# Elementary Science Teachers Adapt Their Practice During a Pandemic

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## Abstract

*The COVID-19 global pandemic created new challenges for teachers and school systems as teachers were forced to rapidly transition to remote learning using new digital tools and resources. Teaching elementary science in "normal times" is challenging due to issues involving teacher preparation, limited access to materials and lack of administrative support due to emphasis on tested subjects, among others. Using reform-based, inquiry practices is challenging when teaching science face-to-face and even more so in an online environment. Compounded with issues of access and equity, teachers faced many problems with moving elementary science instruction online due to COVID-19. This study reports on the experiences of 10 early career teachers who were graduates of a specialized elementary science concentration. Teachers reflect on the challenges faced, how they adapted, and how they designed new learning contexts to teach science. Teachers report on resources they found beneficial, assess needs for the future, and explain how they worked to maintain a sense of community for their students during this unprecedented critical time.*

**Keywords**: Science, Teacher Innovation, Pandemic

## Introduction

The COVID-19 global pandemic created new challenges for teachers and school systems. Prior to March 2020, a typical school day consisted of students convening in classrooms face-to-face adhering to schedules with teachers employing familiar traditional methods, lecturing or using hands-on activities (Konig, Jager, & Glutsch, 2020). The lockdown of schools created an entirely new situation for teachers, students, and parents (Huber & Helm, 2020). Teaching and learning could only continue with alternative means of schooling. Due to this emergency health crisis, teachers were forced to transition to remote learning using digital tools and resources requiring teachers to consider implementing new methodologies (Eickelmann & Gerrick, 2020).

In addition to the challenge related to the use of new technologies, concerns regarding student equity and access emerged. These concerns extend beyond having computer access. For example, even when schools provide devices to students in need, students may not have access to the internet to successfully complete their work (Fox, 2016). Specifically, students from lower income families are less likely to have adequate access to the internet compared to those from higher socio-economic backgrounds (Cohron, 2015). Students living in low income and rural areas are also less likely to have high speed and/or reliable internet available in their communities (Masonbrink & Hurley, 2020) and are more likely to access the internet using a cellphone rather than a personal computer, creating challenges and stress when completing assignments online (Fox, 2016). This is significant because approximately 50% of children in the United States can be described as living in poverty (Sen, A., & Tucker, C.E., 2020).

Classroom teachers across North Carolina were asked to transition to remote teaching and learning in the time period of one week. Immediately, concerns emerged about the most vulnerable students in our state, especially the 57.4% who, according to recent data, qualify for free or reduced lunch (National Center for Education Statistics, 2017). Additionally, in rural parts of the state, it is estimated that 261,000 households lack broadband internet access (Federal Communications Commission, 2019), suggesting that rural students would be more impacted by the shift to remote learning.

The transition to remote teaching was unexpected and rapid due to COVID-19, but this transformation had already begun in school systems through a wider revolution of the digitalization process and implementation of communication technologies (ICT) (Selwyn, 2012; McFarlane, 2019). This digitalization process involves closing the ‘gap’ between students’ conventional learning and acquisition of skills needed by youth to enter the information age (Kozma, 2011). Prior to COVID-19, teachers were transforming their classrooms to integrate their curriculum with ICT, giving students opportunities to use advanced technological and digital tools for creative and innovative problem solving (Kozma, 2011). Also prior to the pandemic, evidence suggested that digital technologies, including ICT, could provide new opportunities for teaching and learning especially in elementary and middle school classrooms (Chauhan, 2017).

Although ICT has demonstrated the potential to provide positive influences on teaching and learning, the presence of these technologies alone does not impact student progress (Li & Ma, 2010). In response to the increasing implementation of ICT in educational systems, Selwyn (2012) acknowledges the need to extend teacher knowledge categories outlined by Mishra and Koehler (2006), who defined teachers’ technological knowledge (TK) as well as ‘technological pedagogical knowledge’ (TPK). TPK includes teachers’ general knowledge about application of technologies in teaching and learning. In this study, we focused on elementary teachers that graduated from an undergraduate program that incorporated a required technology and education course which uses the TPK framework. Through this framework, instructors of the course emphasize the following components; how to integrate technology using best practices, digital citizenship, how to utilize digital technologies to develop content and assessments, and how to select and access appropriate digital tools for teaching and learning.

In addition to those challenges presented by transitioning to remote learning and implementing associated technologies, the sub-group of teachers focused on in this study, elementary science teachers, have traditionally faced additional hurdles. Prior to COVID-19, elementary science teachers that wanted to advance effective science teaching as a regular component of their classrooms faced structural constraints that created obstacles for achieving their goal (Bradbury & Wilson, 2020), including a lack of administrative support for science teaching related to emphasis on standardized testing (Milner, et al., 2012; Upadhyay, 2009); access to materials and resources (Carrier, et al., 2017; Murphy, Neil, & Beggs, 2007), and time to prepare for science teaching (Davis et al., 2006; Goodrum, Cousins, & Kinnear, 1992). Overcoming these structural obstacles during what we will refer to as “normal” times of teaching science was difficult for many elementary science teachers (Milner et al., 2012). COVID-19 necessitated a rapid transition to remote teaching using online resources, and we were interested in learning how teachers would respond to this change in teaching science in particular.

The previously stated obstacles to teaching science effectively are compounded by the complexity of science. To develop competencies in science requires a multifaceted approach that provides a variety of experiences that support students’ understanding (NRC, 2007 & NRC, 2012). *A Framework for K-12 Science Education* (NRC, 2012) emphasizes the NRC’s (2007) report *Taking Science to School*, that discusses the four threads of classroom instruction that should be intertwined for the advancement of science learning: 1) Knowing, using, and interpreting scientific explanations of the natural world; 2) Generating and evaluating scientific evidence and explanations; 3) Understanding the nature and development of scientific knowledge; and 4) Participating productively in scientific practices and discourse.

Integrating these classroom threads with the specialized science of the disciplinary core ideas of the *Framework* offers a new structure for designing teacher education programs, especially for elementary pre-service teachers. We designed a concentration in elementary science (explained below) merging reform-based science teaching with social constructivist views of learning. The elementary science concentration promotes an inquiry environment that engages and asks students to be curious of their world by seeking answers to questions, experiencing phenomena, sharing ideas, and creating explanations of their discoveries (Schneider, Krajcik, & Blummenfeld, 2005). The elementary teachers identified for this study selected science as their concentration in their undergraduate program. These teachers were trained to teach science using the classroom threads and framework described above.

When COVID-19 impacted schools, we wanted to know how alumni of the elementary science concentraton who were currently teaching had adapted their science instruction to a remote online context. This study outlines how these teachers dealt with this emergency health crisis by reporting on how they adapted and redesigned new learning contexts to teach science, the type of resources they selected and, importantly, how they worked to maintain a sense of community for their students during this unprecedented critical time.

## Literature Review

### Challenges of Teaching Elementary Science

Research on elementary science education is often framed using a negative lens, focusing on weaknesses that exist in elementary science teaching (e.g., Davis, Petish, & Smithey, 2006; Roth, 2014). Often cited are the Horizon Group reports that regularly survey the state of science and mathematics education in the U.S. since 1977 (e.g., Weiss, Pasley, Smith, Banilower, & Heck, 2003). The most recent report indicates that elementary teachers feel less prepared to teach science and, in comparison to reading/language arts and mathematics, spend much less time teaching science daily. Teachers of early grades (K-3) report that they spend 86 minutes per day teaching reading, 59 minutes on math instruction, and 21 minutes on science (Banilower, et al., 2018). This reflects little change from the 1977 report, in which elementary teachers reported spending 19 minutes a day on science in K-3 classrooms, and noted that only 22% felt very well qualified to teach science (Weiss, 1978). Other findings add to this deficit view of elementary science teaching including elementary teachers' lack of self-efficacy and enthusiasm for teaching science and their lack of preparation and content knowledge (Appleton, 2003; Davis et al., 2006).

### Addressing the Challenges

Despite noted deficits in elementary science teaching, there are elementary teachers that make science instruction a regular component of their teaching and want to improve their instruction (Bradbury & Wilson, 2020). But as stated earlier, there are structural constraints that make improving elementary science instruction difficult. Elementary teachers who persevere in making science a regular part of their curriculum cite factors including and especially the enthusiasm of students for science (Goodrum et. al., 1992). A study of 13 elementary teachers implementing reform-based elementary science pedagogy reported that students' enthusiasm for science was one of the forces driving their willingness to challenge current rules about science teaching and to change their instruction (Carlone et. al., 2010). In the same way, Zembylas (2004) studied an elementary teacher whose students' positive reactions to her new style of teaching science empowered her to confront challenges from other teachers about her adoption of these reform-based practices.

**Elementary Science Concentration Addresses Challenges**

Traditionally, elementary teachers are prepared as *generalists*, learning content and pedagogical strategies of all major subject areas they have historically been required to teach. It is common for elementary teachers to take one course in a science discipline (e.g., Biology, Geology, Physics, etc) in the College of Arts and Sciences and then one course within the College of Education that focuses on elementary science methods and includes a clinical field experience. Training elementary teachers as *generalists* does not allow time to address the specific disciplinary core ideas of science or the varying pedagogical approaches best suited for teaching elementary science (Hanuscin, Lee, & Akerson, 2011).

To address this concern, in 2012, a team of science educators including the authors at East Carolina University designed an Elementary Science Concentration (ESC) for Elementary Education majors. The framework of the ESC is based on the following four components: (1) discipline-specific content, (2) specialized methods for teaching each disciplinary core idea of science in elementary school, (3) application of meaningful field experiences in formal and informal settings, and (4) a humanistic lens that connects concepts through real-life approaches and problems in science (Kier, M., & Lee, T., 2017). The ESC consists of 6 courses, one of which is a content course (e.g.., biology, physics or geology) taken in the College of Arts and Sciences. The remaining courses, all taught by science educators, include three discipline-specific courses (physical, life, and earth science) and two methods courses (formal and informal science education). Pre-service teachers begin the coursework their sophomore year taking the three concentration courses (e.g., Teaching Life, Earth and Physical Sciences in Grades K-6), which focus on the content and pedagogical strategies of teaching these content areas of science to elementary students. During pre-service teachers' junior year, they take the general science methods course (a requirement for all elementary education majors), which focuses on teaching science in a formal school setting. In this course, they explore research-based practices in science teaching and plan and implement a 5-E science lesson in a local school.

In their senior year, students take as a capstone course, the informal science methods course, which focuses on designing events and teaching science in informal settings. Studies have shown that when elementary students are engaged in informal science events that are relevant to their lives and involve the science community, students' interest in science and their aspirations to pursue STEM (science, technology, engineering, and mathematics) careers are increased (Sadler, Burgin, McKinney, & Ponjuan, 2010; Thiry, Laursen, & Hunter, 2011). Having pre-service teachers practice science teaching within informal contexts allows them to design curriculum free of classroom constraints, including lack of science teaching time, managing large groups, testing regimes, and social pressure to teach in traditional ways (Calabrese Barton, 2000; Luehmann, 2007). Thus, our team created an informal science course to provide pre-service teachers a unique context to practice their science teaching and to demonstrate to them the importance of these less formal experiences in promoting a love of science in our students.

**Elementary Science Concentration Design for Online/Remote Learning**

In addition to supporting the framework shared above, students concentrating in Elementary Science engage with technologies that are unique to this program and that may benefit them in this transition to remote teaching during the pandemic. Students in *Teaching Earth Science in Grades K-6*, for example, use Mursion, an interactive virtual simulation, to practice leading science discourse with upper elementary-aged students. Students in this course also have experience using the Augmented Reality sandbox to simulate topographical maps and explore rainfall on different landforms and elevations. Students record their teaching and reflect on their lessons using the online platform, GoReact. They communicate with each other in virtual forums, at times sharing videos of their investigations and results. As with other students at our university, the ESC students also have experience using learning platforms like Blackboard and Canvas.

**Theoretical/Conceptual Framework**

The Cambridge Handbook of the Learning Sciences (Sawyer, 2005) characterizes the learning environment into four components: the people in the environment, technologies, architecture including the layout of the room and the physical objects, and finally the social and cultural environment. Whittle, C., Tiwari, S., Yan, S., & Williams, J., (2020) propose the term Emergency Remote Teaching Environment (ERTE) framework as a conceptual framework where teachers can create plans for teaching and researchers can conceptualize learning in these emergent environments. The ERTE framework positions the teacher as the first responder to the educational crisis, dealing with shifting resources and expectations and serving as the primary point of contact with the student. Through this framework researchers can both understand and support learning in emergent crises.

The ERTE framework consists of three steps: inquire, classify available resources as *constants* and *variables* and design educational experiences (Whittle, et al., 2020). The steps work as an iterative process since working in a crisis calls for constant re-evaluation. The tweaking and redesign are essential to the learning design approach of both the ERTE framework and the realities of emergency education. This revision process enables adaptation to the unpredictable shifts in resources and goals that characterize a crisis. Here is a brief description of each of the steps of the ERTE and how this framework guided our methodology design and analysis.

**Inquire**

The first step of the process involves teachers taking the time to inquire about their situation in order to prepare a response for the crisis. For example, if teachers' instructional responses are to be effective, teachers begin with an inquiry of their own abilities, familiarity with technologies, and time; reflecting on their students' health and safety, access to basic needs, and access to technologies; and their collective resources (Whittle, et al., 2020). As teachers initiate inquiry into their planning, they confirm the pedagogies to be used as actionable and based on available means. A teacher who values the importance of inquiry during an emergency crisis continuously assesses the available resources and factors affecting students' health and performance. We found the inquiry stage vital to the design of our interview protocol. The first theme of our questions investigated teachers' personal feeling/attitudes towards science teaching during the pandemic crisis. Teachers reflected on the inquiry stage as they responded to questions about their initial concerns for their students and their confidence in transitioning to teaching science online.

**Classify**

The classify stage refers to the available resources that are identified in the inquiry stage as *constants* and *variables* (Whittle, et al., 2020). The ERTE framework defines *constants* as resources shared by both teachers and students, for example when a district moves to 1:1 computing, providing a device to each of its students. The *variables* are resources shared by only some students and teachers. For example, there could be social variables such as food, access to the internet or technical devices that only some students would have access to during a crisis. Questions regarding how teachers adapted to online science instruction in light of student resources and access aligned with this phase of the ERTE framework.

**Design**

The design stage of the ERTE framework intertwines eight dimensions of course design informed by Means et al., (2014). The dimensions provide a progressive but iterative strategy for teachers to design a plan using the constants as a foundation for each aspect of the pedagogy and variables as a means of maximizing individual learning. The eight dimensions are as follows: critical learning goals, ratio of teacher to students, communication method, building agency, assessments, social role of the instructor, pedagogy and the student social role, and feedback. In our protocol we asked teachers to identify aspects of these eight dimensions within the design of their new remote learning environment.

We used the ERTE framework as a guide in the design and analysis of our study to investigate how alumni from our Elementary Science Concentration transitioned to teaching science from a traditional context to a remote learning environment during the emergency crisis of the COVID-19 pandemic.

## Methodology

**Research Question**

What are the challenges for teachers with an Elementary Science Concentration to adapt their science instruction to remote learning during the COVID-19 pandemic?

**Study Context**

To investigate how ESC graduates have delt with the rapid transition to remote elementary science teaching due to COVID-19, we contacted 70 ESC teachers from across the state. Using email and social media, 63 ESC alumni responded, and 10 agreed to meet virtually with our team. This study will report findings from 10 completed interviews. Demographic information of the teachers and schools is indicated in Table 1 below. Teachers were provided with pseudomyns for the purpose of discussing the results.

**Table 1: Demographics**

| Teacher | Years of Experience | Grade Level | Title I | Urban/Rural | Self-contained/ Departmentalized |
|---|---|---|---|---|---|
| Ava | 1 | 2 | Yes | Rural | Self-contained |
| Avery | 5 | 5 | Yes | Rural | Self-contained |
| Bella | 4 | 6 | Yes | Rural | Departmentalized |
| Kaylee | 4 | 2 | Yes | Rural | Self-contained |
| Brooke | 4 | 4, 5 | Yes | Rural | Departmentalized |
| Demi | 5 | 6, 7, 8 | Yes | Rural | Departmentalized |
| Haley | 3 | 3 | Yes | Rural | Self-contained |
| Jayden | 2.5 | 5 | Yes | Rural | Departmentalized |
| Kate | 5 | 2 | Yes | Rural | Self-contained |
| Layla | 2 | 1 | Yes | Rural | Self-contained |

All 10 teachers indicated that their respective schools are rural schools designated as Title 1. According to the U.S Department of Education (Title I - Improving The Academic Achievement Of The Disadvantaged, § 70-SEC. 6301), to meet the Title 1 designation, the school's enrollment must have 40% of children from low-income families, which is determined by families that qualify to receive free and reduced lunch.

**Methodology Interview Protocol and Analysis**

The interview protocol addressed demographic information and included 13 questions centered around the 3 steps of the ERTE framework: inquiry, classifying available resources, and design of educational experiences when teaching elementary science during a pandemic. The framework dictated the following 4 themes in our questions: 1) personal feelings/attitudes, 2) adaptation to online science instruction, 3) perception of their adaptation to online science teaching, and 4) future implications on teaching science.

**Data collection**

The 10 teachers that agreed to meet with us were sent an email invitation to meet online (via Webex) based on their availability. Two science professors and authors of the study obtained IRB consent and conducted the interviews of the 10 teachers. Each Webex interview was recorded and then downloaded and transcribed through Microsoft 365 for coding.

**Data analysis**

This study utilized a semi-inductive approach for coding qualitative responses (Lincoln & Guba, 1985; Miles & Huberman, 1994; Patton, 2002). Coding the responses was an iterative process between the three authors. The authors independently read the responses and formed provisional taxonomic schemes. The authors then met to discuss the schemes and address discrepancies until full agreement was achieved. The provisional taxonomic schemes were then applied to the data to develop more refined systematic coding categories through repeatedly reading and constantly comparing (Glaser & Strauss, 1967; Lincoln & Guba, 1985; Patton, 2002).

## Results

Table 1, as stated above, summarizes the characteristics of the teachers. The teachers were split in terms of grade level, with five teaching K-3 and five teaching 4-6. Four of the ten teachers were teaching in a self-contained setting. All the teachers were in rural school districts that received Title I funding, and all teachers had five years or less teaching experience. Five themes emerged from the data *Prior Online Science Education Experience, Student Participation, Access and Equity, Professional Development, Student Wellness, and Planning Future Online Instruction.*

### Varied Prior Online Science Education Experience

Table 2 below organizes the teachers' responses regarding their prior experience with science education in an online setting. The data indicated a range of experience with online science education. The responses were divided into three codes: *No Online Experience, Online Experience as a Student, Online Experience as a Teacher.*

**Table 2: Online Science Education Experience**

| No Online Experience | Online Experience as a Student | Online Experience as a Teacher |
|---|---|---|
| Haley | Ava | Bella |
| Jayden | Avery | Brooke |
| Kaylee | Brooke | Demi |
| | Demi | |
| | Layla | |

### No Online Experience

Responses were coded as no experience if the teachers explicitly stated that they had neither participated in online classes as a student nor instructed an online class. In all, three teachers' responses were coded as *No Online Experience*, Haley (three years of teaching experience), Jayden (two and a half years of teaching experience), and Kaylee (four years of teaching experience).

#### ***Prior Online Experience as a Student***

Statements were considered to be *Prior Online Experience as a Student* if the teachers indicated that they had utilized online resources (e.g., videos, websites) or enrolled in online classes at some point in their post-secondary education. Ava (one year of teaching experience) and Layla (two years of teaching experience) both indicated they had taken at least one online class but did not provide any context describing their online science experiences as a student. Additionally, Avery (five years of teaching experience) provided the following statement regarding her prior experiences with online learning as a student,

> I think that's heavy video related for me…I've kind of always been a visual person, so it's being able to see science in action… Where can I tie this in in nature? Or where can I see what's going on (with) the phenomenon? Can I make a model of this? And then applying that. So, even as a student in science class, if I was like, I don't know what they were talking about today, it would be me going and finding other resources of what kind of visuals can I have? Whether it's a 2D (looking for a picture model) or whatever and bringing their interest.

Avery described searching for and utilizing online resources, like videos, to increase her conceptual understanding as a student in her in face-to-face science classes.

### ***Prior Online Experience as a Teacher***

Brooke and Demi (both four years of experience) stated that they had engaged with online resources as part of their MAEd in Science Education program. Brooke described her experience as follows,

> Well, I mean for our grad. school it was. So, I guess just in general with classes during that program taught me a lot with online learning…We had to do a technology class in grad school too, and it was more science-based, and we had to find a lot of the like simulations or virtual labs which has kind of been helpful now. So, I would say the grad. school program actually helped a lot more with all this virtual stuff. Yeah, I think that course definitely was very helpful.

These responses indicated a level of formal training related to online science instruction. It should be noted that the MAEd Program from which Brooke and Demi graduated is completely online, but their responses emphasized the impact of specific assignments on their pedagogy and, thus, were coded as *Prior Online Experience as a Teacher* rather than as *Prior Experience as a Student*.

While not identifying any formal education associated with online science instruction, Bella (four years of experience) provided the following response regarding her online teaching experience,

> For (*my*) classroom, I always use Google Classroom. I've used that every year that I've taught, too. I always push out assignments that they do when we work in through stations (like)using the PhET [interactive simulations for science and math]. Those (are) online simulations, and then I also have other stations where we use Study Jams, BrainPOP, videos that have questions that follow up with it. I've also used Mystery Science… and Legends of Learning - online gaming science website that the

> students use that directly rely on standards. So those are embedded into my classroom pretty much at least four days out of the week. If our internet is working appropriately, that students have access to do that while we were still in school.

In this statement, Bella identified resources she utilized in her previous teaching experience. This statement differs from Brooke’s in that Brooke had received formal training in utilizing online resources, while Bella was referring to resources that had been utilized under traditional teaching circumstances. However, both types of responses were coded as *Prior Online Experience as a Teacher* because the statements indicated some level of awareness of resources and consideration for implementation of online tools.

**Student Participation and Access and Equity**

The most startling consistency across sampled teachers’ responses was the reported lack of student participation in learning. For example, Kaylee and Layla offered the following,

> Kaylee: Yeah, our district gave out computers and hot spots, but we have been finding out from the parents that they put a data cap on those hot spots. They only gave one per family so if you have five kids at home you’re going to hit that data cap and then you're not going to be able to watch the videos. I've been making lesson videos, but I've been told I have to keep them under 2 minutes. You know, a lot of my families are in crisis mode all the time, so now they're really in crisis mode and they don't..a lot of the parents are still working. They don't have technology. If they do get it, there are issues with it. And so I've had about 5 to 7 kids participating in online learning.

> Layla: Doing these assignments, understanding them because they have no way other than talking to me on the phone, they have no way of like, sending me a picture as a printed packet. The ones that are doing my assignments online.. I can't guarantee that it is the student doing it, and I can't guarantee that they are completely understanding the assignment like they would, you know, in the classroom.

In addition to exhibiting concern over low participation, these statements also included a concern for students who did not have the requisite technology, as well as the role that parents/guardians were playing in the learning process.

To combat the lack of student participation, Kaylee and Layla attempted to design more engaging learning experiences. For example, Kaylee stated,

> I did give them kind of a list of things they could do outside to kind of try to get them to go outside and exercise and explore a little bit. Most of my kids live in apartment complexes, so it might not work, might not always work, but I did give them a list, you know, collect some bugs and record how many legs they have. Record what they're doing. You know, give him some leaves and some different things, see what they're eating. You know just to try to do so. I mean, that's something I think. It was free and easy for them to do.

Likewise, Layla assigned tasks to get students "away from their computer, where they get to explore and create, go outside and explore; anything that gets them to think and use their brain a little more and how it connects to real life." She was using her home garden to reinforce biology concepts. Additionally, she had her students explore plants in their own yards and conduct experiments using household items like slices of bread, water, and apples. The upper elementary teachers (grades 4-6) frequently referenced concerns related to perceived inequity for students. Specifically, all the grades 3-6 teachers discussed concerns for students without internet access who were completing paper packets created by the teacher. Jayden offered the following,

> Not making it passages, that was like my biggest challenge to get over… I guess they have to read, but no one would do it. Because of that I'm going to have to change it up a little bit...I try to align the paper packets as much as possible, but…(*it's*) pretty difficult to try to achieve the same level of interactiveness.

The teachers expressed worry that the experiences were not as similar as the teachers would like. Furthermore, the teachers discussed the difficulties associated with providing support and remediation for struggling students because the students were not visible for the teachers to conduct informal assessments or use nonverbal cues to recognize struggling students. They were also concerned about the effectiveness of their online instruction because students were not engaged, noting that neither the teacher nor the students were enjoying the learning process to the same levels as they did in face-to-face instruction. Bella, who was new to teaching 5$^{th}$ grade, stated, "Not only did I not know the 5th grade content as well, but that's not how we were taught to teach." Brooke added,

> I don't believe that students are getting the engagement in the interactive piece that they would get in a classroom. I don't think that they're getting the collaboration with their peers, which is vital when you're understanding content to be able to talk about it with someone and to explain it to someone which we do a lot of. So, I think that that factor is greatly impacting their learning. It's not the same teaching online. I think this (*using online resources*) would be a great additional resource to have but not be the only resource students receive.

The teachers often discussed that the process of teaching online did not align well with the research-based practices that they had learned in the teacher preparation programs or graduate school.

**Limited Instructional Time**

Ava, Kaylee, Haley, and Layla identified the limited instructional time they were allotted to address science. Ava indicated that she met with her students one day a week for science. While she was instructed by her district to teach both social studies and science on Fridays, this was also the day that the district reserved for all team, school and district meetings. She commented that by Friday her students' level of interest and participation often diminished, thus science and social studies suffered. Finally, Kaylee offered the following,

> And with our online situation we're in now, we were told to just do reading and math…We're not touching on science or social studies at all, which I tried to again integrate so some of the reading passages to hit our science standards, but it's not. The activities they are doing are not focused on science at all.

This exemplar is evidence that teachers were being instructed to prioritize math and language arts instruction. Despite this mandate, the ESC teachers were still attempting to integrate science instruction into their lessons.

**Varied Professional Development**

There was a disparity in the professional development (PD) districts had offered to teachers. Ava indicated that the only PD offered was an optional session on using Zoom and Seesaw. Whereas Kaylee indicated that, beyond videos provided to instruct teachers in the use of various platforms, PD had only been offered after several weeks of online instruction. Haley volunteered that PD was offered for working with non-native English-speaking students and for using Classroom Dojo for communication with families. Additionally, Haley indicated that her district offered various methods of support for new teachers. Finally, the grades 3-6 teachers reported PD being offered to them and that the PD was valuable to their transition to online instruction but did not provide specific details. Additionally, professional learning communities (PLC) conducted by a district level science specialist were mentioned as being extremely beneficial.

When asked what types of professional development they felt would be most beneficial, teachers repeatedly mentioned motivation and engagement strategies for online instruction. Demi said that it would be helpful to have PD on how to design instruction to challenge students' thinking. In their desire to help all students achieve success, she and Brooke cited that assignments often lacked rigor. As noted by Brooke, "I don't feel like it is as rigorous and as inquiry-based while it's been online...Usually they come into my room so excited for what they are doing for science and now not so much." Teachers noted the difficulty in teaching science using a hands-on inquiry-based approach when students do not have resources to do investigations and don't have access to the teacher scaffolding the experience as they would in a classroom. They complained that teaching and learning science online is just not as fun as teaching it face-to-face, Bella laughingly said, "I have to be a boring teacher now."

**Student Wellness**

Finally, all the teachers expressed concern for their students' well-being. For example, when asked about her initial thoughts regarding the transition to online instruction, Avery stated,

> Oh, mostly heartbroken, I mean I have a crew of very emotional beings, but because we were so open and honest with each other (*about*) myself and what was going on with my home and them that you just end up even closer....they're more than just students or kids. They become a family within your class, and it is like, wait a minute, I'm not gonna get to see them again. I'm not going to get to take them on our field trip. We're not going get to go and continue building these memories, and let me hug you all and cry when I know you're on the last day of school and it's just those sweet things that you look forward to because you seen them grow so much throughout the years, like man.

This exemplar clearly demonstrates the emotional nature of transitioning to remote instruction. Avery expresses the familial relationship that is developed over the school year and the memorable experiences that she and her students missed.

**Planning Future Online Instruction**

Teachers commented on how they will address teaching online science classes if they are required to do so in the future. Teachers noted how overwhelming selecting resources was and mentioned it would be helpful if the districts vetted resources and shared these lists with teachers. Also, they cited the abruptness of the change to online instruction and mentioned that, if given the opportunity, they would provide more instruction while they were face-to-face as to how to use the technology and platforms and additionally discuss etiquette for environments like Zoom meetings. They were hopeful that the current confusion and communication issues they face could be alleviated by preparing students more effectively.

Despite the many challenges moving forward, teachers did note some positives and expressed encouragement about future online instruction. Demi noted, "We can really make a difference now that there is no (*standardized*) test – teaching them for understanding, not just for how to decode a question." She also stated, "One of the hopes out of all of this happening…is that people realize from this is that we have the wrong focus in teaching." She explained that since the end of year state assessments were not being implemented this year, she could focus on teaching as opposed to testing strategies.

## Discussion

The purpose of this study was to determine the challenges graduates from an Elementary Science Concentration program encountered as a result of transitioning their teaching to online science instruction. Ten early career elementary teachers were interviewed by two of the authors approximately one month after schools were required to transition to remote instruction. When interpreting the data through the Emergency Remote Teaching Environment (ERTE) framework, it is evident that graduates of the Elementary Science Concentration (ESC) program have approached emergency remote teaching in a manner consistent with the extant literature.

According to the ERTE framework (Whittle, et al., 2020), teachers who are effective in times of emergency remote teaching begin the process by assessing their technological abilities, or Technological Pedagogical Knowledge (TPK) (König, Jäger-Biela, & Glutsch, 2020) and familiarity with digital resources, which the authors refer to as the Inquire phase. The majority of the teachers in this study identified experiences from their post-secondary education that better positioned them to effectively teach their students, whether that be explicit assignments from a college class or generally engaging with online science education as part of the college program. Six of the 10 teachers interviewed indicated that they had some level of experience with online science teaching either as a student or as a teacher. Brooke and Demi both completed master's degrees in Science Education via an online program that required them to engage with various digital resources, while Bella had previous experiences implementing digital resources in a traditional classroom setting. Ava, Avery, and Layla stated that they had participated in online science instruction as students.

Despite the exposure to online science education through their college experience, the teachers commented on the range of professional development (PD) offered by their various school districts. The teachers clearly recognized that, while having some TPK, there is a need for more if the goal is to design effective online instruction, as Bella mentioned in her exemplar regarding the rigor of her current class. This experience with online science instruction is important because teachers with professional knowledge about technologies for application in teaching and learning are more likely to communicate with parents and students in online teaching environments, introduce new content, and effectively differentiate content (Hakverdi-Can & Dana, 2012; König et al., 2020).

The Inquire phase of the ERTE framework also addresses the importance of assessing the health, safety, and access to technology of the students. These concerns permeated the data and are evident in Kaylee and Layla's exemplars in the *Student Participation and Access and Equity* section, as well as Avery's exemplar in the *Student Wellness* section above. In these cases, the teachers were planning instruction based on the technological limitations of their students, as well as considering their students' overall health. This is particularly important because students of low socioeconomic status tend to be more adversely affected by long periods of time away from school (Fox, 2016; Müller & Goldenberg, 2020) and is also important because of the false assumption that students who are considered "digital natives," or individuals who have grown up being exposed to technology, do not necessarily have sophisticated digital skills (Hakverdi-Can & Dana, 2012). Likewise, Kaylee's comment expressing concern over students' limited access via school-provided Wi-Fi hotspots exemplifies her recognition of what Whittle et al. (2020) call a social variable that impacts some groups of students more than others and is imperative for teachers to consider when designing emergency remote learning experiences.

Finally, the teachers entered the Design stage of the ERTE as they intuitively began designing remote learning by considering their strengths and weaknesses, as well as the shortcomings of the current learning environment. The teachers acknowledged the inequitable amount of time allotted for science instruction and considered novel ways to embed science content in the context of other disciplines; however, this proved challenging as teachers struggled to successfully infuse science in the other content areas.

## Conclusion

The inequity of student access to both broadband and technology was one of the main challenges that our ESC teachers faced when transitioning to remote elementary science teaching. We recognize that our sample is limited but feel that their concerns are representative of teachers across the U.S. The disparity in access impacted how all of the teachers designed instruction. The lack of access to technology hindered the teachers' ability to plan and monitor instruction and to stay connected to students. The limitation of communication between teachers and students not only impacted learning, but more importantly it limited the essential emotional support teachers could provide their students, especially during this extraordinary time.

In our conversations with teachers we recognize their resilient nature. They were able to adapt and transition their science instruction. They expressed frustration with transitioning to this format of instruction since it is not representative of their philosophy of teaching science. Meaning, from their knowledge and training in teaching elementary science, they believe quality teaching is to provide students with hands-on, minds-on interactions, using multiple experiences to teach concepts. Even though the teachers communicated the difficulty of teaching elementary science remotely and during an emergency crisis, they dedicated themselves to finding effective resources, designing more engaging instruction accessible to all students, and rose to the challenge of communicating with "all" students during this time of teaching in an online environment.

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