students home in the early part of 2020 with the hope of seeing them return after a couple of weeks. Due to the increase in

COVID-19 cases, however, it became apparent that they would not be returning for the foreseeable future (Sahu, 2020). As a result, they found themselves quickly transitioning into synchronous and asynchronous remote teaching (Barton, 2020; Crawford et al., 2020; Currie et al., 2020; Humphrey & Wiles, 2021; Johnson et al., 2021; Quezada et al., 2020). Though many turned to packaged online platforms (e.g., Zoom) to ease the move from in-person to online instruction, they still needed to build their own "instructional digital technology toolboxes" (Quezada et al., 2020, pp. 482) of resources to work with students (Crawford et al., 2020; Johnson et al., 2021). Many educators either reduced or eliminated learning outcomes of their courses in response to the changes in instructional format (Barton, 2020). Overall, many university instructors noted that the sudden change to remote teaching activities led to a less student-centered structure and relatively poor quality substitutes for field activities or other hands-on activities. As a result of the physical closure of educational buildings and sudden switch to new digital instructional strategies and methods, the emerging body of research shows that the pandemic tested educators' flexibility and willingness to change. Many of them had to take quick action to develop an online plan with little-to-no training or experience (Choi et al., 2020; Quezada et al., 2020). In addition, these educators, a substantial number of whom previously had little motivation to change, had to set the tone of inclusiveness and encouragement throughout the online teaching to facilitate students' engagement and effective learning (Choi et al., 2020; Lashley et al., 2020). Further complicating the process, many of the assessment processes that had been in place for decades had to quickly change to fit into the online structure. Many of these ended up being used while still underdeveloped and failed to evaluate learning outcomes properly (Sahu, 2020).

Studies on student learning experiences during the Covid-19 pandemic reveal that most students valued in-person learning experiences over remote ones; particularly regarding the science laboratory and research classes (Choi et al., 2020; Hvalshagen, 2021; Humphrey & Wiles, 2021). They believed the face-to-face learning experiences were clearly superior to online ones with respect to the student-teacher interaction, student-student interaction and learning outcomes (Choi et al.; 2020). Students noted difficulties in maintaining schedules of online classes regularly and self-motivation due to the drastic changes of course structure, disrupted internet connection, time zones and staying with families (Hvalshagen 2021; Humphrey & Wiles; 2021). Choi et al. (2020) noted that even those students majoring in the computing and engineering disciplines, who are relatively more familiar with internet

technologies and connectivity than others, also faced challenges such as online fatigue during the pandemic. Many found the online learning environment more exhausting (Choi et al.; 2020). Furthermore, the rapid increase of infected cases left students with a sense of uncertainty and anxiety which caused tremendous levels of stress (Sahu, 2020). This stress has led to unfavorable effects on the learning and psychological health of students.

In summary, the COVID-19 pandemic clearly resulted in pedagogical and logistical challenges to higher education. The pandemic highlighted an ongoing need for educational research on how to effectively shift the teaching of important learning outcomes from face-to-face to remote teaching in international contexts (Currie et al., 2020; Sahu, 2020). It is within this backdrop that this study was situated. The study sought to understand the struggles and challenges of ITA within a sudden, seemingly intractable disruption that impacted science education in higher education.

Research Context

This self-study took place during one semester in an inquiry-based science course for undergraduate non-science majors at a large university in the Midwest. The course was a general education science course for the university and students from a wide variety of majors took the course to fulfill a science requirement. However, the majority of the students were elementary education majors as they were required to take it prior to being admitted in the major. It was a lab-based course focused on developing understandings about the natural world, as well as the processes scientists use to study that world. The course, based in constructivist science inquiry, focused on having students actively create understandings through scientific investigations. These involved: 1) engaging in science-oriented classes, 2) giving priority to evidence in responding to questions, 3) formulating explanations from evidence, 4) connecting explanations to scientific knowledge, and 4) justifying scientific explanations. There were instructor-led scientific investigations throughout the semester. In the last three weeks of the course, the students conducted independent inquiry projects where they maintained control over their inquiry topics and designs.

This freshman-level course was the first, and likely only, science lab experience these first-year undergraduate students had during the pandemic. Like most of their other university courses, this in-person lab course was quickly adjusted to accommodate for social distancing,

frequent medical testing, and quarantines. The course coordinator changed the structure to a rotation hybrid format which included in-person modified labs and new online modules. To allow for the required physical distancing and individual lab materials, only half of the students were in the face-to-face lab at any period of time. Group labs were adjusted to be individually conducted. In addition to the labs, all discussions or instructions deemed necessary to be completed in an instructor-led approach were completed during the in-person class session. While half of the students met the instructor face-to-face, the other half were independently completing the online instructional modules. The online modules were set up to be independently completed within a two-to-three hour window of time.

The course instructor for the sections referred to in this study was an ITA. She was beginning her second year as a doctoral student in a large mid-western university in the United States. Prior to coming to the U.S., she worked for non-profit educational organizations in her home country of Bangladesh, as well as for organizations in India and China. She was teaching the course described above as a part of her funding packages from her university and doctoral program.

Methodological Approach

The purpose of this study was to explore the challenges and struggles this ITA faced as she taught an inquiry-based science course for undergraduate students during a worldwide pandemic. As she was the lead researcher and main participant in the study, a self-study approach was utilized. Self-study is considered an empirical and conceptual research methodology that advances our understanding of the challenges and practices of teachers and the associated student learning. This methodology aims to view and understand "oneself; teaching and learning; and the development of knowledge about these" (Loughran, 2004, p.9). Self-study provides a means for educators to identify and explore the complexities within their own teaching, practice, and pedagogy knowledge (Loughran, 2007). As Samara (2002, p.68) points out, the purpose and nature of self-study is the "critical examination of one's actions and the context of those actions in order to achieve a more conscious mode of professional activity, in contrast to action based on habit, tradition and impulse." Self-study methodology has been widely used to help teacher educators to address problems in their teaching contexts and settings and practices.

Self-study research methodology differs from personal reflection as self-study involves exploring not only one's self or practices; but, also one's relation and interaction with colleagues, students, the educational literature, and one's own prior work, knowledges, and experiences (Bullough & Pinnegar, 2001; Loughran, 2004). Although self-study focuses on individuals and their practices, the discussion resides within the larger professional community of practice. Self-study invites educators to see their practice from the students' (Loughran, 2004) and colleagues' (Pithouse-Morgan & Samaras, 2015) perspectives. Zeichner (2007) has expressed concern about self-studies becoming overly individualistic and introspective in nature. This concern can be resolved by inviting critical friends to examine understanding issues, problems and challenges and practices in teacher education programs more critically. A critical friend (e.g. colleague, mentor), is a trusted person who can ask tough questions and offer helpful critique. Schuck & Russel (2005) identify the role of a critical friend as a two-way dialogue with a critical relationship based on support and the encouragement of critical reflection. Including critical friends in self-study enables researchers to view their practices from their peers' perspective. In this process, critical friends provide constructive feedback beyond technical advice, as well as opportunities to reframe different teaching approaches. In order to stimulate deeper learning and reflection, self-study researchers are encouraged to invite critical friends who challenge them to go beyond self-justification. To address the concerns raised by Zeichner (2007), this study included a critical friend who also served as the course coordinator of this multi-section course and had taught the course in the past. Her role was to advise in the methodological design, aid in the framing and reframing of classroom experiences, ask for clarifications regarding intentions and rationales, generate more complex ideas of enthusiasm in science teaching; as well as challenge ITA's beliefs, thoughts, and actions underlying her own teaching and understanding and interpretations of the experience.

Data Collection

The data collection for this study included: 1) an instructor's journal, 2) critical-friend interviews, 3) observations, and 4) written documents. The instructor journaled after each class throughout the semester for a total of 30 entries. The entries focused on significant challenges that related to being a science teacher educator in an international context, such as: cultural differences, connections with students and negotiating new professional relationships and learning goals with students during the semester due to the pandemic. The journal entries

were shared with the critical friend on a monthly basis and served as a guide for the critical-friend interviews. These interviews were recorded to generate more clarification about challenges and practices as a science teacher educator in this critical context. A total of 4 critical friend meetings were recorded and transcribed. Due to COVID-19 all the classes recorded via Zoom. These class recordings are observed by the ITA in this study based on how she taught the course both on Zoom and in person, how she interacted with her students and how she handled the COVID related issues during this teaching- learning process. A total of 25 observations were completed and collected from these video recordings. Written documentation also was collected. Written documentation included course documents, online interactions, emails, and course evaluations. The validity and reliability of the research process was strengthened by the use of multiple sources of data.

Data Analysis

All data were transcribed, organized and then analyzed using thematic analysis. Data were coded based on the two questions: (1) How did I maneuver the necessary pandemic-related adjustments to course instruction? And (2) How did existing linguistic and socio-cultural differences impact my experiences in teaching during the pandemic? Example codes included: linguistic issues, sociocultural differences, pandemic-related problems, pandemic-related changes in teaching practices, students' reactions to sociocultural differences, students' reactions to pandemic-related changes. Once the data were coded, segments of data were segregated by themes for further analysis and description. The themes were used to provide context for understanding an attempt to balance science teaching practices. This process was completed along with the critical friend to strengthen the validity of the process.

Findings

Given the self-study approach for this inquiry, the authors switch from third-person to first-person in the findings section to allow the reader to better understand the ITA's challenges and struggles as she taught an inquiry-based science course for undergraduate students during a worldwide pandemic. The first author, the ITA in this study, provides the following narrative and uses the pronouns I, me and my. The second author is referred to as my critical friend.

Question 1: How did I Maneuver the Necessary Pandemic-Related Adjustments to Course Instruction?

The data analysis revealed pandemic-related student issues that I had to maneuver through during the study. These are issues that may be common for many university instructors independent of whether they are international. The first is jumping into a teaching and learning process that neither I nor my students have ever experienced. Prior to the start of this unusual semester, I sought out and read a lot of COVID-related literature to learn what other instructors were doing. Many instructors were sharing how they were adjusting, or planning to adjust, their pedagogical approaches to support the students' learning throughout such a unique and stressful event. This resonated with me and I began to explore new approaches.

> I prepared by participating in workshops and webinars offered for instructors in our university (February Journal -2/9/2021).

I started to learn about effective online pedagogical skills and tools (Webinar on Universal Learning design (UDL); INscribe; Voice thread Assignments; use of Screencast & Kaltura for video lecturing). However, I didn't have much time before the semester started and I didn't get very far in my self-learning process before I found myself using a combination of distance-learning and socially-distanced in-person labs. While using both platforms of teaching, I consistently delivered and organized content through a learning management system (e.g. Canvas and Cengage). The many formats and platforms I was now using were new to me and I had to continue my own learning process as I went. I was a teacher and student. Having some students attend labs via Zoom always fell short of the in-person classroom experience given I could only focus on engaging students in the classroom.

> "It was troublesome to engage the students in Zoom with classroom students, as they were at two different platforms with different tools and resources. Thus, acknowledging these struggles I mentioned in my journal that it was a great struggle for me to engage the students in Zoom effectively except for calling their names (March Journal-3/11/2021)."

This was a great concern and challenge for me during this pandemic to create an environment for all my students for their active engagement.

Following the COVID protocol, I could not do group activities and some lab work with my students. To incorporate group activities in the virtual classes in Zoom, I offered the opportunity to put students in smaller breakout rooms that contain three to five students.

> "I often use breakout rooms in my online Zoom classes to engage my students in the discussion as we could not afford the hands-on activities of lab activities online (January Journal-1/29/2021)."

To support science learning outcomes, I found from my teaching experiences during this COVID that these breakout rooms have a much-needed therapeutic value for students beyond simply helping them to complete group work. For that reason, I considered allowing my students to stay in their breakout rooms for a few extra minutes during class time to allow for candid unsupervised interactions with their peers. For some students, this time may represent the only opportunity they have to interact in such a manner with their peers and help them further to build social networks.

Despite my preparation, I encountered many implementation problems. I quickly had a large number of emails from students about the technical or practical issues- even after I spent a large portion of the first class going over the information they were seeking. For example, I received emails from my students regarding:

> … "I noticed you want us to turn our cameras on during our Zoom. My camera does not work right now, but I am going to be getting it fixed" or "Is the homework due for tomorrow on Cengage or Gizmos? Are they on Canvas?" Addressing and readdressing these issues consumed time that I already desperately needed for teaching and research activities in my Ph.D. program.

The structure for this course was changed to rotation hybrid. It came to include modified in-person instructor-led labs and independently conducted online modules. Any students that tested positive for COVID-19 or put in quarantine due to possible exposure participated in the labs via Zoom. My students voiced concerns about the wide use of Zoom meetings and online modules and limited use of in-person instruction. For example, my field notes show how one student:

> "… was sincere all through the course … and once he needed to participate through Zoom for 2 weeks due to COVID. He got poor grades in those assignments in comparison with his other assignments. He told me that if he was in the classroom during that time, he would be more involved and clear about the instructions and could effectively discuss his questions with me (March journal -3/25/2021)."

Moreover, because most of my students were freshmen, they were not familiar with the university's online education system.

A second issue related to the switch was a decreasing level of engagement by students:

> "In a discussion with my students, most of my students complained about their online courses because they required being in front of computer monitors for a longer time and also, they didn't get enough chances to ask questions to their instructors as they are asynchronous (April Journal-4/13/2021 & 4/15/2021)."

Overall, I found that the students had a difficult time finding the motivation and desire to engage. This situation was further impacted by the fact that most of the students increasingly turned off their cameras during Zoom classes; which hindered my understanding of their engagement. In sum, the change to a hybrid format provided a way to proceed with the teaching-learning process. However, it also limited the engagement between teacher and student. As the student-centered instruction, I valued became increasingly absent in the online modules and Zoom-based lectures, I came to agree with my students that the online/remote learning is less effective in comparison to traditional ways of science teaching. I noted in my journal:

> "I somehow feel that due to the pandemic, the online format badly affected the engagement of students in learning. I can say for science education it definitely has negative impacts on learning and teaching. (March Journal- 3/02/2021). They are not concentrating in Zoom classes; how can I help them to get over these things? This badly impacted the learning outcomes (00:03:32-Audio clip_04/19/2021)."

I too began to feel unmotivated and engaged.

Related to the engagement issue, was a third issue of declining attendance. I noted my apprehension:

> "Again, I have a small number of students and after spring break the number is decreasing rapidly. I did not suffer like this before, not even when COVID hit at 2020 Spring. Even the Fall 2020 was much better than Spring 2021 in terms of student participation and attendance (April Journal- 4/20/2021 & 4/23/2021)."

My colleagues shared similar concerns regarding students' low attendance rate. Together, we were unable to find the reasons behind such a low attendance rate by students. Due to this abrupt shift into lockdown, some of my students were forced to leave campus and were trying to adapt to being a university student from a distance: For example,

> "I received several emails from one particular student about his home issues/family issues frequently. At the end of the course he dropped out due to his failing grades. (March Journal- 3/11/2021 & 00:00:21-Audio clip_03/29/2021). Students also noted they did not attend the class because they were struggling to keep pace with assignments and confused by the different ways of teaching-learning (asynchronous/synchronous) in different classes. I felt that due to COVID now this teaching and learning process transformed into self-learning of which most students are neither equipped for nor accustomed to. This low attendance rate directly impacted my students' learning progress as well as my motivation toward teaching and finishing the semester with enthusiasm (April Journal-4/20/2021 & 4/23/2021)."

A fourth issue that impacted the teaching and learning process was the need for social support. I now found myself serving in another role for which I was not prepared. This whole sudden transition as well as the new online learning arrangement was very frustrating for my students and caused mental issues such as stress, anxiety and depression. I admitted in a conversation with my critical friend that:

> "I didn't grow up in this same environment as them as well as this COVID situation is totally new to me and my students. Thus, I can't connect it to their world and the problems that matter to them. It will be helpful for me if I get some training to handle certain issues with my students (01: 01:00-Audio Clip_03/29/2021)"

Trust became a fifth issue in this study. As there was no way I could verify whether students actually were COVID positive, quarantined, or depressed, I had to trust what they were saying. As noted earlier, I realized that both my students and I were adversely affected by the pandemic. Keeping this in mind, I tried to act with consideration and kindness toward them. I was willing to make changes that were needed in terms of assignments, lesson plans and learning goals. For example, some of my excerpts from my journal entries showed how I allowed my students to join labs via Zoom, I gave extensions for assignments, and I provided support through including extra-credit activities. I noted,

> "I have to make so many changes due to the COVID. Due to COVID-19, all the instructors not only transferred out course content on online platform Cengage but also changed our activities and assignments to suit this special situation. I even changed the assignments' timeframes and structures to reconcile my learning goals as well as to support my students (February Journal-2/9/2021)."

It wasn't long before I began to feel that my students were taking advantage of this flexibility and generosity. I received a great deal of excuses from students for late assignments or missing classes. Example excuses included:

> "I have had a fever this weekend and I have to go and get retested for the virus... In my one other class 5/12 people have tested positive in the last week and a half or so... If there is a way to virtually zoom in for the class, or a recorded lecture you would prefer me to watch." "I realized I did not complete the online Cengage assignments for the module. I was confused and got the due dates messed up." "Yesterday I went home because I have been so sick this past weekend but I got a COVID test and it came back negative so I am pretty sure I just have the flu or something because my other tests came back negative as well" ….. "I am just letting you know because I don't think I am going to be able to make it to class in person tomorrow because I am going to stay home until I get to feeling better."

Most of the reasons were relevant to pandemic-related issues which I could not verify. Given the tumultuous nature of the pandemic and the blurring of the lines between truth and lies, I discovered that I started frequently questioning the sincerity of my students. I noted in my journal:

> "I am upset that some students just appear in Zoom without any prior notice. Or some of them just sent the mail just before the class. I did not want to waste the time to ask them why they are in Zoom instead of in-person class." (Journal -04/01/2021). "She was absent throughout the semester after the 3rd week and did not reply to my several mails. Now she is asking for an extension just before my final grade submission. How do I give her an extension of semester-long assignments just before my final grade submission (Journal-Final exam & Grading)?"

While I was frustrated with the increasing number of late assignments and absences, I also felt guilty because maybe the students were really sick and or panicked. I articulated this feeling in my journal as well as my conversation with my critical friend:

> "Though I made it very clear at the beginning of the course and at the course syllabus about COVID 19 protocols and *valid* excuses, students still came up with inappropriate excuses at different times with different reasons. Sometimes, I became really mad, but again later I felt bad because people are really suffering to cope with so many things due to COVID-19. I want to support my students to an extent. But, at same time I felt I cannot let this happen - students are taking advantage. Sometimes as an educator, you need to make harsh decisions to validate your points to your students" (March Journal - 3/18/2021). "...somehow, I could not trust my students completely. I don't know why, maybe because I could not verify their reasons for not attending the class or not submitting their assignments (00:00:05_Audio clip_ 03/29/2021)."

Question 2: How did Existing Linguistic and Socio-cultural Differences between My Students and I Impact My Experiences of Teaching during The Pandemic?

The data analysis revealed many challenges that have previously been identified for ITAs – prior to the pandemic. The pandemic situation, however, exacerbated these challenges. Non-English speaking background ITAs generally encounter a range of challenges in their socialization process of coming to terms with academic culture in their new contexts in post graduate programs due to their different linguistics, educational and cultural backgrounds (Avsar Erumit et al., 2020). These difficulties also pose challenges for their teaching experiences and impact on their relationships with their undergraduate students.

Teaching students from diverse linguistic and cultural backgrounds involves a range of cultural issues. Such cultural issues often impact ITAs' teaching strategies and instructions, as well as influence their perceptions and expectations from their undergraduate students. Due to the sociocultural differences, I experienced a conflict regarding how I acted, or reacted, to various interactions across the semester. For instance, some cultural issues led to difficulties communicating about and dealing with my students. In my journal, I have mentioned:

> "I feel awkward sometimes when and how to start discussions with my students. I struggled not only to start but also continue the discussion with my students (January Journal-1/29/2021)."

Because of the variance in our cultural background, I often felt I could not become part of their discussions. There is a large gap between my culture and my students' culture as well as contexts. For that reason, it influenced not only my approach toward my students but also the conversation we had in our class regardless of course content.

At the same time, I was often challenged with knowing the boundaries of a teacher/student relationship. My students expected extensive interactions with their teacher. During a pandemic, they felt they could express frustrations, worries and complaints. In contrast, I expected teachers to be viewed as the final authority and expected my students to show a high-level of respect through attending to certain norms such as engaging, not questioning my decisions, treating me with respect, and keeping an emotional distance. These different expectations impacted our classroom interactions in this pandemic in several ways. First, involved my attempts to engage the students. I noted in my January journal:

> "...according to my culture, if a student remains silent, as a teacher it is my responsibility to encourage him/her to take part in discussion, more like forcing him to participate by asking him questions several times / targeting him to express his thoughts on it. But, here in the US, due to their culture, people respect each other's choice to participate. So, if students are not willing to share anything, instructors don't force them to participate here."

I often found myself trying to figure out how much I should push my students to engage in activity or discussion without violating their personal space. As I transitioned into this new culture and highly stressful situation, I felt that I needed to change and learn how to form a teacher/student relationship that they expected. I sought to engage in critical conversations about their lives and feelings.

As an ITA, I also had pedagogical expectations that differed from my students. Such differences impacted our abilities to adjust the teaching and learning process as we managed the pandemic. I made adjustments by trying to guide my students through the process of learning science rather than telling them directly what to do. Despite several attempts, I had encountered these comments : "She did not create a very open classroom community which made asking and answering questions" and "she did not give us specific instructions of assignments" (Students' official reports of their instructors). Such comments made me frustrated and confused and I questioned my own teaching ability. I could not disregard that coming from cultures where the absolute authority of the teacher is emphasized, I found it challenging to communicate openly with my students, articulate my expectations, and handle the tensions. These were the things they were expected and relied on during the pandemic-related stress.

The above noted challenge was further exacerbated by the fact that I was teaching the subject of science. My students were non-science majors taking their first college-level science course during a pandemic with an ITA. Students' prior experiences, attitudes and beliefs about science have a great impact on the teaching and learning process. It is important to understand and explore students' prior experiences with science because this differing status supports prospective teachers' confidence building to teach science (Appleton & Kindt, 1999). However, as an ITA, I didn't always understand what the students were bringing into the lesson. This is difficult to negotiate in any situation, but the pandemic and remote teaching through online platforms resulted in a constant challenge of figuring this out. My journal entries highlighted my struggles such as:

> "As always, this class also failed to understand the reasons behind climate change and climate change concepts. Somehow, every time, my students were not able to understand the science concepts behind climate change like greenhouse gases. Is that

> because they did not learn about climate change in their school science? (March Journal -3/4/2021)."

> "Interestingly, while they are measuring the Ph, most of them do not know how to use the probes. Only one of them told me that she used the Labquest Probe but did not know how to use pH specifically. I wondered what they did in their science labs in high school."

All of these instances made me realize I needed to acquaint myself more about their prior experiences to understand their struggles in this stressful situation. For that reason, I gathered information about their prior educational experiences whenever I could get it. One source was the experiences of my 9-year-old daughter. When we came to the U.S., she was enrolled in a local elementary school. I discussed with my critical friend how I was using her educational experience to better understand my own students' science experiences. I noted,

> "Did my students get the same treatment as my daughter? Then, why don't they understand such simple science concepts? I knew that this was not ideal. I can compare the situations as they were almost 12 years ago and learning and teaching never remain the same for years. But this is all I have to understand their experience (00:32:46-Audio clips_04/19/2021)."

Discussion

The COVID -19 pandemic upended the daily life of every individual throughout the world, however its impact on education is profound. Based on findings from this self-study, this chapter has revealed the common set of barriers for ITAs and their students in science education, such as a lack of engagement, disrupted learning outcomes and goals, lack of pedagogical skills and tools for online format, difficulties in social interactions, and physical and mental health problems that other studies had encountered (Choi et al., 2020; Lashley et al., 2020; Sahu, 2020; Quezada et al., 2020) during this pandemic. But, in the meantime, this chapter has also brought to light how all these pandemic issues further amplify the struggles of ITAs' in adjusting to the new culture in which they find themselves.

The Pandemic Has Exacerbated All of the ITAs' Acculturation Problems

We have noticed that while the ITA was adapting the participative learning teaching-learning style of the US context, the sudden switch to remote learning due to COVID not only disrupted her efforts and exercises, but also overwhelmed her own acculturation challenges. Generally, ITAs face immense cultural and societal challenges as they strive to understand different norms and teaching experiences (Avsar Erumit et al., 2020). With the emergent changes in teaching and learning modalities during the pandemic, ITAs need to learn new and effective pedagogical approaches and tools to deliver an online platform. For instance, the ITA in this self-study admitted that she tried to learn new online pedagogical skills and tools but, due to time constraints, she was not able to equip herself with enough to support the students' learning throughout such a unique and new platform.

Moreover, other studies related to pandemic teaching (Choi et al., 2020; Hvalshagen, 2021; Humphrey & Wiles, 2021) claim that online platforms capture students' learning outcomes and goals less in comparison with the in-person learning experiences they replaced. Similarly, the ITA and her students both felt that it was less effective and useful while they were learning or teaching science courses and lab activities online in comparison with the in-person learning experiences. More specifically, it is challenging for ITAs to obtain students' learning outcomes and goals while they have to adapt both to the participative learning teaching-learning style of the US context and to the sudden switch to remote learning due to COVID. It is clear that ITAs are simply being bombarded with too many challenges, thinking about both their own acculturation process and how to develop efficient and meaningful remote teaching-learning processes.

Hindrances in Building Social Relationships

Chiang (2009) indicates that cultural differences make an implicit rather than explicit difference in the procedures of interaction between ITAs and their students. The ITA in this study expressed her awkwardness and difficulties regarding dealing and communicating with her students across linguistic and cultural boundaries. The new online / remote learning-teaching provides an efficient medium for communication while applying the current COVID-19 remedy, i.e., maintaining the social distancing strategy. However, it has reduced opportunities for interaction and participation among students and their instructors. The ITA

in this study contended that, while she was trying to make transition from her culture, where the absolute authority of the teacher is emphasized, to the open culture of the US context, the reduced in-person classes, Zoom classes, online assignments and meetings breached her communication with her students.

Moreover, she often found herself in a position of disadvantage in trying to understand her students' prior science learning experiences and scientific knowledge due to the socio-cultural differences and this remote learning situation. There are several excerpts in her journal where she expressed how lack of knowledge of her students' experiences and learning with science impacted her science teaching, as well as her interactions with her students in the pandemic. These cultural norms and differences in understanding and expectations as well as interpersonal relationships deeply influence the teaching strategies and academic development.

Emotional Challenges for ITAs

Bozkurt and Sharma (2020) affirm that the learning processes during the pandemic should not aim at purely learning, but rather, be directed towards therapy, empathy, and care (pp.3). For that reason, most educators set the tone of inclusiveness and kindness throughout online teaching to facilitate students' engagement and effective learning (Choi et al., 2020; Lashley et al., 2020). Unfortunately, the ITA in this study felt an agony of trust with her students while she accommodated her students in various ways for their COVID-related issues and excuses. She could neither verify the excuses nor offer better and timely solutions during times of crises after she transitioned into this new culture and highly stressful COVID situation.

Moreover, like other teachers, the ITA in this study also did not receive enough support from the institution to provide emotional and mental support for her students (Auger & Formentin, 2021). It was critical and stressful for the ITA to display a positive attitude while she was uncertain about her own decisions as well as the instructional and educational context and policy of the USA during the pandemic. It is noteworthy that the ITA here earnestly wanted to reach out to and support her students during the pandemic and cooperate in adjusting the teaching and learning environment despite less support from her institution. On the other hand, this study indicated that the ITA also had difficulties getting herself motivated, along

with general anxieties like maintaining standards of pedagogy, adjusting to the new context, learning how to deliver content remotely and how to support her students during this whole pandemic process. This clearly implies that it is important for universities to build a climate of support, empathy and care for ITAs to provide efficient and meaningful learning and experiences.

Conclusion

The study sought to understand the struggles and challenges of ITA within a sudden, seemingly intractable disruption that impacted science education in higher education. The delivery of remote teaching and learning during the COVID-19 pandemic is a quintessential adaptive and transformative challenge and it demands huge resources and efforts in order to ensure the quality of education not only from the institutional level but also from the individual level, i.e., from students and instructors. Further, this new form of teaching-learning poses more challenges for the ITAs who already have their own share of difficulties in adjusting to interactive, participatory and competitive US teaching and learning methods and systems.

Based on our findings, we found that the instructor faced more challenges to process new pedagogical approaches in the new context and cope with the new crisis with her students due to COVID. It becomes more complex for the instructor to conduct interactive science teaching through online platforms because of the mismatch arising from different cultural understandings, academic cultures and practice conventions. However, the instructor acknowledged that she learned about various approaches to teaching, online tools, and resources to support remote learning, even though she concluded that remote science teaching is less interactive and effective in comparison with conventional ways of teaching.

On the other hand, this study demonstrates that cultural views, different education systems, and linguistic- and culturally-driven logical thinking play a significant role in the relationships between ITAs and students as well as ITAs' interpersonal relationships. This self-study has revealed some of the sociocultural, personal, and educational struggles of an ITA and how those struggles affect teaching and her emotions specifically amid COVID 19. However, to have a better understanding of the importance and roles of universities, departments, students, and academic advisors in how they shape the experience of ITAs, we

recommend further research using a mixed method approach to examine the level of acculturative stress in the teaching approach among international teacher assistants. Also, attention should be given to all the different factors that foster or inhibit ITAs' adjustments and that negatively impact their teaching and academic pursuits in the United States. Establishing mutual understanding and engaging ITAs, their students and institutions will help ease the challenges of ITAs in this new teaching and learning process and community.

Recommendations

ITAs play a critical role in educating the next generation of professionals (Gardener & Jones, 2011). However, they receive little-to-no professional development to prepare for these critical roles. This study explored how an ITA addressed unique challenges and demands during the pandemic due to her own set of acculturation barriers. The findings inform others and provide support to those in similar situations.

Several recommendations can be made from this self-study. First, universities need to create a safe space for ITAs to go where they can get social-emotional support and discuss personal, academic and professional challenges. Second, universities should provide unique instructional resources as well as developmental programs for ITAs, addressing their socialization challenges and their constituent needs. A developmental program focusing on translating the new context and instruction (Gardner & Jones, 2011) will help ITAs to gain confidence and take ownership in their teaching abilities. Third, Daniel (2021) noted that the remote teaching-learning process poses the greatest challenge for freshmen students in universities, who need a rich mix of independent and interactive learning activities. These are often the courses assigned to ITAs. COVID posed sudden changes to the ways in which remote teaching-learning process require additional effort to address new skill sets for students. Fourth, ITAs' and students' experiences and feedback about their transitions to remote learning should be incorporated to improve future online courses and learning experiences. Although these challenges arose in a unique context, we need to take this opportunity to consider initiatives and actions to help both ITAs and their students to meet such challenges. As we've recently been reminded, situations can come about quickly and we may not have the time to study how to respond.

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Commentary: Teaching University Science Content Courses During COVID-19

Teaching science is typically very hands-on and inquiry based. We had two chapters in this section that were written by the instructors of content courses. Qiu and Shukufe both conducted self-studies in their content courses, and were teaching the same courses, but in different semesters during covid. However, they were the same delivery mode of hybrid rotation. Both were second year doctoral students, and both were international students. Both were fully in charge of their classes, but were under the guidance of a faculty advisor who oversaw all sections of the course.

Both faced challenges that were exacerbated by the COVID- 19 outbreak. Both talked about being frustrated by technology issues, and difficulty with switching away from hands-on inquiry. Both shared how they strove to be flexible for their students, and yet wondered whether the students were taking advantage of them. Both talked about the difficulties navigating not only a different culture, but in modifying their courses at the last minute, and in trying to engage their students. They struggled with students who had their cameras off during the Zoom sessions, and were frustrated by low attendance to the in person classes.

They talked about struggling with their student identities as well as their instructor identities, and how being students helped them understand their own students' struggles, as they were trying to learn in formats that were also very different, as they were striving to teach in formats that were very different.

They spoke of being very tired, and felt overwhelmed and that teaching was very labor intensive. They were concerned because it was difficult to conceptualize what their students were learning, as they could not use their traditional hands on inquiry methods. Qiu spoke about feeling at a loss with how to react about the "Stop Asian Hate" movement, as she is Asian.

Both recommended more support for doctoral students in transitioning to teaching, in particular for international students who struggle with managing a new culture as well as teaching a new course. They recommend having the students who will be teaching the courses be involved in modifying the assignments, and that faculty and teaching assistants consider the kinds of traumas that their students face. Both shared how the critical friends groups they had were more than support for their research, but also for their teaching during COVID-19, and recommend similar support groups for new instructors in the future.

Citation

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SECTION III - TEACHING PRESERVICE SCIENCE TEACHERS DURING COVID-19

Chapter 6 - Feeling Like a First Year Teacher All Over Again: Teaching Elementary Science Methods During COVID-19

Valarie L. Akerson, Ingrid Carter, Claire Cesljarev

Chapter Highlights

- Being a first-year teacher is challenging, and there are ways to increase the chance of success.
- Pandemic teaching can be like first-year teaching all over again, even for experienced professors
- Maintaining confidence and flexibility can increase the chance of success
- Finding a collaborative group with whom to discuss, share, and question contributes to success
- Quick changes in teaching can be very difficult, yet students can still learn and be successful

Introduction

One thing is for certain—I absolutely love teaching elementary science methods. I have done it for over twenty years. At least once or twice per school year I have had the pleasure of teaching eager preservice teachers about how to teach science to elementary students. Generally, these courses have met in person twice per week, for about an hour and a half in each meeting. The way I have previously structured my courses was to have the first day in the week be the theoretical day, where the preservice teachers discuss the readings, and engage in small activities to reinforce ideas in the readings. The second day that we met each week is usually an activity day, where we engage in activities related to the week's readings that are meant to help preservice teachers see how to teach science to elementary students. In each case, all activities are inquiry-based, and embed nature of science (NOS) ideas and debriefs of content and NOS understandings from the activities. In this way we unpack ideas from the readings and put them into play using student-focused activities and debrief in ways that help preservice teachers focus on student thinking and learning. Additionally, as part of the methods course, preservice teachers design science lessons that they will teach in their field experience. On occasion in the methods course we will have a workday so that the instructor (me!) can provide feedback on the lesson plans.

So, shortly before spring break during March 2020, I was shocked to find out that COVID-19 had hit the U.S. and that Indiana University would be going to fully online for the remainder of the semester. Most of my students had not even had a chance to teach their science lessons in their field experiences. There was no way to continue with the activity portion of the class, though I thought I might be able to do some kind of demonstrations. Also, I knew they could not do their field experience teaching, so I basically entered full credit for each of them on their assignments to analyze and reflect on their teaching. I also ended up cancelling their final project, as it just did not make sense in terms of COVID-19 overtaking the last three weeks of the semester. When we did meet, we met on Zoom, and we met once a week, and generally very few showed up. Just those who wanted to talk. I had no teaching supplies at home but was fine with having a safe space to allow preservice teachers time to talk and vent about COVID-19 circumstances. And so, the semester ended. While I hoped that things would return to normal by fall, they certainly did not. Indiana University developed plans for teaching using masks, social distancing, and technology for the fall semester. Plans were made to provide personal protective equipment for safe teaching. Faculty were asked to

decide whether they would teach online, hybrid, or in person (knowing that their students would need to be socially distanced, and to take into account the size of the room).

Context of Fall Semester COVID-19 Teaching

Over the summer Indiana University developed COVID-19 teaching protocols as well as a plan for mitigation testing so COVID-19 positive people could be identified early and quarantined. As mentioned previously, faculty were asked to choose their teaching formats. Given my emphasis on hands on inquiry, and the importance of that teaching style to teach the very nature of science, I decided to teach using a hybrid strategy, where I could use some online teaching and some in person teaching. It was not possible to teach fully in person due to social distancing requirements because my classroom was not large enough to accommodate all my students. I was assigned to two elementary methods courses for the fall, and they were back-to-back on Mondays and Wednesdays, so I was able to be on campus two days a week. There was a materials person who not only arranged materials for classes, but also sanitized the materials and the classroom in between classes. Additionally, IU required students and faculty to wear masks any time on campus, and students were required to sit in the same seats all semester, to allow for contact tracing.

I held out hope that hybrid would be a great way to have the hands-on inquiry that would enable preservice teachers to learn methods for teaching science to elementary students. To fit my groups of 24 students in each class into my assigned classroom, I assigned half the class to attend in person on Mondays, and the other half on Wednesdays. There could only be thirteen in the class at one time, including the instructor, for appropriate social distancing. I found an online text that included modules, and I was excited to use that one day a week in place of having the readings discussions. On the other day of the week, each half of my classes would engage in hands on activities that were connected to the chapter topics. In this way I hoped the modules would provide the theoretical background, and the hands-on components would provide the experiences with strategies that would enable preservice teachers to see how to put those theories in to practice. At the same time, the field experience became more of just teaching to one another, so I adjusted my lesson plan assignment to being three individually designed lessons that built on each other, rather than co-written lesson plans that would be taught to elementary students. I had high hopes but was still very nervous about teaching methods in this way. I remember thinking it was very similar to how I

felt as a first-year teacher long ago. My research question became:

> How can I teach elementary science methods through a hybrid online in person format using social distancing and wearing masks?

Literature Review

In this section I review previous literature regarding first year teaching and first year elementary science teaching, to determine whether and how teaching elementary science methods was similar to and different from being a first-year teacher. While research on first year elementary science teaching is limited, a search did yield several research articles, which I will review in the paragraphs below. Most research was conducted on elementary science enthusiasts, which in essence, I was one in the past, and still have enthusiasm for elementary science and elementary science methods teaching, so it seemed to apply in my case.

First Year Elementary Teaching

A search for prior research on first year elementary teaching experiences yielded several interesting studies. For instance, Weinstein (1988) explored expectations about first year teaching held by elementary teachers. Weinstein found that first year teachers were optimistic that they would have less struggles than other first year teachers. They believed there might be a heavy workload, difficulty managing tasks and students, struggles finding materials, and possible lack of support by administration. They believed these struggles would get easier with experience. They had some ideas of the struggles teachers may have, and still persevered to become teachers, and held optimistic viewpoints that though teaching may be hard, they could do it. Romano and Gibson (2006) explored a beginning elementary teacher's successes and struggles to discern insights into a beginning teacher's day. They postulated that while all teachers face problems they have not seen before, beginning teachers are almost always facing new problems. The teacher in their study clearly remembered struggles she held, and less often recalled successes, unless she consulted the log she had kept of her teaching. Some of her struggles and successes were from policy over which she had no control, special needs students, classroom management, personal issues that were not part of teaching, pedagogy and parents, and teaching evaluation. One of her personal struggles was exhaustion, and also an injury she sustained trying to hang a poster in her classroom. Her doctor told her to work less, but she could not due to limited sick days, and the need to plan for a substitute. She

definitely had many struggles over the year.

In a comprehensive study of six beginning elementary teachers, Gourneau (2014) identified five major challenges experienced in the first year of teaching. These five challenges were classroom management, working with parents, differentiating instruction, handling difficult student behaviors, and figuring out how to assess student learning. Classroom management was a major difficulty in terms of navigating how to distribute materials, how to manage students during activities and how orchestrate class discussions. Working with parents and families was identified as a challenge as there was sometimes a clash between parent beliefs and the teachers. Differentiating instruction was a challenge because it is hard to teach different groups of students simultaneously. It is difficult to know what content to teach different groups, what kinds of activities are best for each, and what kinds of products each can develop to showcase learning. Dealing with students with difficult behaviors was very challenging for the new teachers. It is hard to navigate difficult behaviors, and to develop relationships with those who exhibit unanticipated behaviors. Assessment of student learning was a challenge as it is never possible to truly know what students have learned, but there needs to be some type of product in the end that enables the teacher to infer what the students have learned.

In another study that explored new teachers, Fry (2009) studied characteristics and experiences that contributed to the success of novice elementary teachers. She had a sample of four elementary teachers who completed their elementary teaching degrees at the same university, in the same cohort, taking all their professional methods courses together. The two teachers who remained teaching after their first two years strove to develop classroom communities, and to teach using student-centered approaches. Though they were new teachers, they were successful in navigating these goals into reality. The other two teachers who were part of the study did not hold this same goal and were not successful in student centered teaching or developing a classroom community. The obstacles that all teachers faced were minimal support in transitioning from preservice to inservice teacher, but the two teachers with high self-efficacy were more successful. Teachers who developed collaborations with others at their new schools, and held higher efficacy, and those who strove to be student-centered as well as develop classroom communities, were more successful, and the other teachers left teaching after two years.

First Year Elementary Science Teaching

Most studies that focused on first year elementary teachers were not science teaching specific. However, there were a few studies found that did focus on the science teaching of first year elementary teachers. Most of these studies focused on science enthusiasts, or those elementary teachers who were excited about teaching science, rather than tending to avoid teaching it.

In a qualitative study that focused on how first year teachers implement scientific inquiry, Avraamidou and Zembal-Saul (2010) found that the two teachers selected were enthusiastic about teaching science and intended to teach science in their elementary classrooms. They found that the second-grade teacher they studied strongly believed in hands-on science, and implemented hands-on science in her practice. She was able to have students focus on evidence and develop arguments for their claims. The fifth-grade teacher also emphasized evidence and claims, as well as data collection and interpretation. The researchers noted that these were "well-started" beginning teachers, who were using curricula as new teachers they had used in student teaching, and so had some experience even as new teachers.

In a similar study, Avraamidou and Zembal-Saul (2005) followed a first-year teacher to determine whether she taught giving priority to evidence. This was an enthusiastic second grade teacher who enjoyed science and sought to teach science to her students. She was in a supportive school context that enabled success as a first-year teacher, in terms of technology, supplies, and administration. Previous research by Zembal-Saul, Kracjik, and Blumenfeld (2002) showed that school culture was important, and context of the school must support induction as a new teacher, or teachers will have difficulties adjusting to complexities of teaching and must learn to teach "on the job," trying to teach effectively.

Abell and Roth (1994) followed one of their preservice elementary teachers into her first year of elementary teaching, to determine constraints and successes in her endeavors to teach elementary science. They found that while the teacher was very excited about teaching science, she was not sure how to go about it. She encountered constraints that she saw as "threats" to her ability to teach science as she wished. She found that there was inadequate equipment, requirements of the adopted text, perceived expectations by the supervisors and other teachers, and her wish for students to be successful on their textbook tests. The teacher

needed to find ways around those constraints to successfully teach science. She found ways to infuse science despite the constraints. Regarding the textbook, she did use it, but supplemented it with activities that were not included. She persevered into teaching science in a hands-on fashion, using the text, but modifying its use. They note that the teacher was confident in her abilities, and the confidence enabled her to persevere. Therefore, another study emphasized confidence and efficacy in teaching science enabling perseverance.

Mulholland and Wallace (2005) conducted a ten-year study on the growth of an elementary science teacher. I am using the portion from the first year of their study to describe this teacher's first-year experience. In her first year, the teacher taught sixth grade at an elementary school. Though she tried to plan ahead in the semester before she was hired, the curriculum at the school was changed before she actually began teaching. The new program required students to interact with materials, and though she was excited about this development, she struggled with management, as the students used the materials in ways other than she intended. She additionally struggled with managing large and small group discussions. She discontinued using small group activities but decided to try again in the second semester. She still met with little success. Students were excited and held limited attention to what she was asking them to do. She cancelled her planned discussion and had students write responses instead. Thus, the new teacher struggled with managing the group, managing discussions and materials, and struggled with a new curriculum.

Summary

From the review of studies on first year elementary teaching and first year elementary science teaching, it is clear that first year elementary teachers are met with several struggles. These struggles include classroom management struggles, feelings of exhaustion, feelings of being overworked, feelings of certain things being out of their control, perceptions of lack of support by management, issues with technology and curricula, and lack of adequate materials. However, there were certain characteristics of first year teachers that contributed to their success, such as persistence, self-efficacy, confidence, positive attitudes, ability to add to or modify the textbook, and development of classroom communities with student-centered activities, along with collaborating with colleagues were related to success for first-year teachers.

Method

Because my research focused on how I was adapting to teaching during Covid, I used self-study methodology. Self-study methodology has been used in preservice science teacher education previously to explore university science methods teaching (e.g. Buck & Akerson, 2016), and I was teaching elementary science methods. Self-study is a component of action research which is a learning experience embedded within the process of creating and testing new experiences (Zeichner, 2001). There is generally a dissonance felt between what is expected to happen and what actually happens as an instructor endeavors to navigate uncharted waters (Richardson, 1994). Below I will describe data collection and analysis procedures.

Data Collection

Data were collected in the fall 2020 semester. Prior to the start of the semester, I began writing in a researcher/teacher log to make records of my planning. I maintained this log throughout the semester with my final entry on December 9 after my last class. I made a minimum of two entries per week, once after each class. During these entries I described what lessons were occurring in class, as well as how students were reacting and any challenges or successes after each class. Additional entries were made after each critical friends meeting as I reflected on our meeting discussions.

Regarding critical friends, two colleagues (second and third authors on this manuscript) were also conducting their own self studies on their COVID-19 teaching practices. We formed a team of critical friends (O'Dwyer, Bowles & Chroinin, 2019) (a common way to ensure valid interpretation of data for self-studies) who met twice each month during the fall semester. During these critical friends meetings we shared our teaching each week, asked for suggestions when faced with challenges, and provided suggestions and feedback to those in our group on their teaching questions. We also asked critical and thought-provoking questions of one another, to help each other think through the approaches we were taking in our instruction during COVID-19. These meetings that took place on Zoom were transcribed and included in our data sources. We shared our researcher/teacher logs with one another at the end of the semester for data analysis (described below). Additionally, I used preservice teacher interactions and work provided in class to determine influences on preservice teacher

learning. While my goals were not to determine student learning outcomes, I couldn't help but wonder whether my current preservice teachers were at a disadvantage given the hybrid structure of the course, which was very different from the numerous in person courses I had taught over the previous 25 years.

Data Analysis

At the end of the semester, I reviewed my teacher/researcher log searching for patterns of challenges or successes in teaching. I tallied the number of instances that arose in each theme. Additionally, I reviewed the critical friends meetings transcriptions, searching for patterns indicating challenges and successes pertaining to my self-study. I shared my teacher/researcher log with my critical friends along with the emergent themes and asked them to read my log with my themes in mind, and to raise any other themes that they saw from my semester. We met for a final critical friends meeting to share themes, raise questions regarding analyses, and to finalize themes. Also, as part of my semester, I reviewed my preservice teachers' work to see the type of quality they produced. This took place as I graded assignments and interacted with preservice teachers in class. It was not a formal analysis but enabled me to determine whether the preservice teachers seemed to gain sufficient knowledge and skill to teach elementary science.

Results

Upon data analysis there were three major themes identified that took place while teaching hybrid elementary science methods during the COVID-19 outbreak: 1. Feelings of being overwhelmed by technology, Zoom, and perceived lack of faculty support, 2. Glad to be in person (on the in-class days) and engage with students, 3. Exhaustion. These themes were agreed upon by the three researchers through the analysis. Each theme will be addressed in the sections below.

Overwhelmed by Technology/Zoom/Lack of Faculty Support

A major theme in the data was feeling a lack of support in terms of using technology as well as other types of faculty support. This lack of support was felt early in planning for the hybrid semester. Of course, in retrospect it is clear to see that everyone at IU was doing their best

and most were concentrating on safety issues. But still the pedagogical issues were top in my mind as I was planning to teach in a way that was very different from what I was accustomed to. In one late July log entry I note:

> "I have been trying to get an online text ordered for weeks now. I finally went ahead and made myself a textbook orderer so I could just do it myself. Very frustrating and almost missed the deadline. Also, a huge battle to get my CANVAS courses up. Too many blocks from registrar given last minute changes due to COVID. Which meant I finally met with the textbook rep and set up a mock class so I could at least get some planning done."

This perceived lack of support extended throughout the summer as I planned, with a cheer shortly before the semester began when I found out I would only need to teach in one classroom instead of two simultaneously as I write in my August entry:

> "My classroom was reevaluated for the number of students it could hold! I was originally slotted to teach in two classrooms simultaneously to one quarter of my students at a time, but in the 3009 room we can now fit thirteen, including the instructor, which is great given my classes have 24 in them and I meet half of them once a week."

In another perceived lack of faculty support I could not find a way to get whiteboard markers. I was the only one teaching in the room and had only one barely working whiteboard marker. I asked faculty support, and my department chair. I end up buying my own whiteboard makers. I write in my September 10 entry:

> "I finally decided to just buy my own whiteboard markers. It is like being a classroom teacher again when you have to buy your own supplies. You can get all the PPE you want, but no way to get markers for the board. Sigh."

The technology issues were overwhelming, beginning from the planning stages. I do not consider myself a technology wizard, and that showed throughout the semester. I chose the online text that included modules so that I wouldn't need to design the modules. I did, however, need training in using the modules, and embedding them in my CANVAS sites,

which took many meetings with the textbook reps, and there were still issues at the beginning of the semester. The preservice teachers also struggled with the technology. Over the first weekend of the semester I reported "I got at least 3-4 emails from each student trying to figure out the online system, telling me they need to quarantine, etc. I ended up setting up standing Zoom links for our semester so students could connect by Zoom if/when they need to quarantine."

By the second week of classes many preservice teachers were in quarantine and I had to zoom them in. In week three the technology wasn't working and only three people attended in person in the Monday morning (Labor Day) course. Given it was a holiday, I kind of understood the need for a break. I wrote "The university is trying to keep the students busy and not going home. So it is almost like the faculty are babysitting by teaching. Staff are not required to work." And the technology was not working for sound, and those who were zooming simply turned off their cameras. This week was hard because it is usually one of my favorites of the semester, where we explore electricity, but technology issues (and teaching on Labor Day) redirected that joy. As the semester went on, so many more students attended via Zoom. Often half the class would be on Zoom. This happened by mid-September. Many were in quarantine. I used my iPad to zoom students so I could move it around so they could see different activities, the board, etc. I tried to use it for outdoor science, but the WIFI dropped.

By September 21 preservice teachers were telling me the online modules were difficult, and while these were developed from textbook company, I also selected too many things for them to do each week, which is what made it difficult. I could have initially selected fewer assignments after the readings, but did not do so, as I had no experience with this text. I had to make some adjustments but couldn't figure out how to do it in CANVAS, and had to just tell them which things to ignore. This caused some issues given students could not always remember what I had said, particularly when they were on Zoom. So the online portion was a struggle the entire semester. That same week the mathematics methods professor and I heard from one of our students that she would not return to in person classes and would zoom the rest of the semester. We were shocked. By September 30 she had decided to attend class in person again, after discussion with us. However, by October 5 so many other students were on Zoom that it seemed to be the default, and fewer students were attending in person.

Indiana University decided to end the semester online, so I chose to put in the Population Connection module at one of those weeks. This is a good, independently designed module that engages students, and provides access to sets of elementary science lessons to those who complete it. Generally, this workshop is done in person, but they had developed an online module for COVID-19. The following week I scheduled a work week, with the option to Zoom to answer questions, and the last class was simply to share children's books designed by the students to teach about Nature of Science to their own future students.

Glad to Be in Person

After concluding the prior semester online, it was very exciting to have the possibility of being in person, despite having to also teach partially online. My first day of the semester was bittersweet, as I wrote "drove up to the campus and the parking lot was empty! I was literally almost crying!" It is not usual to see the parking lots empty, as it is generally difficult to find parking on most days. However, even though I report intense nervousness at the thought of the start of the school year, I was so excited to see my students, and spoke of them as being "FABULOUS," noting that they "stated they were happy to be meeting in person, and to be engaging in activities.

Indeed, even in the second week of classes, despite some students needing to quarantine, those who were in person stated they really wanted to attend in person, and hoped it would continue. Even at the Iron Pit Gym that I go to which is not on campus, I met an undergraduate student who wasn't part of the School of Education who claimed that she hated Zoom classes and will never miss in person classes again. My students continued to tell me that across the semester.

One of the best class sessions of the semester was when I decided to have small group work. We built Rube Goldberg machines to complete various tasks. To make it a safe activity we wore masks, gloves, and sanitized, but were also engaged together in small group work—three groups of about three in each class. Each group in each class was excited and engaged, and the classroom seemed to be buzzing, *almost* like a normal semester.

On Oct. 21 I noted that I had almost 100% attendance across all classes—only one person met on Zoom! In this class I shared teaching resources and strategies, and it was a work

session. I believe students found it valuable, and they were all on task, ready to develop lesson plans. I was able to provide feedback to them on their lesson plan ideas as they were brainstorming their set of three lesson plans. So even though students needed to join by Zoom due to quarantine, at least sometimes throughout the semester they were very happy to be in person, and so was I. It does not explain the students who chose to Zoom more than being in person, nor those who always turned off their cameras when they Zoomed. It was simply a juxtaposition of people being in person, and on Zoom. Almost like teaching different groups of students simultaneously.

Exhaustion

The final theme that ran through the semester was that of exhaustion. Exhaustion for the instructor as well as the students, in reality. From the first week of the semester when students were constantly emailing, during evenings as well as weekends, I realized how exhausted and overwhelmed they were. It was the same for me, trying to email back quickly and reassure them.

By the third week I was personally struggling with how exhausting it was to teach in a way I was not accustomed to. I was teaching partially in person and partially online, and though I only had two classes it seemed like I was teaching four as I had four separate groups of students. Plus, we even had to teach on Labor Day when most places were given a three-day weekend. I noted in my log:

> "When I got home from teaching, I fell asleep on the couch. I find it very exhausting teaching in a mask. Hard to breathe, talk, etc., and two classes back-to-back twice a week is rough."

When September 28 hit, which was about a month into the semester, it was clear that exhaustion was sadly a theme. I mentioned in my log that I was "very tired" and that I "made it through" the class. I wrote this a day after I had taught, and noted that I had been in five Zoom meetings that day, and that having so many Zoom meetings along with teaching in this unusual manner is very difficult. I talk about the difficulty in supporting new doctoral students who are also teaching this same course this semester to different groups, but having to do it during a pandemic. So not only figuring out how to teach my own courses, but also

how to support others in their endeavors, as contributing to feelings of exhaustion.

Later in the semester (Nov. 9) I reflected further that it was difficult teaching the same things four times:

> "I'm growing weary of teaching the same thing four times, and teaching on Zoom and in person at the same time. I feel I was fighting being lackluster today. Also, the lab assistant was not here due to the need to quarantine, so I had to rush to the office and it was hectic getting everything ready, and when hardly anyone is at class, it is a bummer."

November 18 marked the end of face-to-face teaching. I commented in my log that people were generally glad. I noted "People are tired and just ready to move on." I did also note that "a huge number of my group will be good teachers. And now it is time for me to go take a COVID test."

Do I Believe My Students Will Be Good Teachers?

Toward the end of the semester (November 18) I wrote "a huge number of my group will be good teachers. And now it is time for me to take a covid test." On December 9 I noted "these students had to learn through a pandemic, and yet they will be great teachers, partially because of the persistence they had to use in order to persevere and complete the semester." I do still think that it would be better to have a field experience where they practice working with elementary students. However, they were able to design science lesson plans that would be good to use with students, and design assessment tasks to assess student learning. It will be great for them to have the opportunity to try them out with students, but that was simply not an option during COVID-19 due to schools not wanting the preservice teachers there, not even doing remote teaching. So, I still believe that most became the best they could be under the circumstances they were forced to be in. We all worked hard, and I believe they learned a lot about teaching elementary science and will one day get to put that into practice.

Discussion

Teaching during COVID-19 was by far one of the most difficult things I have done

professionally. It truly felt like I was a brand-new teacher again. Thinking back on the research on first-year teaching and first-year science teaching, it was clear to me that I shared many of the same struggles. In fact, the only thing I did not experience was any problems with parents! Thank goodness! I believe I was similar to the science enthusiast first-year teachers, who was determined to succeed despite the struggles and constraints (e.g. Avraamidou and Zembal-Saul, 2010). The reason I say this is because one of my main strategies is to use hands-on activities to model how to teach elementary science, and this proved very difficult to do even through a hybrid model, but I persevered. Preservice teachers were not able to work even in pairs for most of the semester. Materials had to be distributed in advance, meaning that preservice teachers would see all materials available, including those I would normally not share immediately in an activity, which limited how much I could model about elementary science teaching. This issue with figuring out how to distribute materials safely definitely was similar to the classroom management struggles noted by Gourneau (2014). The online modules that I did not have to create were confusing to the students, and the in-person portion was a struggle due to the hybrid nature and the fact that so many students needed to quarantine and therefore engaged in class through Zoom. These struggles were similar to conclusions of Romano and Gibson (2006) when they found difficulties with curriculum that needed to be overcome in order to teach as desired. Teaching in person, online, and through Zoom was challenging, and also similar to Gourneau (2014) who found that differentiating instruction was very difficult for a first-year teacher. To me, this was a new kind of differentiating instruction and it was exhausting changing my teaching so rapidly. It was hard teaching in a way I had never taught before. Despite all my teaching experience, I truly felt like a first-year teacher again.

There are several ways that I felt like a first-year teacher again. I clearly remember being surprised about so many things that happened in my first year as a teacher, such as our reading text being classified as “teaching witchcraft.” This classification from the surrounding community caused many flight or fight reactions from most teachers, similar to COVID-19, such as questioning the text, wondering how to react with one another, how to portray ourselves to parents, and such. As a first-year teacher I had to learn all the adopted curricula, norms of the school and the community, figure out how to receive support for teaching, along with technology that the school had, and needed to react and readjust quickly when the unexpected occurred. These similar events occurred during COVID-19, with needing to figure out new curricula, new styles of teaching, figuring out how to get supplies

for teaching, technology, learning new norms, such as teaching in masks, sanitizing, and social distancing. These challenges are similar to Romano and Gibson (2006) where teachers felt challenged by things beyond their control, and Gourneau (2014) where teachers felt challenged by classroom management, differentiating instruction, student behaviors, and Abell and Roth (1994) and Mulholland and Wallace (2005) where the text, equipment, and materials management were found to be challenges.

Another way I felt like a first-year teacher is the sheer exhaustion I felt. I clearly remember falling asleep on the couch each Friday evening after a week of teaching in my first year. I felt the same when I went back to teach elementary school during my first sabbatical. I noted throughout my teaching/researcher log how exhausted I was teaching during COVID-19, citing masks, odd ways to teach, struggles with students, and taking naps, among others. This was similar to Mulholland and Wallace (2005) who found that the new teacher was exhausted, and it was even recommended by her doctor to work less, but she could not due to struggles with substitutes and lack of sick days. In my case, there are no subs. If I had actually gotten sick, I do not know what I would have done. I guess tried to teach through Zoom.

Being glad to be with my preservice teacher students was another way I felt like a first-year teacher. Expecting difficulties, but being excited was a way that Weinstein (1988) found that new teachers had as an expectation. I was absolutely thrilled to be with my students as a first-year teacher, despite the struggles that I wouldn't even have imagined or anticipated. I felt the same with my in-person portion of my course, as I could see my students and interact with them. It was very different with the social distancing and the masks, but I appreciated every instance of in person interaction. I also felt the same bittersweet feelings at the end of the semester as I did at the end of every school year, when I was so exhausted, so glad to be done, yet very sad to say goodbye to the students. I know these particular preservice teacher students of mine had an especially rough year due to COVID-19, online teaching, quarantining, lack of experience with elementary students, among other challenges. I know they were equally exhausted and ready to be done, but we did develop a bond that will hopefully not need to be shared again—teaching and learning during a pandemic. I do believe these preservice teacher students will be able to take with them the ability to react to change rapidly, and understand the need to be proactive with planning, but also be ready to adjust. Similar to Avraamidou and Zembal-Saul's (2005) findings that confidence boosts success in

uncharted territory, I did feel confident that I would be able to do teach these science methods courses. I did not foresee how challenging it would be, but I knew I could do it.

What about Fry's (2009) findings that success in your first year is related to the development of classroom communities, student-centered teaching, and collaborations with others? In my case, I always have tried to develop communities with student-centered teaching in my methods courses. This goal did not change during COVID-19, as I tried to talk about how well-prepared they would be despite the changes made, and tried to provide in-class feedback on assignments, tried to relate to students who were having problems, whether or not they were COVID-19 related. I remember sharing with my students that almost no teacher will have had the experiences they have had in becoming teachers during COVID-19, and that they had developed great perseverance to do so under trying times. I provided feedback and opportunities to revise assignments so students would have the best lesson plans and assessment tools they could have under the circumstances. These statements and practices were made to reassure them that they could still become excellent teachers.

But what about collaborations with other teachers as an influence on success? While I did meet with two graduate students who were also teaching science methods in the same semester, their influence on me was minimal. It was their first semester teaching this course, and so I helped them with planning, assessment, and other issues. I'm sure their semester was very hard as well, but I did not ask them to support me in my teaching. Where I found support and collaboration was with the other participants in this current study—the critical friends. They were the more experienced instructors who were also quickly adjusting their teaching to fit the COVID-19 pandemic times. Meeting with the critical friends gave me a place to discuss issues, raise challenges, get advice, and simply complain about the situation we were all in. Certainly, it gave me feedback on my research and teaching (O'Dwyer, Bowles, & Chroinin, 2019), but I am not sure I would have been quite as successful in the semester if I had not been doing a self-study, due to the opportunity to meet and discuss teaching with my critical friends. I do believe it provided the collaborations and feedback that Fry (2009) found necessary for a successful first-year teacher.

Conclusion

Well, would I ever want to teach methods in a hybrid fashion again? No, not really. Were

there any things that went well during the semester? If you had asked me during the semester, I would have said no, as I was so focused on the struggles. This was similar to Romano and Gibson's (2006) finding that it is easier for first year teachers to focus on the struggles and forget the successes.

But reading through my teaching/researcher log did remind me of the successes. One of these was that I was still certain that my students would become good science teachers, because I was able to see their lesson plans and assessment tools, and knew they were interactive activities, and had assessments that matched these activities. These tools and lessons could be put into practice once they were able to be with a classroom of elementary students.

The other main positive outcome was reminding myself of the importance of sharing ideas about teaching, and having collaborations with others. Again, this collaboration took place during the critical friends meetings, and it shows up in my researcher log nearly weekly. My comments run along the lines of "oh good, time to share with Ingrid and Claire!" and "I wonder if they are struggling with this too?" and "I need to ask Claire and Ingrid what they think about this strategy," and "Are we all just so tired?" Therefore it is clear that this critical friends group that was set up for research definitely influenced teaching and served as a place to share ideas, collaborate, and commiserate. It would be important to have such a collaboration throughout teaching.

Recommendations

Hopefully we will not have to teach through another pandemic and quickly change our teaching strategies to enable us to do so. But if we ever do need to do any quick switches in teaching strategies, there are some recommendations we can make for others, based on outcomes of this study. First, while it is important to have safety first, it is also important to have faculty support for pedagogy. There should be somewhere that faculty can go with questions about how to teach online, hybrid, how to order whiteboard markers or other equipment necessary for teaching. Additionally, it would be wise as a faculty member to maintain technological savvy. I realized that there were opportunities at Indiana University to boost my technology skills. I was aware of courses I could take that would help me teach online. In fact, I am enrolled in one of those courses now. However, I did not choose to take those opportunities previously, and certainly it made it more difficult to learn the technology

"on the fly" while adapting to teaching in a different format.

Finally, as others have found in previous studies, attitude does make a difference. I did believe I would be successful, though I was initially blissfully ignorant of how difficult it would be. Persistence and confidence are key. Though I felt like a first-year teacher, I of course was not, and could still draw upon teaching experience despite it being very different. I knew I could be flexible with whatever came, and could make quick changes, and that there are many ways to prepare teachers. Somehow, we need to instill this confidence into our new teachers—the confidence that they can—and will—be great teachers for their students. No matter if they do need to teach during a pandemic.

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Chapter 7 - Reflections on Teaching Fully Asynchronously: A Self-Study of Elementary Science and Health Methods during the COVID-19 Pandemic

Ingrid Carter, Valarie Akerson, Claire Cesljarev

Chapter Highlights

- This chapter shares the first author's experiences teaching fully asynchronous online elementary science (and health) methods
- Successes and challenges of teaching asynchronously are discussed
- Self-study results describe both professional and personal experiences of teaching methods online

Introduction

The COVID-19 pandemic seemed to change my world of teaching overnight. Likely as did many teacher educators, Ingrid (henceforth "I") experienced this shift to teaching fully online within a matter of days. After the initial jolt in Spring 2020 of transitioning to online teaching and shifting my face-to-face elementary science and health methods course, I had a summer to prepare to teach fully online in Fall 2020. I taught one section of 33 students; a larger than usual class size as online there were not concerns about physical room capacity. In this transition to online teaching, I explored various ways to focus on critical thinking and rich learning experiences, and reflected often on the pedagogical strategies and relationships I was building with the preservice teachers in my course. I was able to reflect bimonthly with valued colleagues, Dr. Valarie Akerson and Ms. Claire Cesljarev (second and third authors, respectively), to explore our experiences in teaching science methods courses online.

This chapter focuses on my own experiences and reflections on teaching a fully asynchronous online science and health methods course for preservice elementary teachers during the COVID-19 pandemic. Through a self-study methodology, I examined the successes and challenges of this 15-week experience in the Fall 2020 semester. My hope is that my systematic exploration and description of this experience will offer helpful insights and recommendations to others. Thus, this self-study explored the following research question: *What are the successes and challenges of teaching a fully online asynchronous elementary science and health methods course?*

Literature Review

The following literature review examines scholarly work related to online elementary science methods teaching and learning, as this was the focus of the self-study. The first section reviews works pertaining to typical elementary science methods course content and the second section explores works related to teaching preservice teachers in a fully online format. These two scholarly areas combined provide insight into how I modified the elementary science and health methods course I taught as it compares to what others have done, and provide a context for the successes and challenges of my own work teaching online.

Elementary Science Methods Course Content

While there is likely a broad spectrum of topics within elementary science methods courses, various scholars have shared patterns within science methods courses across contexts. In their review of the literature, Treagust and Tsui (2014) noted common instructional approaches within science teaching—demonstrations, explanations, questioning, scientific reasoning, and representational learning. Moscovici and Osisioma (2008) discuss their process of developing an urban elementary preservice science methods course and suggest consideration of the following critical elements while engaging in course design: addressing "sciencephobia," considering personal experiences, consulting literature on curriculum development and elementary science methods courses, and examining trends in science education as well as the national standards. Furthermore, they compiled a list of recommended course topics, which include "inquiry science, learning cycles, active learning, cooperative groups, nature of science, assessment, integration with other subjects, equity and diversity, technology, constructivism concept mapping, curriculum evaluations, safety, misconceptions, and reflective practice" (p. 20).

Indeed, with the publication of the *Framework for Science Education* (NRC, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013), it seems logical that elementary science methods courses focus on effective strategies for engaging students in exploration of the disciplinary core ideas, science and engineering practices, and crosscutting concepts. As mentioned previously, Moscovici and Osisioma (2008) included national standards in the framing of their exploration of important topics within a methods course. Science education articles have been published that discuss how to embed the three dimensions into instruction (e.g., Cian, Marshall, & Cook, 2019; Goggins, Haas, Grapin, Llosa, & Lee, 2019) and how to prepare teachers to effectively facilitate instruction driven by the three dimensions (e.g., Richman, Haines, & Fello, 2019). Furthermore, research suggests that conceptualizations of the Nature of Science (NOS) teaching and learning can be an important component of the elementary methods course (Akerson, Morrison, & Roth McDuffie, 2006).

Beyond the recommendations of Treagust and Tsui (2014), Moscovici and Osisioma (2008), and the logical incorporation of the Framework, NGSS, and NOS into the elementary preservice methods course, other powerful elements may include an emphasis on integration

of science with other content areas and an opportunity for preservice teachers to examine different perspectives of science teaching. Within the elementary science methods course, course instructors can choose to discuss, and perhaps even emphasize, the integration of science teaching and learning within other content areas such as mathematics or language arts. This interdisciplinarity could be beneficial as Blank (2013) examined trends in time spent in the elementary classroom on science teaching and noted that, "Instructional time in elementary classes for language arts, reading, and mathematics has increased whereas instructional time on science continued to decline" (p. 842).

One tool that can highlight interdisciplinary teaching is a science notebook. The use of notebooks can also be used to promote preservice teachers' reflection about different perspectives within the methods course, for example thinking about the student and the teacher perspectives as well as how professional scientists use notebooks (Carter & Schliemann, 2020). Digital science notebooks were a focus of my online asynchronous course during this self-study.

Online Preservice Teacher Education

Tomas, Lason, Field and Skamp (2015) explored a science content course for preservice teachers in a "blended" or hybrid environment. Their study was grounded in literature that supports online learning, providing evidence that online learning can offer responsive, engaging, and robust learning experiences. Utilizing a framework that examined engagement, they explored preservice teachers' experiences in a hybrid learning environment with regard to personal, academic, professional, social, and professional aspects of the experience. They found that clear directions and instruction, especially with video support, and assessment and feedback were critical components to the online learning format.

Despite the COVID-19 pandemic being a recent and, at the time of authoring this book chapter, an ongoing phenomenon, scholars have already published some of their experiences teaching online. Brown (2020) described how she transitioned to a fully online elementary science methods course, and how she already had a system in place with the use of the learning management system Blackboard™ to provide course information and communicate with preservice teachers. She also included a wealth of resources to enhance online instruction such as video with instructor-embedded questions via edpuzzle™, at-home

investigations, curricular resources, and preservice teachers creating their own video with Flipgrid™. Brown (2020) reflects on how she can use and adapt these innovative and interactive experiences when teaching a hybrid, predominantly online science methods course in the upcoming Fall semester. Gilles and Britton (2020) also discuss their experiences shifting to an online learning environment during COVID-19. Their methods course included a rich final assignment wherein preservice teachers interviewed their cooperating teacher to glean insights about the shift to teaching fully online as well as designed an online lesson plan through video. The two authors of this paper (Gilles and Britton) presented their assignments in a slightly different manner, as one instructor asked preservice teachers to create a video for other preservice teachers and the other instructor presented the assignment as a video for students and parents. The authors conclude, "The interview portion of the assignment was particularly valuable to have PSTs conduct their own inquiry, reflect upon what they learned, and develop a teaching tool that addresses the challenges shared" (Gilles & Britton, 2020, p. 22).

Hudson (2006) examined preservice teachers' perceptions of a fully online elementary science methods course. He aimed to align this course with best-practices methods course teaching, including a constructivist and reflective approach. Through a posttest-only design, he assessed preservice teachers' perceptions of science education theory, conceptual thinking in science, planning of science lessons, and implementation of effective lessons. Although the survey response rate was only about one-third, results indicated positive results on the four assessment components. Furthermore, using a qualitative approach Hudson analyzed preservice teachers' perceptions of the benefits and challenges of online learning. Benefits included flexible learning to adapt to various other life commitments (e.g., work), and challenges included preservice teachers' uncertainty about their work (e.g., if they were meeting the expectations of the course/assignment) and varied levels of participation by students in collaborative online discussions.

Method

Study Design

This study was framed within the self-study methodology. Self-study is an approach wherein the educator examines their own teaching with the intent of reflection and insight to improve their teaching, as well as how this may have implications for other educators. LaBoskey

(2004), as cited in Pithouse, Mitchell, and Weber (2009), describe self-study in a teacher education context and note that self-study includes four critical aspects:

- seeks improvement and transformation of practice
- includes engagement with peers, students, literature and or own inquiry
- utilizes qualitative research methods
- is intended to share with and inform others

Bullough and Pinnegar (2001) note that self-study should provide a balance between being autobiographical (personal) and impactful (research). Furthermore, they indicate that self-studies relate to issues of educators, and should be written so that they have relevance to others. This self-study occurred during the COVID-19 pandemic and was influenced not only by the quick shift to a fully online format, but also by other contextual factors caused by the pandemic. While the approach is centered on my own experience during this time, the hope is that the implications of this experience can be helpful to others who, either by choice or need, teach elementary science methods in a fully online asynchronous format.

Pithouse, Mitchell, and Weber (2009) also note that self-study is a form of inquiry that is action-oriented and allows the instructor to examine multiple perspectives of "self." Thus, the purpose of self-study is not only reflective, but also to inspire change and improvement to one's practice as well as to provide pedagogical insights to others. In this study, Valarie and Claire served as not only as collaborators and co-reflectors, but also as critical friends (Schuck & Russell, 2005) in the self-study process. Schuck and Russell (2005) state: "It is our shared view that a critical friend is essential if self-study is to involve critiquing existing practices and rethinking and reframing practice (Loughran & Northfield, 1996); a critical friend also provides essential support and maintains a constructive tone" (p.108). Valarie and Claire provided both this support and constructive feedback and reflective prompts throughout our work together.

Context within the self-study investigation is important, and in particular the context of the COVID-19 pandemic was a critical one. The COVID-19 pandemic resulted in a work-from-home situation for many, as well as remote learning for school-aged children. Scientific information about COVID-19 was at times unclear, not only because scientists were still studying the virus, but also because of how the information was distributed via the media.

This complexity of the context supports rich self-study inquiry, as in this case, my "self" was impacted not only by the learning environment but also by the personal factors that impacted my work.

Context and Instruction

This study was conducted in the Fall 2020 semester and through this study I endeavored to explore my first attempt at a full semester of teaching elementary science (and health) methods in an online asynchronous format. The 15-week methods course included a variety of topics such as the science and engineering practices (NGSS Lead States, 2013), questioning, "claim, evidence and reasoning" (or CER), integration of science with other content areas, assessment, and differentiation for diverse learners. While the shift to online teaching was abrupt, I was able to plan a Fall-semester fully asynchronous course during the summer of 2020. I appreciated having some time (as well as a stipend!) from the university to delve into Canvas™ , the university's new learning management system. The transition to the use of Canvas™ in the Fall offered me a further opportunity to consider how to restructure the course. The format Canvas™ includes modules, wherein the instructor can create "Pages," similar to an online document, as well as upload resources, URLs, and course assignments.

After reflecting over the summer on my online instruction from mid-March to the end of the Spring 2020 semester, I decided to focus on a few critical aspects of the course and to delve deeply into those aspects. I decided to streamline the format of the course to focus on a few key online platforms. The science methods course was part of a block that included mathematics methods and a shared field experience. I collaborated with the mathematics methods instructor before the Fall semester began to reflect on the experiences we were designing for the preservice teachers in our block of courses. She was embedding a variety of technology resources such as Flipgrid™, edpuzzle™, Jamboard™, and Padlet™.

Because the preservice teachers would experience this variety of resources in the mathematics methods course, I decided to streamline the experiences in my course to include readings and the digital notebooks through Canvas™ and Google Slides™. Thus, I maintained the majority of the course topics/lessons that were in the in-person methods course, but streamlined the learning platforms and course assignments. This included taking a

student and a teacher perspective (Carter & Schliemann, 2020) throughout the course, use of notebooks to support preservice teachers' thinking, and design and implementation of an inquiry-based lesson framed with the 5E learning cycle (Bybee, 2014). Because I had decided to continue using notebooks with preservice teachers that included a student (or elementary science investigation) side and a teacher (or pedagogy) side, I created task cards through the "Pages" feature within Canvas™ for each of these perspectives. I included instructional videos in each module that explained the task cards, as well as reviewed the notebook templates in Google Slides™.

Within the digital notebook and task cards, I embedded video and other Internet resources. Each week, preservice teachers engaged in an investigation through a "student side" page in Canvas™, which asked preservice teachers to either conduct an inquiry investigation at home with common household materials (e.g., exploring if various objects "stick" to a magnet), as well as engaged in a "teacher side" page that presented opportunities to reflect on, analyze, and/or apply the pedagogical concepts that were modeled on the student side. Preservice teachers then recorded their thinking in digital science notebooks via Google Slides™. I provided templates each week for the Google Slides™ that preservice teachers could copy and paste into their own digital notebook. After preservice teachers completed the "student side" and "teacher side" tasks for the week, they were asked to complete a written reflection. The written reflection questions prompted preservice teachers to think about their experience as a student learning the content, to reflect on the pedagogical aspects of the week's tasks, and/or to integrate reflections and thoughts about the week's readings. Additionally, I included a short video to introduce the module each week which provided an overview of the tasks. I often included video of the investigations so that preservice teachers could view these if they did not have the materials at home to be able to complete them on their own.

In addition to the weekly student and teacher tasks, preservice teachers had a three-part lesson plan assignment to complete at the end of the semester. The lesson plan assignment included submission of a lesson plan draft (created using a course-specific adaption of the departmental lesson plan template), revision of the lesson plan, and a lesson reflection. Preservice teachers were asked to revise the lesson upon receipt of their lesson draft feedback from me and to teach the lesson either to a child or adult with whom they could safely interact in person, or to teach it to them virtually. After teaching the lesson, preservice teachers were asked to color code their revisions based on either my feedback or on their

experience teaching the lesson, annotate their revisions, and complete a lesson reflection.

Finally, I requested an optional mid-semester and final virtual meeting with preservice teachers in small groups. The purpose of these meetings was to connect with preservice teachers and answer any questions they had about the course. The mid-semester virtual meeting was intended to offer an opportunity for preservice teachers to reflect on their learning, consider their strengths, reflect on what they may need to be more successful in the course, and provide me feedback to improve their learning experience. The final virtual meeting involved preservice teachers reflecting on the semester and their ideas about teaching science, health, and engineering. Additionally, preservice teachers were asked to reflect on their experience with the digital notebook and how they might use it with elementary students. In both the mid-semester and final virtual meetings, the preservice teachers had the option to complete a written reflection rather than attend the live virtual meeting.

Data Sources

Data sources for this study included my reflective teaching journal and recorded Zoom™ meetings with my critical friends, Valarie and Claire. My teaching journal for Fall 2020 contains 17 entries, dating from August to December. I tried to reflect each week of the 15-week course, although I reflected more frequently when I felt there was a notable occurrence, and I reflected less frequently when other areas of my workload increased. Our one-hour bimonthly Zoom™ meetings were open-ended and included time for each of us to share how our teaching was going. We offered one another support, ideas, and camaraderie as we each discussed our individual teaching contexts and experiences.

Data Analysis

To analyze the data, I engaged in an inductive qualitative approach wherein I labeled units of data and took notes on the patterns and themes that emerged (Creswell & Poth, 2018; Merriam & Tisdell, 2016). I then examined categories or themes that emerged from the data (Merriam & Tisdell, 2016). I examined my teaching journal for themes as well as explored my own words in the Zoom™ meeting transcripts. I began my analysis with my teaching journal, reading through the entire journal and labeling chunks of the data. I then used open coding for emergent themes, focusing on positives and negatives (which later became

successes and challenges).

The themes that emerged from my teaching journal included: *innovation, use of technology,* and *planning for the future* (successes) and *uncertainty about my teaching*, *feeling disconnected from students* (a.k.a., preservice teachers) and *juggling personal and professional roles at home* (challenges). I also chunked and labeled my own words in the Zoom™ meeting transcripts. I then examined these chunks and labeled them either with the themes that emerged from my teaching journal, or new themes if appropriate. The themes within the journal were evident in the Zoom™ transcripts and three new themes also emerged. These included general *successes* and *challenges*, for example, "Positive: students like consistency" was labeled as a "success" and "Negative: Hoping no more furloughs" was labeled as a "challenge," and *considering context.* Considering context involved ideas such as thinking of ways to support or accommodate preservice teachers.

Finally, one Zoom™ session with Valarie and Claire was dedicated to discussing my teaching journal for which they served as critical friends. All three of us read through the journal, and Valarie and Claire shared questions and prompts to deepen my thinking. For example, Valarie asked, *the virtual meetings appeared important to you—can you describe more about them in terms of your teaching?* Claire asked, *could you talk more about the first two themes you identified; technology/innovations and disconnect from students? What were your worries, aspirations and perceived successes and failures around these?* These questions and prompts allowed me to reflect on my teaching journal more deeply—this was particularly helpful to do at the end of the semester when I had finished teaching the asynchronous online course and I was able to see the bigger picture of the semester in hindsight.

Results

Results of this self-study aimed to answer the research question: *What are the success and challenges of teaching a fully online elementary science and health methods course?* Results suggest both successes and challenges related to my teaching as well as my personal life. These successes and challenges in my personal life impacted my teaching. In the following sections, I will first describe the successes I experienced during the Fall 2020 semester, and then I will describe the challenges I experienced in the same time period.

Successes Teaching Online

The opportunity to shift to online learning allowed me to achieve certain successes in teaching the science and health methods course. Coding of my teaching journal resulted in the following themes related to these successes: *innovation, use of technology,* and *planning for the future.* These codes were also evident in my Zoom™ transcripts, and in addition a theme of *considering context* emerged from the transcripts.

Data that were coded as *considering context* included reflections on the various circumstances of the COVID-19 pandemic with which the preservice teachers in my course were dealing. While I initially coded some of these as "negative," as they suggested challenges the preservice teachers were experiencing, I adjusted this theme to a positive one because I believed I was adapting my teaching to support the preservice teachers in my course. These circumstances not only included facilitating online learning experiences but also considering the various life changes the preservice teachers may have been experiencing, such as managing a different work schedule, supporting their children's own remote learning experiences, and/or adjusting to new learning modalities not only in my course, but also across their coursework. In our October 1, 2020 Zoom™ meeting, I stated:

> It models that…teaching is really dynamic and that…even people like us who've been teaching for a while we still have wanderings and we still are trying to do things better. And, you know, and then [COVID-19] happens and you have to totally change your (Valarie: Rules)…one thing I find myself saying to my teacher candidates a lot is, like, you're never done learning how to teach.

In the October 29 Zoom™ meeting, Valarie, Claire and I discussed how to support preservice teachers in the new and everchanging context of the pandemic, while still maintaining high expectations. One approach my university took was to ask instructors to consider "compassionate grading." Indeed, Gelles, Lord, Hoople, Chen and Mejia (2020) discuss the importance of compassionate and flexible pedagogy during COVID-19, in particular for women who faced "personal and gendered challenges" (p.1). This is relevant to my course as 29 of the 33 preservice teachers identified as female.

One of the successes I experienced in teaching online was that I was excited to make some

changes to my methods course. This theme that arose within the data was coded as *technology/innovations*. While the shift to online learning was a challenge to do so quickly, I was happy to be "pushed" to make some innovations that I had been considering for quite some time. Most prominently, I choose to focus on fewer topics to delve into selected critical topics more deeply. My goal was to focus on simplicity and access.

As mentioned previously, the two platforms I used to streamline the assignments and access for preservice teachers were Canvas™ and Google Slides™. I reduced the number of assignments in the course and focused on readings, the tasks in the notebook (which I saw as similar to what I had been facilitating in-person), and on developing strong pedagogical practices in the lesson plan. The course outline of topics remained largely the same compared to the topics I taught in the in-person format. I also focused on accessibility (namely, Canvas™ and Google Slides™) and on embedding multiple modalities into those platforms. For example, I embedded a simulator activity for a "student side" task card on observing Moon patterns—preservice teachers could either create a Moon journal for one month or observe the two simulators that were embedded in the task card. In my teaching journal I wrote:

> This week I planned a lesson I really like on Patterns of the Moon. I embedded an opportunity for simulators, so I am hoping the students enjoy checking out the moon phase simulators. I realized that September 26 [2020] was International Observe the Moon Night (https://moon.nasa.gov/observe-the-moon-night/about/overview/) and I wish I had known that sooner so that I could have had my students observe the moon that week. Also, the moon cycle started at the beginning of October so it would have been perfect for them to have done this activity last week rather than this week. Oh well, at least they can observe the rare "Blue Moon" (https://www.farmersalmanac.com/blue-moon-supermoon-2020-104546) on Halloween!

In addition to embedding multiple modalities, I also requested to meet with small groups of preservice teachers in a live and virtual format. These meetings occurred Wednesday, September 30 – Tuesday, October 5. Twenty five of the 33 preservice teachers attended one of the mid-semester small group meetings, while the other 8 completed the written reflection (26 of the 33 participated in the final small group meetings, largely the same preservice

teachers who participated in the mid-term meetings). Recall that when Valarie served as a critical friend, she asked me about the mid-semester virtual meetings I had with the preservice teachers in my course. It was a powerful experience to meet with the preservice teachers, as I was able to see their faces (if they chose to turn on their camera) and/or hear their voices, ask them how the course was going, and receive feedback on what was working for them in the course and how I could improve their learning experience.

For the purposes of another research study, preservice teachers were asked to turn off their cameras during the final virtual meeting in December. Preservice teachers largely stated that the organization and consistent format of the course was helpful. Regarding improvements, preservice teachers' suggestions included incorporating multiple modalities and being able to see examples/share one another's work. The preservice teachers in my course inspired me to be more innovative in embedding multiple modalities, I wrote in my teaching journal:

> Students reflected on digital notebooks recently and many have said that we can incorporate photos and video...Next week I am going to ask them to select one of a few options: photo, video, or maybe a drawing. I think that I can ask the students to share more and it will remain equitable and sensitivitive as long as I give them options (*Teaching Journal, October 28, 2020*).

While I was not able to incorporate preservice teachers' viewing one another's work in the Fall, I did so in the following Spring semester. The next paragraph includes more details about how my work in the Fall impacted my ideas for future teaching.

Another theme that emerged from the data included *planning for the future*. Shifting the course to a fully online format allowed me to reflect on what I was doing well in the course, and how I could improve the preservice teachers' learning and experience. I often reflected on how I would revise what I was doing in the Fall to improve it for the Spring, when I would be teaching one fully asynchronous section and one hybrid synchronous/asynchronous section. The teaching journal provided me with an opportunity to reflect regularly on my teaching and the experiences I was facilitating for the preservice teachers in my course. The mid-semester live virtual meetings with small groups provided preservice teachers an opportunity to reflect on their learning in the course and provide feedback on how I could improve their learning experiences. I offered a variety of morning, afternoon, evening, and

weekend meeting times, however since the course was fully asynchronous I felt that I could not require attendance at these meetings. I thus created a written reflection alternative to the virtual meeting. I realized that this was critical for honoring the format of the course, and I included this option for the fully asynchronous section of the course I taught the following semester. Thus, the feedback I received from these meetings was helpful for me in planning for the future. As stated previously, most preservice teachers attended the virtual meetings, and their reflections indicated that they appreciated the format of the course.

Furthermore, they indicated that they enjoyed the asynchronous format as they were juggling many responsibilities and shifts in their lives due to COVID-19 (e.g., change in work schedule, managing online remote learning for their children). As I reflected on these meetings, I thought about the aspects of online teaching and learning that were impactful and how I could bring those into my future teaching. I appreciated the variety of modalities I could bring into the course and wanted to continue using the powerful tools I had embedded into the online course. I appreciated the reflective stance I took throughout the semester—since I was developing the modules in Canvas™ not only as a new learning management system but also in the fully online asynchronous format, I was able to consider week by week how I wanted to design the course activities. For example, when I had the idea to use Moon pattern simulators I realized this was a great way not only to engage preservice teachers in a new modality, but also to model how preservice teachers could use such online tools in their own elementary science teaching. I also believe it was helpful to intentionally plan tasks that included creating schematics, charts, etc. for preservice teachers to organize and demonstrate their thinking. In fact, in Fall 2021 when the campus will be fully open for typical operations, I am excited to teach a hybrid (50/50 in-person and asynchronous online) methods course. The intent is to capitalize on the benefits of online and in-person learning.

Challenges Teaching Online

Despite feeling positive about the ways I was able to adapt the course to a fully online format, there were certainly challenges in doing so. I experienced a variety of general challenges (which were given this label in the data), such as increased workload, worrying about COVID-19 and the health of my family, being on "lock down" to protect myself and my family and missing typical life activities, and the effects of campus budget cuts such as furlough and a delayed opportunity to apply for a sabbatical at work. Indeed, in our Zoom™

meeting on October 29, I shared with Valarie and Claire that I had a lot of grading to do, as each week I provided feedback on both the notebook and the reflection for each preservice teacher in my course. My teaching journal also reflects this challenge:

> "Grading, grading, grading! So much grading! With [33] students submit[ting] notebooks and reflections each week, I am grading almost 70 items each week. It's hard to keep up" (*Teaching Journal, October 29, 2020*).

The most prominent challenges that emerged from the data include *uncertainty about my teaching*, *feeling disconnected from students*, and *juggling personal and professional roles at home.* Valarie, Claire, and I often reflected on how we felt like we were learning how to teach all over again—learning to teach online felt like a whole new way to teach the methods course. Indeed, throughout my teaching journal and the Zoom™ transcripts, I expressed uncertainty about the choices I was making in facilitating the preservice teachers' asynchronous learning experiences. Below is an example of the uncertainty I was feeling:

> I intentionally have streamlined the asynchronous course activities so as not to overload or overwhelm, especially based on feedback from last spring in which some students said that what I gave them to do was too much. But now I am worried that they could engage rather minimally and still complete the work. If they are not doing the hands-on activities at home, nor are they reading the readings, they could potentially engage in course activities for less than an hour a week. I am thinking about I can require more accountability without busy work or being a "helicopter teacher" (*Teaching Journal, September 3, 2020).*

I addressed the above situation by including a rubric for the preservice teachers' weekly reflections (see Figure 1). Within the rubric, I included depth of thinking and connections to the readings as assessment indicators. I hoped that this would make my expectations clear as well as provide more guidance to the preservice teachers beyond the weekly feedback I was giving them on their task card assignments.

Another challenge I experienced in the asynchronous online format was feeling disconnected from the preservice teachers in my course. In my first entry on August 25, 2020, I wrote:

> I suppose as always, the key is being flexible and open to feedback. My big concern is that I cannot gauge how students are doing or feeling in the course—in F2F situations, you can "read the crowd" or ask for immediate feedback through course discussion. In asynchronous learning students may be confused, annoyed, or overwhelmed and I could easily not know (*Teaching Journal, August 25, 2020).*

Weekly Reflection Rubric

Criteria	Ratings			Pts
Depth of Thinking	**5.0 pts** **Proficient** Each question in the reflection is answered thoroughly and demonstrates a depth of thought. The teacher candidate includes analysis, compare/contrast thinking, connections, and/or questioning to demonstrate critical thinking in their responses.	**3.0 pts** **Developing** Each question in the reflection is answered somewhat thoroughly and demonstrates some depth of thought. The teacher candidate may include some analysis, compare/contrast thinking, connections, and/or questioning to demonstrate critical thinking in their responses.	**0.0 pts** **Needs Improvement** Some or all of the questions in the reflection are answered only briefly and/or do not demonstrate a depth of thought. Analysis, compare/contrast thinking, connections, and/or questioning to demonstrate critical thinking is missing in the teacher candidates' responses.	5.0 pts
Connection to Course Activities and Readings	**5.0 pts** **Proficient** The teacher candidates' responses demonstrate clear engagement in the week's activities and readings. The teacher candidate clearly either completed the hands-on, minds-on activities or watched the video(s). The teacher candidate clearly read the required readings for the week carefully and made explicit connections to the readings in their reflection responses.	**3.0 pts** **Developing** The teacher candidates' responses mostly demonstrate clear engagement in the week's activities and readings. The teacher candidate somewhat clearly either completed the hands-on, minds-on activities or watched the video(s). The teacher candidate somewhat clearly read the required readings for the week carefully and made vague connections to the readings in their reflection responses.	**0.0 pts** **Needs Improvement** The teacher candidates' responses do not demonstrate clear engagement in the week's activities and readings. Is it not clear if the teacher candidate either completed the hands-on, minds-on activities or watched the video(s). It is not clear if the teacher candidate read the required readings for the week carefully and/or they did not make connections to the readings in their reflection responses.	5.0 pts
				Total Points: 10.0

Figure 1. Rubric for Weekly Reflections

While it is logical that I would feel this way without in-person interaction and communication, I was surprised at how challenging it was to build a relationship with preservice teachers and to support those who were struggling in the course. On September 8, 2020, I wrote in my Teaching Journal "I am experiencing challenges with online learning in that it is hard to gauge how my students are engaging in the class." Indeed, some preservice teachers reached out regularly with questions, and one preservice teacher even took me up on my offer to the class to meet one-on-one virtually any time to discuss questions about the

course and course assignments. Other preservice teachers, however, were difficult to reach even when I sent emails to check in about their progress or missing assignments. I thought that providing weekly feedback on their notebook tasks would support preservice teachers' thinking—and it appeared that it did indeed for some, but not for others. The mid-semester virtual meetings did support my connection with preservice teachers, as having the time to speak in small groups and ask each preservice teacher how the course was going was a powerful experience for me. Of course, I was not able to speak with all preservice teachers as some chose to complete the written reflection, and I would have liked to have met individually with the preservice teachers in my course to alleviate any hesitation they may have had to share their ideas in front of others. In part, I chose small groups because I thought it would help them to connect with one another as well as share ideas to spark their own thinking. In my teaching journal and in the Zoom™ transcripts, I reflected on the value of the virtual small group meetings. In the Zoom™ transcript dated October 15, 2020, I stated:

> I got to see a lot of their faces, so that was nice, for the first time. And really I just kind of checked in, like, how is your semester going, how's the class going, is there anything I can do differently, you know, those sorts of things. And then I actually went through the lesson plan assignment with them. So I shared my screen and went through the lesson plan assignment because that's kind of the big assignment for the semester. And I wanted to be able to explain it kind of in person. And then also, you know, allow an opportunity for questions, so [it went] pretty well *(Zoom™ Transcript, with slight grammar revisions due to auto-generated transcript, October 15, 2020).*

In these meetings, I was also able to receive feedback from the preservice teachers about their learning needs. For example, one preservice teacher indicated that he wanted to view more video of science teaching. I thus included video in a subsequent lesson[s] using online resources, such as "Ambitious Science Teaching." In my teaching journal, I noted "Students reflected on digital notebooks recently and many have said that we can incorporate photos and video" (*Teaching Journal, October 28, 2020*). I was hesitant to include this because I was aware of the sensitive nature of asking preservice teachers to share video of their home environment. I therefore offered video or audio responses as an option but did not require them.

The final and perhaps the most profound impact I experienced was a personal one. This

element was in fact somewhat negative but also positive, as it involved working full time from home as a mother. Once campus closed and all faculty, staff, and administrators were required to work from home, I found this transition to be both helpful and challenging. My young twins had not been in daycare and therefore my husband and I were accustomed to having our children at home with us.

Before the COVID-19 pandemic, I went to campus regularly for teaching and advising. On the one hand, it suited my personal life of being a mother quite well to have the flexibility of teaching an asynchronous course. I typically worked on the week's modules on Saturday and Sunday and recorded the instructional videos thereafter. I posted the modules on Mondays for preservice teachers, and they had until the following Wednesday to complete the tasks in the module. I tried to record the instructional videos on Sundays, but sometimes I posted the module with a message of "coming soon" for the video, and then posted them as soon as I was able to record them.

Finding time to record the videos was difficult, as I wanted time to prepare myself to do so and I needed a quiet space in my home. I could provide feedback to the preservice teachers on their notebook tasks and weekly reflections throughout the week, typically in the morning before my children were awake or during their naptime. This flexibility was very helpful, and in fact quite a few of the preservice teachers in my course also indicated that the asynchronous format was helpful for their lifestyle, which often included work, supporting their children with online remote learning, caring for others, etc. The challenge that existed with working from home was the result of blurred boundaries between work and home responsibilities. In my teaching journal, I wrote:

> "There isn't a clear 'just finished teaching' moment through the online asynchronous format as there is when I am teaching face-to-face in which there is a logical time to reflect on the course" (*Teaching Journal, September 14, 2020).*

My husband was also working from home full time, and we had to balance meetings and other work responsibilities while taking turns being with our children. There were times when I turned on PBS Kids™ so that my children could be in the room with me, watching something educational while I was in a virtual meeting and my husband was also busy working. While my husband and I had rather firm ideas about limiting "screen time," I often

planned my children's time in front of the screen around my work responsibilities. I was also that colleague whose children came into the camera view during a meeting—I am lucky that my colleagues are all very gracious and understanding, and never seemed to be bothered by my children showing up on camera. On the contrary, my colleagues often greeted my sons when they appeared on camera. Despite this grace, I still often felt stressed out when my children began talking to me during meetings, and I remember thinking that they always seemed to talk to me right when I unmuted my settings to speak during a meeting. I found myself trying to schedule meetings during my children's naptime so that I would not be interrupted. Furthermore, my husband and I were very cautious about COVID-19 and strictly adhered to social distancing protocols. I remember feeling cooped up in my home and missing my transition time in my commute to and from campus. I found it challenging to switch quickly between meetings (logging off one meeting and immediately logging on to another) as well as immediately switching between work and mothering tasks. In my teaching journal I wrote:

> This past week was particularly challenging juggling my work and mommy roles, for some reason this week (I think it is just catching up to me) I had a hard time switching back and forth throughout the day between work and mommy mode. [My husband] and I have to take turns with our work meetings, and then fit in all of our other work in between being with [our children], cleaning the house, dealing with other things like bills, etc. Previously (pre-COVID), my time was more "chunked"… with the boys napping less it feels like my time is rarely undivided, other than my morning time when I wake up at 5:30 to get a couple of hours of work done before the boys wake up. I am looking forward to a rest and a break over the winter holidays! (*Teaching Journal, October 5, 2020*).

I also spoke about the challenges of balancing work and home life in the Zoom™ meetings with Valarie and Claire. Although Claire's children are older than mine, we both shared challenges we experienced working from home while our children were also at home. Valarie shared her experiences supporting her son through the pandemic, in particular as he managed a university life—this was also a critical part of motherhood though her son no longer lives with her. Valarie and Claire's reflections on their own families made me realize that we were all navigating new territory of motherhood as the COVID-19 pandemic impacted everyone's lives, albeit in different ways.

Discussion

Despite the challenges I faced teaching a fully online methods course, I was able to see the positive aspects of teaching online. Moscovici and Osisioma (2008) discuss typical topics addressed in an elementary science methods course, and many of these are topics that I kept in the course in the transition from an in-person to an online format, for example, teaching science as inquiry (in this case, the science and engineering practices [NGSS Lead States, 2013], learning cycles, integration of science within other content areas, and common alternate conceptions). I aimed to keep the components of the course that were effective in the in-person format of the course I taught but pared down the requirements of the course in order to focus deeply on key aspects of the methods course. While I streamlined the platforms I was using and the assignments preservice teachers completed, the topics of the course remained largely the same compared to the in-person format.

In the online format, I aimed to maintain a similar level of engagement to that of the in-person course by asking preservice teachers to either complete investigations at home or to watch video of me engaging in these investigations. As stated previously, Treagust and Tsui (2014) shared common approaches to science methods courses. In alignment with this review, I tried to maintain these approaches through the task cards on Canvas™ to engage preservice teachers in demonstrations (via video), explanations, (via claims, evidence, and reasoning), questioning, scientific reasoning, and representational thinking (via at-home investigations or simulators). The compilation of lesson plan assignments (lesson plan draft, final revised and annotated lesson plan, and lesson reflection) served as a "final exam," wherein I assessed preservice teachers' learning in the course. The lesson plan template includes specific mention of course topics, for example in the Explain phase, preservice teachers are asked to embed a discussion that includes claim and evidence statements.

Similar to Brown (2020) and Gilles and Britton (2020) I had to switch to teaching science methods in an online format quickly due to the COVID-19 pandemic. Brown (2020) stated that she used Blackboard™ as a resource that she already had in place, and embedded innovative technologies such as Flipgrid™ to enhance her preservice teachers' online learning experiences. I, too, utilized the learning management system to facilitate online learning experience, and I was confident that my mathematics methods colleague was providing preservice teachers critical experiences working with a variety of innovative

technology tools. I chose to focus on the digital notebook and the Canvas™ "Pages" task cards as the central facilitation tools for my online course. Similar to Tomas et al. (2015), I found that clear, direct instructions were critical, and that organization of the course was imperative to the preservice teachers' learning experience. I utilized video to record instructions for each module, and I believe this was helpful. I did find, however, that this, along with a lot of grading/feedback, resulted in an increased workload.

Considering context was an important aspect of teaching during the COVID-19 pandemic and allowing flexibility while maintaining rigor seems to be a critical element of online teaching. The online asynchronous format allowed me and the preservice teachers in my course the flexibility to complete weekly tasks related to the course throughout the week. Hudson (2006) noted this benefit of online learning, indicating that online learning allows preservice teachers to adapt to various other life commitments. While for me this posed a challenge by somewhat blurring the boundaries between my work and my home life, it also allowed me to spend time with my children at home and work at times that I may not have previously worked (i.e., early before my children work up in the morning).

Indeed, I noticed that by no longer having to commute to campus (usually a 45-minute trip each way), I was able to get a lot more work done, especially in the mornings. I believe this context actually increased my productivity. For some university contexts a fully asynchronous course may be a benefit to preservice teachers who are also juggling a variety of responsibilities. To me, the key is providing rich and robust learning experiences in this asynchronous format. I am not certain I fully achieved this in the Fall of 2020, but I was happy with the successes I experienced in working toward a more powerful asynchronous online teaching and learning experience as I continued to adapt in Spring 2021 and will continue to do so moving forward.

Conclusion

Results of this self-study indicated various successes and challenges to teaching fully online in an asynchronous format. While I was pushed to innovate and update the modalities of my methods course, I embedded more technology and focused on flexibility, simplicity, organization, and access. The reflections in which I engaged throughout the semester provided me an opportunity to consider which of these innovations I would keep in the

methods course once returning to an in-person format. I am excited to teach a hybrid in-person/online elementary science and health methods course in Fall 2021 to take full advantage of the benefits of each format.

In addition to successes within the online teaching format, there were also challenges including uncertainty about my teaching, feeling disconnected from the preservice teachers in my course, and juggling personal and professional roles at home. These challenges were at times overwhelming, however the self-study allowed me to not only reflect on them throughout the semester, but also to receive support and feedback from Valarie and Claire. The bimonthly meetings with Valarie and Claire were like a support group, as we all shared our experiences with teaching online. I recall a meeting wherein I was struggling with how to ask my preservice teachers to teach the lesson they were going to plan, and Valarie suggested having them teach it to an adult if they did not have a way to interact safely in-person nor online with a child. I thus offered my preservice teachers the four options to either teach their lesson to a child or an adult with whom they could safely interact or to either one online (i.e., live and virtually). This support helped me to reflect on my successes and challenges and gave me ideas about how to improve the online learning experiences I was providing the preservice teachers in my course.

Recommendations

This self-study research allowed me to delve deeply into my experience teaching a fully asynchronous online elementary science and health methods course. The bimonthly virtual meeting reflections with valued colleagues who served as critical friends allowed me to share and obtain ideas for how to improve my teaching. Based on these insights, the following recommendations for teaching a fully asynchronous online elementary science methods course emerged: a) find ways to connect with preservice teachers in the course; b) provide clear and organized directions; c) explore ways for preservice teachers to engage in multiple modalities; d) aim to balance and/or set boundaries between work and life responsibilities; e) consider finding a colleague with whom you can reflect and share ideas.

Although I felt disconnected from the preservice teachers at times, in particular when they were not completing their course tasks in a timely manner and/or not demonstrating critical thinking in their responses, I was able to connect with the preservice teachers in the course

who participated in the virtual meetings. The meetings allowed me to "meet" them and hear about their experiences in the course. Furthermore, I was able to adjust my teaching to meet their needs. Preservice teachers indicated that providing clear and organized directions and in particular the consistent format of the course and the video overviews of each module were helpful. Thus, similar to Tomas, Lason, Field and Skamp (2015), I found that clear directions and instruction that included a video overview of each module was a critical aspect of the online learning format. Although the weekly assessment and feedback I gave was overwhelming to me, it did allow me to regularly gauge the preservice teachers' thinking and progress in the course. In the future, I hope to find effective ways to manage this critical feedback for preservice teachers. In Spring 2021 I tried the "peer review" feature in Canvas™ for one week's assignments (notebook and reflection) but either due to my lack of experience or the design of the feature, some of my preservice teachers and I found it to be a bit unclear. My hope is to continue exploring this feature in the future, as my preservice teachers did mention it was helpful to see and review one another's work.

Preservice teachers inspired me to include multiple modalities, and in fact I continued to do so in the Spring semester. I realized that I needed to encourage preservice teachers to respond in their digital notebooks in ways other than writing, and video and audio responses later were powerful. While teaching asynchronously appears to have many benefits, such as being able to engage preservice teachers in a variety of modalities and offering flexibility, one area that was critical for me was to explore balance and boundaries between my work and personal life. This is an area in which I continue to strive, however one strategy I plan to employ is to "chunk" my time, or set times when I will work and when I will shut off my computer and take a break from grading and answering email. Finally, Valarie and Claire were pivotal aspects of my experience teaching online, as we were not only able to offer advice and to listen to one another throughout the process, but they both served to support me and validate my feelings. I remember them saying "You must be busy with twins at home!" and I remember thinking, "Yes, I am!"

In conclusion, while it was challenging to connect with preservice teachers in a fully asynchronous format, I enjoyed the opportunity to work with them through somewhat familiar platforms such as Canvas™ and Google Slides™ as well as to meet with them virtually. Furthermore, I made changes to the course for Spring semester that allowed more interaction, such as asking preservice teachers to upload photos, audio, and video responses

to their task cards. My intention is to my own include audio feedback within Canvas™ in the future. I am excited to teach a hybrid in-person/asynchronous online course in Fall 2021 in order to maximize the benefits of both course formats.

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Chapter 8 - Wholehearted Lessons: Developing as a Teacher Educator During a Global Pandemic

Claire Cesljarev, Valarie Akerson, Ingrid Carter

Chapter Highlights

- Developing as a teacher educator while attending graduate school while being a mother is a precarious balancing act.
- Teaching an online secondary science methods course 100% online during the COVID-19 pandemic negatively affected teacher educator-efficacy as pedagogical tensions arose.
- Pedagogical dissonance was further increased from pandemic related stressful events in my role as graduate student and mother. Lower teacher educator-efficacy was also attributed to technological anxieties.
- Understanding the holistic needs of a teacher educator is important in repositioning teaching in support rather than stress.
- Teacher educator well-being is critical for preparing preservice teachers to model mitigation of stress and anxiety leading to productive and supportive learning experiences.

Introduction

In March of 2020, I was deeply anchored into my third year as a doctoral student in education. As a scholar of curriculum and instruction with emphasis on science education, my graduate assistantship position of teaching secondary science preservice teachers in a methods course brought me a great amount of joy and satisfaction. After all, I was given the opportunity to do what I loved most, teach science, but this time from the perspective of a teacher educator. I was so encouraged at my progress in learning about preservice teachers' particular educational needs and my graduate coursework served to support my theories and challenge my practices. My seminar in equity in science education was one such course and was the last class I attended on the second Friday in March. As we bid adieu for a week of spring break, we knew the chances of coming back to school were steadily declining due to COVID-19 infection and death rates excrementally climbing to a precipice of viral outbreak in the U.S. The university indeed shut its physical doors during that recess and after a double-sized break, teaching and learning at the university moved online. While we maneuvered through the last weeks of the spring semester of 2020, my thoughts were anxious, my professors were lenient, my students were graceful, and somehow we finished the semester. The following summer break provided a respite from teaching and course work but due to continuing isolation, uncertainty about the future, and worry of physical and emotional health for myself and family, it was anything but a relaxing holiday.

That autumn, I was to teach a secondary science methods class as part of our preservice teacher program at the school of education. This course was slated to be a hybrid class on meeting in person one day of the week and online another. After several of my students shared personal and family health concerns about gathering in person, I consulted my overseeing course professor and we decided that the science methods course would instead meet 100% online. It was after this decision was made that I was presented with what would be the biggest challenge in my graduate career. Sleepless nights ensued as my graduate student/mom/teacher brain went into overdrive. Would I have to dismiss my own inquiry and experiential focused pedagogy? Would I be able to recreate productive experiences online in which my students could recognize the enormous value of having a nature of science foundation on which to scaffold their developing pedagogies? Furthermore, was I really even achieving this anyway, back in my pre-pandemic campus classroom? This line of thaught led me down a proverbial rabbit hole in which I questioned my very existence in the PhD

program. Could I really do my best work in graduate classes or would I have to lower my personal educational standards? Was I prioritizing myself over my children in a time of global crisis? Did I really have the emotional endurance to support not only my own two teenagers but also my students while experiencing devastating empathy in witnessing these precious young, effervescent, and expanding lives sidelined indefinitely? It was from this mind-set and context that my research question was born:

Research Question

How was my development as a teacher educator influenced by teaching an online science methods class from home while navigating multiple roles of teacher educator, graduate student, and mother during the second semester of the COVID-19 pandemic?

Literature Review

Online Teaching

The rapid transition to online learning at the onset of the pandemic presented technological and instructional challenges unlike anything experienced in education in the U.S. Instructors with little to no experience teaching online fared worst (Sunasee, 2020), likely being caused by inexperience (Giles & Britton, 2020) and low digital competence. Digital competence can be described as a group of skills, knowledge, and attitudes employed when using digital devices to perform responsibilities such as online teaching and learning (Adedoyin & Soykan, 2020). Digital competencies are embedded in pedagogical content knowledge (PCK) which can be framed as knowledge of principles and pedagogical foundations needed to enact meaningful online curricula (Rapanta et. al., 2020). In the move to online education, useful information was abundant if not overwhelming making the starting weeks of online teaching even harder (Sunasee, 2020). Logistically, basic conditions of a good connection to the internet, IT training, and adequate equipment were imperative to teaching from home (Popa, et al., 2020). Even with these in place, the Zoom platform presented technological challenges for instructors and students trying to adapt to the new learning environment (Sunasee, 2020). From effort to replace the "*dynamic nature*" of face to face interactions with a virtual environment arose provocations such as uneasiness with breakout rooms, threats of Zoom bombings and connectivity issues (Sequeira & Dacey, 2020). The ability of the platform to replicate face-to-face instruction is unclear, one study found that students became

disconnected with their student identities while another discovered that the Zoom interface had a positive impact on learning experiences (Sequeira & Dacey, 2020; Mohamad et al., 2020). Brown (2020) was not fearful of teaching an online science methods course due to experience with tools such as white board applications but noticed great limitations with facilitating natural world experiences critical to the teaching and learning of science. In addition to the technical elements of hindrance in teaching during the fall of 2020, the COVID-19 pandemic became another daily element interrupting online education.

Pedagogical Considerations for Online Science Teaching

Bloom and Fuentes (2020), speak of the COVID-19 outbreak as an opportunity for getting a pulse on scientific literacy. Mitigation strategies proven effective in the fight against the virus were met with misinformation campaigns successful in casting doubts about wearing masks and social distancing. One of the reasons that these scientific understandings about viral processes were so easily up for debate in the general public could be attributed to limited understandings of how scientists go about their research. For example, the process of scientists making claims based on evidence gathered from observations and inferences followed by a peer-review intended to vet the original claims is not adequately understood among many people who are not in the field of science research. The confusion around physiological processes of viral interactions with their hosts raised the stakes for science-methods teacher educators already attending to low rates of scientific literacy (Roberts & Bybee, 2014) in an era where science denial in climate-change realities, vaccination safety, and the effects of genetic modification on people (Rutjens, et al, 2018) was already being propagated. Diminution strategies for COVID-19 were rebuffed and in the U.S. executive and legislative branches, scientific knowledge often took a backseat to *antiscience conspiracy beliefs* promoting political ideologies (Rutjens, et al., 2020; Gauchat, 2012). The pandemic increased urgency of transmission of science teacher pedagogical practices best suited for the uptake of scientific understandings and applications.

Five principles of high-impact teaching for online education are appropriate relevance, effective delivery, sufficient support, high-quality participation, and contingency plan preparedness (Bao, 2020). Student engagement (which can be characterized as a psychological investment in and effort towards learning and mastery) is very important in online university learning as opportunities for connections are lost with abandonment of in-

person learning (Martin & Bolliger, 2018). Innovative pedagogies for distance learning can alleviate anxiety and improve learning outcomes (Unger & Meiran, 2020). A student-centered approach supplying a wide range of activities is important for successful online instruction (Tartavulea, et al., 2020). The adaptability of professors in an online learning environment can lessen student concerns around lack of flexibility and interactions, and a lack of a feeling of belonging to a community (Popa, et al., 2020). Due to the experiential nature of science learning, course disruptions presented particular challenges for science education (Day et al., 2021). Scientific inquiry, for example, typically relies on field activities occurring in laboratory or natural settings; these environments and scientific pursuits should be replicated as it is possible for students of science (Barton, 2020). As researchers found in another self-study, knowledge about inquiry does not necessarily translate into being able to *do* inquiry (Bowen et al., 2016). So, the prominent difficulty with emergency remote learning was continuing to provide interactive learning experiences that model constructivist approaches for preservice teachers in science methods courses (Wu, et al., 2020).

Secondary Stressors

Similar to a natural disaster, COVID-19 set off a series of adverse events. For example, a high-magnitude earthquake initially exposes one to destructive quakes and aftershocks but subsequent *secondary stressors* can also be debilitating as survivors grapple with losing their homes, insurance difficulties, and stalled rebuilding efforts. For instance, unmet mental health needs after a disaster were found to be of major disturbance for university staff persisting to fulfil academic, teaching, clinical and administrative roles after one such earthquake (Bell, et al., 2016). Analogous to a natural disaster's initial devastation and the onset of secondary stressors, COVID-19 not only filled hospitals and took lives but also catalyzed the advent of unique secondary stressors unprecedented in pre-pandemic times. Emergency remote teaching and learning was improvised rapidly and for teachers working online from home, secondary stressors mounted (Rapanta et al., 2020). The impact of the virus on academic mothers was acute, being disproportionately greater than for academics in general (Fulweiler et al., 2021). For mothers who were also graduate students, the juggling act was messy. The following graduate student/parent perspective illuminated the challenge: "During the first 3 weeks, I was struggling and my kids were confused. Instruction from the school kept changing and my own tasks were neglected. I needed a strategy" (Bal et al., 2020, p. 796).

Method

I utilized a self-study approach to understand how teaching my secondary science online methods course during the pandemic affected my development of becoming a teacher educator. Self-study can be characterized as an systematic and intentional inquiry into one's own practice (Gatzeke, et al., 2015) and are often utilized to *come to terms* with the changes that occur with the shift from a K-12 or teacher to a teacher educator (Wood & Borg, 2010). The ability of this methodology to be a tool in understanding my own practice, situated in my personal context, made it well suited for the semester of online teaching from home in quarantine. The self-study methodology also helps educators to understand the tension that exists between self and the *arena of practice* (Bullough & Pinnegar, 2001). Therefore, this methodology was particularly suitable to employ in a semester in which that *arena of practice* literally got closed into my house with the only source of connection to my students (and professors) being my desktop and internet connection. Self-studies seve to help new teacher educators explore the dissonances they could experience between "telling and learning" or the struggle to find appropriate methods in which to help preservice teachers develop a solid pedagogical foundation (Loughran, 2006). Teaching online in an emergency context created a situation where the dissonance became multi-faceted now to include finding appropriate methods in which to teach future science teachers outside of the classroom laboratory and with no access to the field. Perhaps contextually most important, self-studies create a *promise of recognition and a connection*, forming a space for readers' to understand their own experiences in light of the researcher's reports (Bullough & Pinnegar, 2001). This recognition and connection is of value for teacher educators and all teachers allowing us to unpack how the pandemic and online teaching influenced not just ourselves but how these experiences can create understandings of the collective experience in education during the COVID-19 pandemic and post-pandemic world.

Context of Fall Semester Teaching

This self-study was situated in the online teaching environments of my science methods course for preservice teachers in secondary education. As mentioned in the introduction, this course was intended to be hybrid and moved to 100% online learning with a week to go before the start of the semester. This would be my third time teaching this particular course and the first time teaching it virtually. The class was composed of 13 students, roughly half of

whom I had taught in the spring semester of 2020. In addition to the teaching context, the study was positioned from my role as a graduate student with 10 hours of online course work and a mother of two teenagers who were attending school from home, in an online format. Usually, there is a field component in the secondary science methods in which the students are afforded experiential opportunities in local science classrooms to work alongside practicing teachers. However, in the midst of the crisis, as local school districts moved their student populations to online learning and were no longer able to support tertiary educational goals. The field experience was cancelled or replaced with a tutoring session on Zoom. Therefore, in addition to moving the traditional science methods coursework online, I needed to find ways in which to best replicate classroom field experiences in the online environment.

Data Collection and Data Sources

The data were collected through three sources, with two of these collected continuously throughout the 2020 fall semester. These sources included a journal completed by me with weekly entries and transcriptions of bi-monthly critical friends support group meetings. The third source was a video and transcription of the critical friends journal review meeting at the end of the semester. The critical friends support group meetings were thus named after I understood how beneficial these meetings would be for my research but for my emotional well-being. The critical friends group served as a place where three of us were in the same position of switching our teaching to comply with COVID-19 requirements, and conducting self studies on our experiences. My bi-weekly meetings with my critical friends (coauthors on this chapter) became a highlight of my semester. These meetings allowed me to engage in helpful dialogue about my experiences and build understandings from these conversations (La Boskey, 2004).

Data Analysis

The analysis was interrelated with the data collection through continuing critical friends support group meetings in which dialogue helped delineate and challenge emerging themes in the journal and support group meeting conversations. Data pieces were then compared by incidences of expression related to each thematic category looking for the most and least common themes that appeared (Creswell & Miller, 2000). Triangulation of multiple data collection sources established validity by procedurally searching for convergences among

these sources to identify themes (Giles & Buck, 2016). At the culmination of the semester, analysis continued by identifying the most repetitive, similar, and different expressions across the data-sets to identify thematic categories. Next, critical friends were employed to read and reflect on the completed journal, increasing awareness of some common ideas and themes while challenging others (Nyamupangedengu, 2016). The critical friends journal analysis meeting served to establish thematic categories (Ryan & Bernard, 2008). Validity was further supported by the process of open-coding for characterizing expressions consistent with or disconfirming of the established thematic categories (Creswell & Miller, 2000). Two data sets (the journal and transcripts from critical friends support group meetings) were then analyzed chronologically to observe trends and relationships in categorical themes as the semester progressed.

Results

The expressions compiled across data sets led to the identification of three thematic categories associated with my development as a teacher educator in the fall semester of 2020. These thematic categories were labeled: pedagogical dissonance, secondary stressors, and technological difficulties. In the following sections, I describe the labels and characterizations of the thematic categories with evidence derived across the data sets.

Pedagogical Dissonance

Curriculum and Instruction

The most prominent theme that arose from the data was pedagogical dissonance with the majority of expressions indicating that my practices and pedagogy were in a greater discord in that semester than any other time in my three years as a graduate assistant and my tenure as a middle school science teacher. In the fall semester of 2020, my flattened teacher educator-efficacy made me hyper aware of my shortcomings and belief in a lack of ability to provide a rich and robust science methods course for my students. My journal from September 1st indicates that I felt like I needed to reinvent my entire course due to the switch from the hybrid model to 100% online instruction:

> I am in the second week of teaching class and I have already realized how much my entire focus needs to change. I digress. When I thought I was teaching a hybrid situation, I was preparing to teach an entire unit on Ecology, with the two-fold result of

> modeling a unit plan execution while also delivering content for subject acquisition.
>
> Due to covid-19 and the uncomfortably expressed by many of my students (a couple are not even in town), I ended up going to a 100% virtual class. We Zoom on Mondays and do a CANVAS discussion on Wednesday. I am quickly realizing that I will not be doing any science! Well, one demo video to show them the expectations for making their own. Maybe.

Evident in the last statement above, the inability to model science teaching from the classroom and field context had me stumped. It felt like a square peg in a round hole situation as I grappled with how to provide experiential and inquiry based experiences for my preservice teachers in an online forum. This pedagogical dissonance became a thread running through the data as I continued to ponder how to best facilitate curricula development and model effective lessons. My journal entry from September 25 is evident of my befuddlement of proper methods in which to deliver important lessons:

> So, I am really pushing my students to create a PBL unit through backwards design and also incorporating the 5E model for lesson planning. I SO want to model this 5E lesson plan but really can not figure out a way to do it without taking up way more time than I have to video the whole thing with my kids and their friends. That is really what I would love to do this weekend as I have rockets I would love to launch! Also, I have really great stations for exploring Newton's laws of motion. I also have a lovely practical assessment that I would like them to see.

Teacher-Student Disconnection

Curricular planning and facilitation of my science methods class in an 100% online setting was certainly a conundrum for me, and part of this stemmed from my sense of disconnection between me and my students. I was not convinced that I would find ways to establish relationships conducive to authentic engagement. This engagement to me was so important to establish a safe and productive space in which to develop as educators. The following excerpt from the September 28 journal entry describes my awareness of teacher-student disengagement:

> The students whom I don't know from last semester are very hard for me to engage with. I actually had a few stay on Zoom after class and that was really nice for them to ask questions and for me to get to know them a little bit.
>
> I think I will keep class open after from now on, but I know only students with questions will stay on unlike in person, where we may just have a conversation. I wonder how I can "create" this space online. I am teaching in-person next semester and CAN NOT WAIT to actually be able to do science and be face to face. Mask to mask.

On October 21, I was trying to decipher just what it was about Zoom that promoted this disconnection with my students and my thoughts reflected my high levels of frustration of not being able to connect with my students. I did not meet a student on campus and never would have or even remotely discuss this with them, I maintain a high morality of conduct as a teacher educator and graduate student. Rather, I include this quip to highlight the sense of desperation I was feeling mid-semester to repair faulty communications with my students in order to help them through the course work.

> I want to be able to help my student get through this because it's not that hard and I really think if I could just meet him in person, it would be so much easier to explain things. Agh. I don't know what it is about the Zoom that doesn't help me communicate… I don't know, I suppose there is a body of research on this but what I do know is that I REALLY DO NOT like teaching online.
>
> I'm going to see if my student can meet me on campus, I don't care if it's against the rules. I will social distance and wear a mask outside.

In-person Teaching Bias

In the aforementioned journal entry, my bias for teaching in person is not subtle in depiction. In fact, from the beginning of the semester to the end, this clear proclivity to in-person science teaching and distaste for online science learning persisted. I tended to blame the online format for a cacophony of problems that seemed to reverberate through most of the factors associated with teaching a semester-long methods course to include: instructional

strategies, logistics, student concerns, and classroom ecologies (a holistic and equitable interpretation of classroom management).

As a teacher educator trying to simulate what classroom interactions might look like, I have found that incorporating role-play into the secondary methods classroom provides experience for the person in the teacher role and also opportunities for the rest of the class to engage with teenage science student perspectives. I thought role-play over the internet could serve well in the simulation of teaching but the activity was unsuccessful and I held the online environment at fault as I reflect on in the following journal entry from November 2 or as I put it, election eve:

> The students who I do know seem to act differently, more serious, than last year. This could be due to current times/stress or maybe the format of Zoom but probably both. It is really hard to get any role play going, like we did last year. I am right there with them, I have lower energy teaching online.

In the fall semester of 2020, one of my most respected former science teaching partners was gracious enough to be a guest speaker addressing particular questions about teaching middle school science. I've had many guest speakers visit my classrooms over the years and always look forward to the social and professional interactions I have with them. Also, I am confident in my ability to facilitate the day in a way that makes the guest feel comfortable and is of significant curricular value. Additionally, I had no reason to worry because our guest speaker was my friend and I knew she would be there. Clearly, though, I was fraught with anxiety. This new experience of hosting a guest online must have been at play. Not only did I find that Zoom was responsible for my low energy as mentioned in the previous entry, it was also a culprit in my unusually high anxiety level as evidenced below:

> I am so nervous for class to start, I have a guest speaker and she has not gotten back to me. It occurs to me that this feels very different then if she were to be joining us in the physical classroom as I would have given her a parking pass, directions etc.. right now she seems to be out there in space and I'm all worried about how to actually do it. Share screen with our questions? Invite students one at a time to ask? Use the little blue hands? Why am I so nervous? I never would be in the physical classroom, not like this. Maybe it's a lack of physical movement, I would be walking upstairs, to the classroom

> etc., this energy needs to go somewhere!

Along with logistical anxieties, limited ability to address student concerns was also attributed to not being in the campus classroom. I thought that in a face-to-face situation, I would be able to achieve fruitful dialogue supporting effective teacher-student reflections, feedback and discussion. This is exemplified in the September 21 journal entry:

> One of my students was asking me about his field experience….he needs a lot of direction. I suspect that if we were in person, he would have stayed and we could still be talking about it. Man, do I miss teaching in person.

With years of experience teaching in the classroom setting, I was pretty confident of the inner workings of creating a climate of community, respect and responsibility. As a teacher educator, I found that redirection in the university classroom could often be accomplished with the same nuanced actions and gestures that I called upon in the middle school classroom. For example, just as a middle schooler who is misusing lab equipment can be encouraged to redirect their actions with close proximity, it is also helpful in stimulating cooperative engagement in my science method courses. A quick walk by, stop, and listen sometimes is all it takes to compel students to dig deeper in collective thought. I did not feel successful doing this online.

Secondary Stressors

I was able to sub-categorize the secondary stressors as being associated with my role as a graduate student, role of mother, and my personal well being. However, the stressor expression indices were hard to tease out from one another in the data. More often than not, such indices wove throughout the expressions of secondary stressors.

Role of Graduate Student

In academia, finding the balance between conducting research and teaching courses is seemingly impossible. Everywhere from research and webinars to workshops and social media advice is plentiful. Such declarations of reaching this precarious balance might sound like, *carve out time to write every day!* or *your students should be working harder than you*

are! Include graduate coursework to research and teaching duties and the balancing act becomes an exercise in learning how to juggle. Of course, balls are dropped but in my third year of graduate school, I was feeling good about my ability to balance the workload. I was able to notice patterns in the semester in which I would need to pay attention to one part of my life and let up just a bit on others.

For example, summers were devoted to developing my syllabus and planning my semester of teaching while working on research projects. The beginning of the semester was often when my mental attention was primarily on my children. At this time, they had recently started their own new semesters in middle and high school and needed extra support in these transitions, experiencing the typical nervousness and fears children and adolescents have at the start of a new school year. As any graduate student could tell you, when midterms roll around, coursework amps up and the great slide into finals begins. Pre-pandemic, I found plenty of time to lock myself away in a library or my home office and get it done. With my semester coursework managed, I could then turn focus toward teaching. Just in time to provide the large amount of support and feedback my students needed as they finished final projects. At the end of the semester, my finals and grading would be completed, and I would come full circle back to a holiday break where mothering, once again, took the front seat.

But in March of 2020, I had to drop the act and finally admit to myself that I was indeed, in survival mode. I could no longer sustain the juggle of my teaching, parenting, and student roles. Self-care had rolled away. In an effort to figure out how to redistribute my time and attention based on new crisis-driven priorities, it was my course work that suffered the most. This is first mentioned in September 11th's journal entry when I say, "I'm really trying to find this balance with the class I teach and my own course load. I'm finding that I have to protect my time, from myself!"

In addition to losing balance, I felt a sense of disconnection with my fellow students and professors. As a graduate student, I've always relied on these connections to help me conceptualize new concepts and theories in social learning situations. I thrive in an educational environment steeped in productive collaboration. I also simply find joy and intellectual stimulation through casual conversations with fellow students and my professors. Before, field experiences were my favorite opportunities to learn science content, how lucky I felt to make observations and collect data on a walk in the woods with an authority in

ecological sciences. Online class sessions stripped away all of these social aspects of cognition as described in my September 11th journal entry:

> My course work seems much more intense than in any other semester and although climate change...is a tough class, I just know it would be so much easier in person. I already feel like a fish out of water in my [environmental and public affairs] classes but was coping by positioning myself in the front, and meeting others in the class who I could ask questions of. There are a few people in the class that I know, thank goodness because there is no way I'm going to get to know anyone on Zoom. Even the group I'm working with, it's so hard to put my finger on why I feel so disconnected because we Zoom as a group, but I do. I'm thinking it's because of the light banter at the beginning of class, the interactions during and follow up questions I don't ask on Zoom that I would have asked in person.

I also was feeling pretty low about the social unrest and political climate in the world. I could not ignore the parallels between my coursework and socio-political life in the U.S., could not and found it to be very disheartening. The following is also from September 11:

> It's hard to motivate myself to complete the large amount of course readings, and put down my teacher educator duties to concentrate on my classes. Admittedly, I also found my climate change and history of American education to be interesting but depressing.

I was having a really tough time prioritizing my role as a graduate student in the fall semester of 2020. The precarious balance that I had found between my role as teacher, mother, and student in the first years of my PhD program had fallen to the wayside. Feeling disconnected from my student-peers and professors added to the sense of isolation and the coursework which I used to find so interesting and important felt heavy and burdensome as I implemented tactics for my new mode of operation which was survival.

Role of Mother

The decision for me to go back to graduate school was not taken lightly by myself and my husband. We have always prioritized our children in making career changes, stiving to make decisions that are consistent with what we feel is best for their daily lives. The first year of

my program was definitely a hard transition. As my husband took on the lion's share of the housekeeping responsibilities we both began to understand the profound effect my program would have on our routines. As I moved through the first few years of graduate school, we eventually fell into a rhythm that was working for everyone. Then, the viral outbreak and subsequent quarantine changed everything. We knew we needed to revise our roles as we prepared to live, attend school, work, and play together.

However, during the pandemic, knowing what you needed and being able to get it were two different things. Even with the support of fabulous teachers tirelessly working through video conferencing and learning management systems, we knew that our teens' online education needed to be highly monitored on our end. I was also very concerned about the lack of socialization our kids would experience due to being in lock-down and aware of the need to keep them busy to help alleviate feelings of social isolation. We never did hit our stride in our new routine and between moments of sweet family time, there were dark days for all of us. In the fall of 2020, we were tired of cooking, games, and the same old hike. We were exhausted by the politicization of the virus and anti-maskers (my kid was heckled for wearing a mask!). I tried to remain positive and remind the children that there would be a return to normal even though I wasn't sure myself. The following notes from the journal highlight my mothering anxieties during the fall semester:

> November 11,
> Having the kids at home has made this all way more challenging, it is so crazy working together, we are all zooming all day. I feel lucky that they are older so they run their own show but still, we have to monitor to make sure they are attending class, listening, etc. Add on top, my worry for their mental health and my students' mental health and it all feels like a huge load coming down on me, especially days when I'm not sure I am ok. It's like moming and teaching on steroids.
>
> December 1,
> I think a lot about what has made this semester so hard is the loss of momentum. In our previous busy lives where we were all off in many directions (I miss that life!) we seemed to have a sense of momentum that would push us through. A bad day for one of my kids could have been completely upended by meeting a new friend or just having a good conversation with a teacher or a great night on the basketball court. Of course

> there were bad nights, but we seemed to pull the weeds and plow right through, now sometimes it's hard to even get the trowel out.
>
> December 17,
> I think the absence of writing gives indication to how well the end of the semester wrapped up. Not well! I have had so many personal challenges that I really have not been able to keep up.

Like everything else, my self-care routines were very hard to maintain during quarantine. This was detrimental to my emotional health as evidenced in these journal entries from October 21 and December 1st respectively, "The double whammy of teaching online and my own personal stresses at home are really affecting my teaching I think. I am actually in tears right now" and "Worst. Semester. Ever. I am crying because I feel like a failure. I just couldn't do my best work, we were up many nights with worry".

Technological Difficulties

The technological diffculties theme had the least amount of indices of expressions. Nevertheless, it was consistent throughout the data sets and semester. Time constraints are a fact of life in education. As I was moving my course online and experimenting with new learning tools, time management became unusually problematic for me in part because of the incorporation of technology in every aspect of my course. In the September 14 journal entry, I said, "Today, it took me three precious hours to prepare for class. I used a new white board application and assigned break out rooms which took me a lot of time." On November 2, after spending a large amount of time preparing a Nearpod lesson, I reported stress due to failure in lesson execution. "Today, I had a Nearpod set up, I took a lot of time setting it up because I wanted to go through a real lesson but it did not work well and was quite stressful. It dropped."

The following expression from the October 14 exemplifies how stressful it was for me when I lost internet connectivity:

> My internet went down twenty minutes before class was over. The students were teaching and could not get back on. Had to load my CANVAS app on my phone to say

> goodbye to them and explain what happened. They were doing well with teaching their demonstrations and my internet quit...teaching online is so awful when this happens. This is a very, very hard semester and I am trying not to feel stupid but I do. Yuck.

As we approached the end of the semester, I was feeling gloomy for myself and teachers everywhere as noted in my journal entry from December 17:

> I believe teachers have to be risk takers to be good teachers and tried to model that but bombing (NearPod) is awful. I just can't describe how stressful it is. I feel such a connection to all teachers and feel so sad when people are criticizing them because I know they are feeling a type of stress that is foreign and awful.

Throughout the semester, my technological anxieties were centered around not having enough time to learn how to use educational web-based applications and also internet connectivity issues that I falsely attributed to user error. Technological failures in execution of lessons led to increasing anxiety and lowered my self-efficacy for online teaching. Due to this, my willingness to be a risk taker when planning lessons was thwarted and my empathy for teachers everywhere having a similar experience was palpable.

Discussion

Pedagogical Dissonance Led to Lower Teacher Educator-Efficacy

The expression indices in each of the thematic categories (pedagogical dissonance, secondary stressors and technology issues) all pointed to a diminishment of my teacher educator-efficacy. Teacher-efficacy can be described as the belief that educators possess the ability to affect student learning outcomes. Further, efficacy beliefs are *task-specific* and *context-specific* constructs, self-efficacy levels vary situationally (Wheatly, 2001). This situationally specific factor influencing rates of teacher-efficacy was certainly at play for me as my teacher educator-efficacy beliefs plummeted in the fall semester of 2020. After I knew I would be teaching online 100% of the time, I was continuously contemplating how I would replicate my course in the virtual classroom. Setting a high bar, I did not want to compromise enriching experiences for my students. I scrambled to use various web-based instructional strategies but found little success and was depressed about not being able to effectively model best practices in science teaching. It was early in the semester when I came to the conclusion

that I would not be able to *do* much science at all. I felt defeated and had low confidence in my ability to teach my science methods course. As I continued to introduce ideas about lesson and unit planning, inquiry and nature of science, experiential learning, adolescent brain development, laboratory skills, cross-cutting concepts, and other typical science methods course benchmarks, the inability to participate in science activities created a sense of pedagogical dissonance for me that would continue throughout the entire semester.

Disconnection

The disconnection I felt with my students added to the pedagogical tensions I was experiencing. I was continually reflecting on how I could be more available and how I could recreate causal banter and impromptu conversations so often occurring before, during, and after class in the physical classroom. As the semester ploughed on, Zoom fatigue was taking hold of all of us. Cameras were being turned off more and more and even as I presented carefully planned lessons aimed at sparking engagement, I just did not seem to be able to feel a sense of an authentic connection with many of my students. Again, pillars in my pedagogy were eroding, and I felt extremely frustrated with the limitations created in online learning. I felt that these barriers prevented me from fostering a healthy classroom community.

In-person Instruction Bias

Part of the reason that it may have been hard for me to maintain a positive teacher-educator efficacy was my clear bias for in-person instruction. During the semester, I felt that teaching online was the reason for so many of my struggles. Everything from the classroom climate to my state of nervousness was blamed on the virtual nature of our classroom. I told myself that if I could just meet with my students in person, I could help them with assignment completion and offer better answers to questions they had about teaching teenagers. In the physical classroom I thought I knew how to sustain engagement and interest in learning. So, in the fall of 2020, as I blamed all the pedagogical problems I experienced on remote teaching, my bias for teaching in- person became clear. This sense of in-person educational nirvana seemed to mask the fact that even if my students and I were meeting on campus, we would still be harboring unusual and acute pandemic related stress that would negatively affect teaching and learning in any environment. Bandura (1997), named one main source of efficacy being enactive mastery experiences situationally typified by success in use of coping

mechanisms. With pandemic related stresses mounting, I did not find my coping strategies to be of much success and my masteries of online teaching instructional strategies never materialized.

Pandemic Related Stressors Piled-on in My Roles as a Mother and Graduate Student

As the fall semester of 2020 progressed, secondary stressors mounted. The perceived balance I was maintaining as a graduate student and mother in the first, second, and almost entire third year of the PhD program was gone. Also vanished was my ability to compartmentalize my life into areas of teaching, course work, family life, and self-care. These parts were now becoming a whole as the lines blurred between my various roles and responsibilities. Personal space and bandwidth became hot commodities as we lived in our little family *covid bubble,* a term that came to describe groups quarantining together during the crisis. Time also seemed to disappear. In actuality, I found myself needing more time to engage in all areas of my life. Activities and strategies for promoting physical and mental health for my kids were prioritized, researched and implemented. In the previous summer, one of our favorite things to do was hike or paddle. The prioritization of our well-being could be really fun! Sadly, as the seasons changed from summer to fall in 2020, our nature adventures became less appealing and we spent more and more time struggling with boredom and isolation from friends. Mental health was pitted against potentially getting and transmitting the virus as we re-negotiated the expansion of our *bubble* and allowed the kids to move about the world a little more freely. This act of letting go in the teenage years has always been unnerving for me, but with the addition of surging Covid-19 transmissions and deaths, it was downright scary. Even if I did find time, no amount of self-care could ease the persistent worry I felt for my family's overall health.

As I dealt with the constant allocation and prioritization of the minutes in my day, I pondered where time was lost and where I might find it. For example, I thought about the time I was saving because I was no longer making the 3 hour commute to attend class on campus and therefore should have more time for course-work than ever before. Unfortunately, this was not the case. Distracted by stressors and dismayed by the state of the world, it was hard for me to focus on my course readings. I also experienced disconnection with fellow students in my classes. In pre-pandemic days, I would often strike up conversations with other students before or after class inevitably leading to better understanding of class content. I lost my

ability to discuss content and consider theories and practices so important for learning. In the fall semester, one of my particularly rigorous classes was hard for me to cope with. My strategies for success, such as sitting in the front of class and asking a lot of questions, felt completely inaccessible online. According to Bandura & Adams (1977), accomplishments in performance provide the most reliable indicators of self-efficacy. In the fall semester of 2020, as I prioritize my role as a mother and teacher educator, my sense of accomplishment in learning dwindled causing my self-efficacy as a student to suffer.

A Wider Trajectory for Technology Anxiety

As a teacher, I have traditionally experienced low-self efficacy in the technology department. Because science teachers are often charged with teaching engineering standards as well, I have always tried to overcome my intimidation and anxieties around technological issues. To do so, in pre-pandemic times I would spend many hours learning how to use new tech equipment for the science classroom and web-based learning tools and applications. In this self-study, I repeatedly mention the large amount of time that it would take for me to construct meaningful lessons using web-based tools often new to me. This indicates how time management became almost impossible for me as I tried to recreate my entire course online with little advance notice. As I continued to experience failures like losing internet connection and the NearPod mishap, the more I realized that my coping mechanisms for technological anxiety were not working and with that, my overall teacher educator-efficacy was impacted. The related expectancies associated with coping are *outcome expectations* centered around beliefs in behaviors leading to outcomes and *self-efficacy expectancies* derived from feelings of not being capable of performing a behavior or a set of behaviors (Maddux & Stanley, 1986). So, my repeated failures in my attempts to use technology led me to believe that I was not able to support my students with high-quality academic lessons. I became more and more convinced that I was not capable of effectively using technology as an online educator.

Conclusion

During the fall semester of 2020, my teacher-educator efficacy was influenced by stress and success in all areas of my life. This study illuminated the facade that I created about my life as a teacher educator, graduate student and mother. I had convinced myself that these areas of

my life existed separately from each other. So, even if I was struggling in one aspect, I could still do my best in others. Teaching in an emergency remote situation from home during the pandemic shed light on this illusion of separateness that I once held. My way of coping with an intense PhD program while raising teenagers was to be in continuous effort to reach a balance that was unobtainable. The act of juggling all of my responsibilities had always been precarious and the factors surrounding the pandemic easily ended the notions of balance I once held.

In the peculiar fall semester of 2020, all areas of my life affected my sense of self-efficacy and this study has helped me understand that as a teacher, they always had. Teaching in a state of crisis helped me embrace how important it is to acknowledge this truth. This honesty can help me strive to holistically navigate my life steering for a sense of success as teacher, student, and mother. The popular researcher, Brené Brown (2010), might describe this awareness of interconnectedness of life roles as part of whole-hearted living. The following is her definition for wholehearted living:

> "Wholehearted living is about engaging in our lives from a place of worthiness. It means cultivating the courage, compassion and connection to wake up in the morning and think *No matter what gets done and how much is left undone, I am enough.* It's going to bed at night thinking, *yes, I am imperfect and vulnerable and sometimes afraid, but that doesn't change the truth that I am also brave and worthy of love and belonging"* (p.3).

The more I understand the influences that stressors in all avenues of my life have on my teacher educator-efficacy, the better I will be able to facilitate meaningful conversations about this in my own classroom, creating opportunities for my students to truly value and promote their own well being as they embark on their noble profession of that is teaching. Through this self-study and with the invaluable support from my critical friends, Valarie and Ingrid, I was able to unearth the causes of my low teacher educator-efficacy during the pandemic. As the compartmentalization of my life came to a halt, I was able to understand that operating from this parts-to-whole perspective was creating an illusion of balance that could easily be toppled with a change of situation.

Recommendations

During the height of the pandemic, teachers and students were not ok. In her heart-wrenching autoethnography, Cunningham (2021) posits that there is a "prevailing myth in America that to be a successful teacher, you must sacrifice your own well-being" (p.288). She contends that a false belief exists in which success and anxiety are naturally associated in teaching. This is a dangerous misnomer, putting the well-being of educators and students at risk. No matter our specific life circumstances, teachers must be able to protect our own well-being in order to cultivate a healthy classroom climate. Research shows that no one thrives in stressful schools, and the results of pressures and exhaustion is a great deterrent to emotional well-being. Shame sets in making teachers feel like we are doing something wrong (Cunningham, 2021). During the pandemic, the work of educators was on full display. As I heard our children's teachers attempting to create connections and academic growth from the computer speakers, I made a silent wish that our society would finally acknowledge how challenging and important the field of education is. With this recognition would come the support and encouragement for teachers to thrive fulfilling the common goal teachers have for their students; to be successful, in all avenues of their lives.

The many roles a teacher educator may have influence equal bearance on teacher educator-efficacy. Conceptualizing holistic representations of teacher educator development in which equal attention can be distributed amounts educational attainment, personal life situations, and physical and mental health needs is imperative to high teacher educator-efficacy not just in crisis but as an effort to continue to navigate the waters of a post-pandemic world with more clues on how to heal, change, and learn as we go.

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Commentary: Teaching Preservice Science Teachers During COVID-19

From the authors in this section we learned that university instructors hold multiple roles that likely impact their teaching. These multiple roles impacted many instructors even more during the COVID-19 outbreak. For example, Claire wrote about having multiple roles as a mother, a student, and an instructor, and struggled with trying to balance those roles as well as do justice to each role. It was a struggle trying to teach hands on while being online, and despite trying out different technologies, it was still a big struggle. Claire also had to navigate mental health issues for her teenage children, and support them in learning online. Ingrid wrote about the challenges and benefits of teaching asynchronously online, and also working at home with her preschool age twins. Valarie struggled with her identity as a professor, and also her concern about her son who was in college who was struggling learning online. Though he had his own residence, it was still a concern to Valarie.

While prior experience and context had an impact on each author's unique experience teaching during the pandemic, all authors in this section also talked about the value of having critical friends. Though the critical friends for each group were supposed to be as support for the research, it became clear that the critical friends also became support groups for their teaching, as the instructors could share ideas and receive feedback from the teams in each chapter. Such a group was pivotal in aiding each instructor to do their best in very trying times. Such support for teaching is important in the best of times, but it appeared to be especially crucial during the COVID-19 outbreak. Claire and Ingrid were able to share the critical friend experience with Valarie, a highly experienced and award-winning scholar in science education. Claire was a doctoral student who was teaching within the context of being a student. While Ingrid was a faculty member and therefore her context differed from Claire's, she too benefited greatly from having a critical friend who was highly grounded in the field and a critical friend who was developing strategies from the perspective of a doctoral student. Regardless of where the instructors were in their career trajectory, they all

described challenges and successes that occurred during the pandemic, which involved a need to adapt and be flexible throughout the semester.

Not surprisingly, all of the authors in this section reflected deeply on their experiences and the pedagogical strategies in which they engaged during the pandemic. All of the authors were trying out new strategies, and wondering which of these strategies were the most effective. The self-study methodology appears to have supported that deep reflection and processing.

Citation

Akerson, V. L. & Carter, I. S. (2021). Commentary: Teaching preservice science teachers during COVID-19. In V. L. Akerson & I. S. Carter (Eds.), *Science Education during the COVID-19 Pandemic: Tales from the Front Lines* (pp. 217-218). ISTES Organization.

CONCLUSION

The chapters in this book largely described the challenges educators K-16 experienced in a swift change from in-person teaching to remote/online instruction. While teachers had varying levels of prior knowledge and experience in teaching online and/or using technology in their instruction, all of the authors noted the challenges that teachers experienced in moving to a fully remote format. Indeed, teachers shared challenges with engaging students, personal struggles, navigating administrative and institutional support, and others. Despite these challenges, teachers also indicated the benefits and innovations that occurred as a result of shifting their instruction online. The benefits and innovations about which authors discussed included use of online teaching tools such as video conferencing (e.g., Zoom™, Google Classroom™), use of video of science teaching and learning, at-home investigations, asking students to share photo or video of themselves to demonstrate their exploration or learning, use of applications (e.g., Learning Apps™, Quizizz™ [Avsar Erumit et al.]), and use of radio to communicate with students. Some offerings of online/hybrid learning courses were already available pre-pandemic at the university level, and prior research has indicated some of the benefits of this approach (e.g., Hudson, 2006). For university students who may be juggling a variety of personal and professional responsibilities, online learning opportunities may support their need to balance many roles (see Carter et al.). Regardless of the contextual factors within the educational setting, one can conclude that despite the myriad challenges described by the authors in this book, educators experienced an opportunity to explore new ways of teaching.

The authors in this book engaged in different methodologies to explore online teaching during the pandemic. The methodological approaches chosen supported the emphasis of each study (e.g., self study vs. survey). In the cases of the self-studies, for example, the authors wanted to reflect on and improve upon their teaching, and in the cases of surveys, the authors wanted to explore a variety of teachers' ideas about and/or experiences of engaging in online science instruction. The critical friends that supported authors engaging in self-study

demonstrated a strong support mechanism for the authors who were reflecting on their teaching experiences during the COVID-19 pandemic. Furthermore, the teachers seemed supported in knowing that others were also experiencing challenges, and benefited from suggestions and guidance from their critical friends. Indeed, the methodological approaches authors in this book utilized allowed the authors to explore and reflect on the complexities of an unprecedented need to teach K-16 students in an online environment.

Through the authors' systematic examinations of online teaching, recommendations were generated that can provide insight for educators across K-16 settings. Some authors indicated the need for more support for teaching during the pandemic, which varied from social-emotional support (see Zhong et al.; Rahman & Buck) to institutional/administrative support (see Akerson et al.; Bilican et al.). In some cases, this support referred to resources for teaching and/or curriculum (Asim & Hollenbeck; Bilican et al). A strong theme of professional development to enhance teachers' online instruction and use of technology also emerged from the recommendations of the authors of the chapters in this book. Furthermore, authors discussed the importance of taking the experiences of teaching during the pandemic and bringing the positive aspects of these experiences into future teaching. Bilican et al. and Zhong et al. mentioned the importance of working collaboratively, and Ceslejarev et al. notes the need to honor the work of educators. Indeed, educators and students had to make many adaptations in a short period of time, as evidenced in part by the descriptions of experiences contained within the chapters of this book. The authors in this book provided insightful and powerful recommendations to educators and to others that work within the field of education based on their research studies conducted during the COVID-19 pandemic.

At the time of the writing of this book, many universities and K-12 schools are aiming to return to pre-pandemic modalities of teaching and learning. It is important to note that the pandemic is not over, and at the moment, the Delta variant and the potential for further variants of COVID-19 are causing concern across the globe. While some teachers may choose to return to their pre-pandemic pedagogical strategies and teaching modalities, others may embed some of the pedagogies they utilized during the pandemic into their teaching repertoire. Furthermore, some teachers may request and/or seek out professional development opportunities to learn more about the tools and strategies they used or could use in the future to support remote learning. Indeed, some of the authors in this book noted the potential value in providing educators with professional development opportunities to support engaging

students in remote learning methods and tools (e.g., Asim & Hollenbeck). Some authors indicated that the experience of teaching during the pandemic reinforced their ideas of the importance of in-person learning. Akerson et al. noted that her in-person classes during the pandemic were more successful than the online classes, and teachers in Avsar Erumit et al.'s chapter indicated that in some cases they could not facilitate investigative experiences with students while teaching remotely.

In conclusion, in addition to many other industries across the world, education of K-16 students was greatly impacted by the COVID-19 pandemic. The pandemic forced the way educators approach their work to change in a dramatic way in order to teach remotely. While we imagine we all hope to never experience another pandemic in our lifetimes and we hope the COVID-19 pandemic is on a trajectory to end soon, there were many lessons learned during this time and perhaps an even a greater appreciation was gained for how we engaged with students prior to the pandemic. As we reflect on the pandemic thus far, we can hope to take the positive aspects of learning to teach remotely to further serve and engage our students, while keeping the tried and true strategies we used before the pandemic to support our students in hands-on, minds-on science learning.

Reference

Hudson, P. (2006). Examining preservice teachers' involvement in online science education. *Journal of Interactive Learning Research, 17*(4), 367-383.

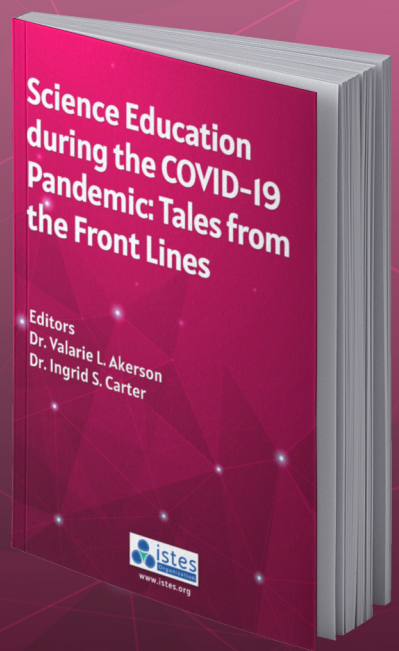
Citation

Akerson, V. L. & Carter, I. S. (2021). Conlusion. In V. L. Akerson & I. S. Carter (Eds.), *Science Education during the COVID-19 Pandemic: Tales from the Front Lines* (pp. 219-221). ISTES Organization.

Certainly the year 2020 will be one for the history books, as COVID-19 made its impact globally beginning in that year. While it did not hit the United States substantially until about March of 2020, other countries felt the effects sooner. Eventually it seemed that the globe essentially was shut down due to the COVID-19 outbreak.

This type of shutdown was challenging for education and educators. How could we pivot to online forums and teaching methods? Would our students still learn? It was especially concerning for science teachers and science educators who were accustomed to teaching using mostly hands-on inquiry instruction. How could students manipulate materials in these virtual settings?

The science educators who have contributed to this book decided to conduct research to determine answers to some of these questions. The book is divided into three sections related to science teaching--COVID-19 science teaching research that involved K-12 teachers, research that explored university science content courses, and research that explored preservice science teacher education. Following each section we include a summary of the outcomes and recommendations. We end the book with conclusions and recommendations from a synthesis of the studies included.



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