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Abstract
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Keywords
science instruction, COVID, equity in science, qualitative study

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A Snapshot of Science Education During COVID-19 in the Spring of 2021

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The COVID-19 pandemic has placed many unique challenges on our education system. Unpacking the many issues that educators faced will allow researchers to understand some of the impacts that resulted from this unique phenomenon. This exploratory qualitative research study sought to understand how science educators and administrators made sense of science instruction during the spring of 2021. Data was collected through semi-structured interviews and online observations with ten K-12 science teachers and four administrators across two different counties within Virginia. Thematic coding was employed to analyze the findings, and results were validated through member checking with participants. Participants shared that the COVID-19 pandemic highlighted the need to be extremely resilient and flexible to cope with the changing landscape. For science instruction issues of scientific engagement, inquiry instruction, and equity were present for science educators.

Keywords: science instruction, COVID, equity in science, qualitative study

In March of 2020, the United States joined the rest of the world in a global crisis involving the outbreak of a coronavirus disease (COVID-19) caused by the virus known as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Society found itself quickly applying extreme measures to slow the spread of the virus (Center for Disease Control and Prevention, 2020). Quarantine measures, social distancing, and "shelter-in-place" orders were mandated by national and state leaders. Schools across the nation closed their buildings based on recommendations and guidance from the Centers for Disease Control and Prevention (Center for Disease Control and Prevention, 2020). Many state governors directed public schools in their states to use remote methods of instruction shortly after school closure was announced (Grossman et al., 2021).

In March 2021 (a year later), 41 states across the country were starting to return to in-person instruction in schools with remote options still available for some families (Decker et al., 2020). Counties across Virginia had adopted different strategies for instruction, including virtual and “high flex” classes. A “high flex” classroom is an in-person class that streams synchronously via Zoom (a video conferencing platform) for online learners. Like many other states, there was no common protocol across Virginia for how to deliver curriculum and when or how to re-open schools (Decker et al., 2020).

The unique circumstances of the pandemic forced teachers to fit lessons that were crafted for in-person instruction onto online platforms (Schwartz, 2020). For science classrooms, this transition to a “high” flex learning environment impacted the enactment of inquiry education. Inquiry science education as defined by the National Research Council is

> A multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data;

> proposing answers, explanations, and predictions; and communicating the results. (National Research Council, 1996, p. 23)

The Next Generation Science Standards (NGSS) of 2012 also support inquiry science education as a best practice for engaging science learners (Bybee, 2013). Enacting inquiry in the classroom is complex and hands-on experience is required to practice this ambitious skill (Newman et al., 2004; Varma et al., 2009; Windschitl, 2003).

Teachers' important roles as decision-makers for curriculum enactment make them vital actors when we try to understand how inquiry science was taught during the spring of 2021 (Remillard & Heck, 2014). Teachers have agency as they are constantly interpreting and interacting with classroom variables and students to maintain engagement (Bolster, 1983). Their interpretations of the events that unfolded in their classrooms create a window into what happened within those "high" flex environments during science instruction.

Administrative support is necessary for teachers to be confident in their abilities in the classroom (Corbell et al., 2010). Administrators can play a crucial role in the success of science programs at the school level (Brogdon, 2015). Including administrators' voices in this research helps to uncover the types of support administrators were providing for their teachers and their communities during the spring of 2021.

The purpose of this exploratory research was to gain insight into how elementary and high school science teachers and school administrators navigated remote and in-person learning environments during the spring of 2021. Through interviews and online observations, this qualitative study aimed to highlight the meaning-making experiences of teachers and administrators in two school districts within Virginia during the March-April of 2021. The following research question was explored: what were science teachers' and administrators' meaning-making experiences when trying to implement inquiry science instruction during COVID-19?

Literature Review K-12 Science Education During COVID-19

Empirical research centered on the COVID-19 learning landscape in K-12 is just starting to be published (Dibner et al., 2020; Schwartz, 2020). Virtual science teaching has been shown to favor traditional, didactic methods (Dibner et al., 2020) that are less rigorous and less engaging than in-person instruction (Lan & Hew, 2020). The transition to a virtual classroom during COVID-19 has challenged teachers to be creative and highly flexible with instructional strategies (Schwartz, 2020).

For elementary classrooms, the effects of COVID-19 instruction highlight a slightly different issue. Science plays a critical role in the elementary classroom, providing experiences that support language and logic skills. Science also helps to develop curiosity and wonder, facilitates critical thinking and problem-solving skills, and provides students with the foundations and experiences that will assist them in functioning as scientifically literate citizens (Eshach & Fried, 2005; Krajcik et al., 1999; National Science Teachers Association, 2014). Despite these benefits, elementary teachers often forgo science instruction, succumbing to the pressures of high-stakes accountability performance in reading, writing, and mathematics (Blank, 2012). This trend has the potential to be exacerbated in a pandemic landscape. Uncovering how and if science was taught in elementary settings during the pandemic can offer insight into the novel ways teachers incorporated science instruction along with the heavy pressures of teaching reading, writing, and math.

Virtual Instruction

The use of distance learning techniques like videoconferencing platforms (Zoom) is not new in higher education, but it is novel in K-12 settings (Sayem et al., 2017; Wang et al., 2018). Results from studies specifically looking at videoconferencing have reported mixed results. Before the pandemic, Wang et al. (2018) conducted a study that investigated a blended synchronous learning environment (BSLE), like the "high flex" environment in this study. Results indicated that students liked the flexibility and convenience of attending lessons via Zoom; however, researchers observed that students' participation through Zoom was low. They noted that students shut down their webcams during class lectures, thus making it difficult for the professors to assess student engagement. Sayem et al. (2017) found that the use of Zoom virtual tutorials resulted in increased student satisfaction and reduced instructor workload within university engineering classes.

Researchers have started investigating Zoom learning during COVID-19 (Adnan & Anwar, 2020; Agarwal & Kaushik, 2020; Serhan, 2020), but this research is limited to higher-education settings and contains divergent conclusions. Agarwal and Kaushik (2020) studied medical students' transition from face-to-face (F2F) to Zoom lectures and found that all participants enjoyed the flexibility of the Zoom format and recommended adding Zoom lectures to the medical curriculum. Serhan (2020) studied the transition from F2F to Zoom during COVID-19 with thirty-one university students and concluded that students and instructors struggled with learning and teaching using Zoom. Issues included internet access, curriculum delivery, and student satisfaction.

For general online coursework in K-12 settings (separate from video conferencing), Cavanaugh et al. (2009) completed a meta-synthesis of literature (226 documents) about online education and found that empirical research was limited in three key areas: pedological best practices, online support for students of all abilities, and student interaction. A decade later, Arnesen et al. (2019) completed a similar synthesis of literature and criticized the empirical research base for online education highlighting the lack of apparent focus on pedagogy and learning. In science MOOC environments (Massive Open Online Courses), K-12 participants are less engaged in interactive activities with other people, making it difficult for learners to develop a sense of relatedness (Lan & Hew 2020).

Another tool for online science education is the use of virtual lab exercises and activities. For elementary, secondary, and college-level science instruction, virtual science labs have been found to be more effective in teaching abstract lab constructs compared to in-person labs when performed in a classroom with teacher guidance (De Jong et al., 2013). In terms of learning gains, the instructional medium (virtual labs versus in-person labs) has been shown to have little effect on overall learning gains (Clark 1994; Klahr et al., 2007). Both physical and virtual lab experiences aid high school students' understanding of naturally occurring phenomena (Pyatt et al., 2012). When used in combination, virtual and in-person lab activities have been shown to increase the cognitive understanding of scientific principles (De Jong et al., 2013).

Student Engagement During COVID-19

Student engagement is a multidimensional construct consisting of three distinct yet interrelated parts: behavioral, emotional/affective, and cognitive engagement (Fredricks et al., 2004). Behavioral engagement refers to how involved students are in learning activities in terms of attention, participation, or persistence. Cognitive engagement refers to how much mental effort students spend in completing learning tasks. Emotional engagement refers to the feelings students have toward teachers, peers, learning activities, and school experiences

(Fredricks et al., 2004). Student motivation and engagement are influenced by various contextual factors such as teacher and peer support (Lietaert et al., 2015). Teacher support is one of the most important factors, as teachers play a crucial role in fostering student motivation in schools (Allen et al., 2013).

For engagement during COVID-19, having a digital support structure that focuses on students' autonomy, competence, and relatedness in online learning helped to increase all types of student engagement (Chiu, 2022). When teachers successfully attend to these three needs, students feel a stronger sense of autonomy to choose their preferred technologies, a stronger sense of competence to access online learning, and a stronger sense of relatedness to connect (Chiu, 2022). Without these supports, teachers prioritized behavioral engagement during COVID-19 (Roman, 2022). School closures make it difficult for students to maintain important relationships, and this may take a toll on students' social and emotional engagement (Oosterhoff et al., 2020; YouthTruth, 2020). Students with access to high-speed internet and internet-enabled devices consistently reported higher levels of engagement than those without (Domina et al., 2021; Dorn et al., 2020).

Methodology

According to Erickson (2012), qualitative methods are best utilized when the meaning-making perspectives of actors in a particular event are being studied. This phenomenology considers the way teachers and science administrators reflect on how science was taught a year into the COVID-19 pandemic. Specifically, the researcher looked at how participants were "COVIDing" during the pandemic. "COVIDing" is an interaction verb that the researcher will apply to make meaning of the ever-changing context of the COVID-19 pandemic in the spring of 2021. The meaning was derived from interviews and field analysis of teachers' and administrators' perspectives about their social interactions. The interpretation came from coding teachers' and administrators' perspectives of their context as they enacted and aided teachers in enacting science instruction.

Setting

Apple Blossom and Freeburg County schools in Virginia were chosen for convenient access to site participants and observational data. Pseudonyms were used for both school names and participant identities. Apple Blossom County serves nearly 14,000 students in preschool through 12th grade in central Virginia. Apple Blossom, though primarily rural, also contains suburban and urban settings. There are fifteen elementary schools, five middle schools, and three high schools. Teachers and administrators from two high schools and four elementary schools participated in the study. Twelve percent of the students have disabilities, twenty-seven percent are economically-disadvantaged, and ten percent are multi-language learners. Seventy percent of the teachers hold advanced degrees, two percent are national board-certified, and on average, teachers have fourteen years of teaching experience.

Freeburg County is the 20th largest school division in Virginia and serves 14,000 students. There are 23 different schools including twelve elementary schools, four middle schools, three high schools, and a career and technical/alternative learning center. Teachers and administrators from one high school in Freeburg County participated in this research. About eighteen percent of the students have disabilities, thirty-two percent are economically-disadvantaged, and ten percent are multi-language learners. Forty-five percent of the teachers hold advanced degrees, less than one percent are national board-certified, and on average, teachers have nine years of teaching experience.

Participants

Participants were recruited through a school-wide email that the researcher authored to be sent out to participating schools. The science coordinators for the different counties sent out a recruitment email to all schools. In Apple Blossom County, six different schools responded to the email. In Freeburg County, one high school responded to the recruitment email. Consent for participation was documented by signing an informed consent form that was approved by the Institutional Review Board for the Protection of Human Subjects (IRB) protocol through the University of Virginia. All participants volunteered for the study. There was no monetary benefit for their time during the interviews or observations.

From Apple Blossom County, the researcher interviewed two high school teachers from two different high schools and four elementary teachers from four different elementary schools. Semi-structured interviews (see Appendix B) lasted over an hour and were conducted one time over Zoom. A follow up interview was conducted to validate the transcription and findings from the interview data that lasted about 30 minutes. The high school teachers were teaching in a "highly flex" context. One experienced teacher (five years of experience) taught Environmental, Earth Science and AP Environmental Science. The other teacher was an Astronomy teacher in her first year of teaching. The Astronomy teacher also participated in a field observation that lasted ninety minutes over Zoom. All the elementary teachers started online but were back in person in the classroom during the interviews. Two of the elementary teachers were in their first year of teaching, and two had five or more years of experience. One elementary classroom allowed the researcher to take field notes during a 5^{th}-grade classroom online observation. The observation lasted forty-five minutes and was conducted over Zoom. The researcher interviewed one elementary principal and the science coordinator for the district. These participants were considered administrators, and their interview questions were slightly different based on their context (see Appendix C).

In Freeburg County, the researcher interviewed four high school teachers all from the same school. Semi-structured interviews occurred one time over Zoom and lasted over an hour. A follow up interview was conducted to validate the transcription and findings from the interview data that lasted about 30 minutes. All the teachers were teaching in a "high flex" context. Two classrooms included special education students or students that needed behavioral and emotional support. Three teachers were teaching Biology, and one taught Chemistry. All the teachers had at least five years of experience. The researcher conducted a field observation over Zoom in one co-taught Biology classroom. The observation was conducted one time solely by the researcher and lasted ninety minutes. The researcher interviewed the science administrator for the high school and the county science coordinator. All data was collected by the researcher from March 2021 until April 2021.

Data Collection

The data collection spanned from March 2021-April 2021. Semi-structured interviews and classroom observations were conducted over Zoom. The use of two data sources help to triangulate research findings.

Interviews

In this study interviews were the primary source of data collection due to the limiting nature of the pandemic and access to sites. Interviews were conducted to gain an insight into the participant's constructions and verification of science instruction during COVID-19. The researcher asked the participants to reconstruct what happened as the pandemic changed through different stages. Each participant was interviewed twice over Zoom (once for data collection and once for data validation) for a total of about ninety minutes. The first interview followed the interview protocol. The second was a follow-up interview to validate the transcription of the interview and to review the themes that were discovered during the coding process. Interview protocols are attached in Appendixes B and C.

A semi-structured interview format was used that allowed the researcher to scaffold questions around the research topics, while still allowing for emerging questions and issues to be discussed. The questions were descriptive, allowing the participants to describe their meaning-making experiences when trying to implement and support inquiry science instruction during COVID-19. Interviews were audio-recorded on Zoom to ensure completeness and to provide an opportunity to review later. When possible, the interview was transcribed into Word within 24 hours for data analysis. The researcher saved all recordings and transcribed data on a personal computer that was password protected to ensure security. After transcription, all audio files were deleted to maintain confidentiality.

Observations

The researcher observed three classrooms for this study; each observation lasted 90 minutes over Zoom. All observations occurred in March and April of 2021. Participants were made fully aware of the nature of the study and the fact that they were being observed. Classrooms were not video recorded due to privacy concerns. The researcher took field notes during the observations and used the observation protocol which can be found in Appendix A. According to Graue and Walsh (1998), data records deteriorate geometrically over time, so the researcher tried to jot down as many points of observation as possible during and right after data collection.

Observations were supplemented with teacher input and collaboration. The researcher observed one "high flex" class of inclusion Biology (a class with special education students), one "high flex" Astronomy class, and an in-person 5th-grade elementary science lesson. The in-person 5th grade class was observed synchronously by the researcher. The teacher set up a computer at the back of the room and the researcher used Zoom to observe the setting. Data were analyzed within 24 hours of data collection to limit memory bias. When observing classrooms, the researcher made notes about the interactions taking place in context. Notes were made about student engagement and inquiry lessons being taught by the teacher. To limit observational bias, the researcher kept a methodological journal and shared all field notes with the teachers after data collection was complete. Comments and feedback from the participants were included within the analysis.

Data Analysis Methods

Data analysis was completed simultaneously whenever possible with data collection and after data collection was completed. The researcher drew from the general methodology of thematic coding (Erickson, 2012) to develop categories from the data. Open coding was used to analyze interview transcripts and observations. Coding was conducted line-by-line by defining actions or events within each line of coding. Field notes were compared to video recordings from the Zoom sessions and were coded for themes. This form of coding aided the researcher in focusing attention on participants' perspectives rather than the interpretations of the researcher. Thematic codes included engagement, inquiry, challenges, equity, and instruction. The constant comparative method was used to examine and reexamine the data to analyze categories and meaning.

Data analysis validation was addressed utilizing member checking with interviewees after data collection. Once the interviews were transcribed, participants were given copies of the interview transcripts with the thematic coding. The researcher then had a Zoom call with all participants to ensure that the themes that were gleaned from the transcripts were correct. Participant feedback was included in the analysis. If there was a mistake or a clarification, the researcher corrected the information based on participant feedback. Participants who were observed were also given copies of the field notes with thematic coding for review. Participants added context to some of the researchers notes about student engagement in class. All feedback was incorporated within the data to ensure validation.

Criteria for Validity

According to Charmaz (2006), there are four constructs of validity in constructivists' use of qualitative methods. Credibility can be achieved through intimate familiarity with the setting or topic. The researcher did not spend endless hours in the field but argues that the credibility of this study rests on the triangulation of data (data from interviews and observations). Another criterion for validity is originality. The researcher weaved the narratives of participant words into the developing categories of COVID-19 science instruction. Through these narratives, original ideas were represented. The third category of validity is resonance. To resonate with participants, the researcher conducted member checking with participants. Interviews were transcribed and coded and these transcripts and codes were shared with participants during a follow-up Zoom call. The final criterion for validity is usefulness. The researcher thought of usefulness in terms of transferability. To create a manuscript that would be transferable to other contexts, the researcher included thick descriptions of the research, participants, methodology, interpretation of results, and emerging categories.

Researcher's Positionality

The researcher is an observer within the context of this study. During classroom observations, the researcher made an overt assertion into the field by introducing her presence on Zoom. Whenever possible the researcher included participants in member-checking interviews and collaboration on observations but did not participate in delivering science content or answering student questions during observations. The positionality of the researcher as an emergent scholar with fifteen years of classroom experience might bias the data because of previous knowledge. She has an acute knowledge of the inner workings of a classroom and taught during spring 2020 during the first spring of the pandemic.

The researcher assumed that most students were not going to be engaged during instruction. This bias came from the experience of teaching high school biology online during the spring of 2020. The researcher also assumed that most instruction was going to be didactic and hard to translate into an inquiry format. Having experienced the uncertainty and exhaustion of teaching during COVID-19, the researcher also assumed that teachers were still feeling this stress.

To account for the potential bias in analyzing data, the researcher kept a methodological journal during the research process to account for potential assumptions. Journaling after interviews and observations allowed the researcher to reflect upon the data. Before coding, the journals were read to ensure that any potential bias was not incorporated into the data analysis. After each interview, the researcher would reflect upon her positionality within this context. Before coding, the researcher would visit this log to reflect on potential assumptions that might be made from the data.

Findings

Themes

Data were grouped into four themes. Major themes were connected to science education and the action of "COVIDing" through the pandemic learning landscape. The entire context is situated within participants resilience and flexibility. Other themes included online engagement, inquiry instruction, and equity. Figure 1 demonstrates the connections between categories. Participants had to apply the skills of resilience and flexibility to manage the unpredictability of the COVID reality. The transition to "high" flex learning impacted students' cognitive, behavioral, and emotional engagement. The constraints of the "high" flex Zoom environment limited what teachers could do with inquiry-based science education. Access to technology and the internet prevented some students from joining the classroom, thus highlighting issues of equitable access to educational materials. These themes all worked together during the spring of 2021 and impacted how teachers were able to enact the science curriculum during COVID-19.

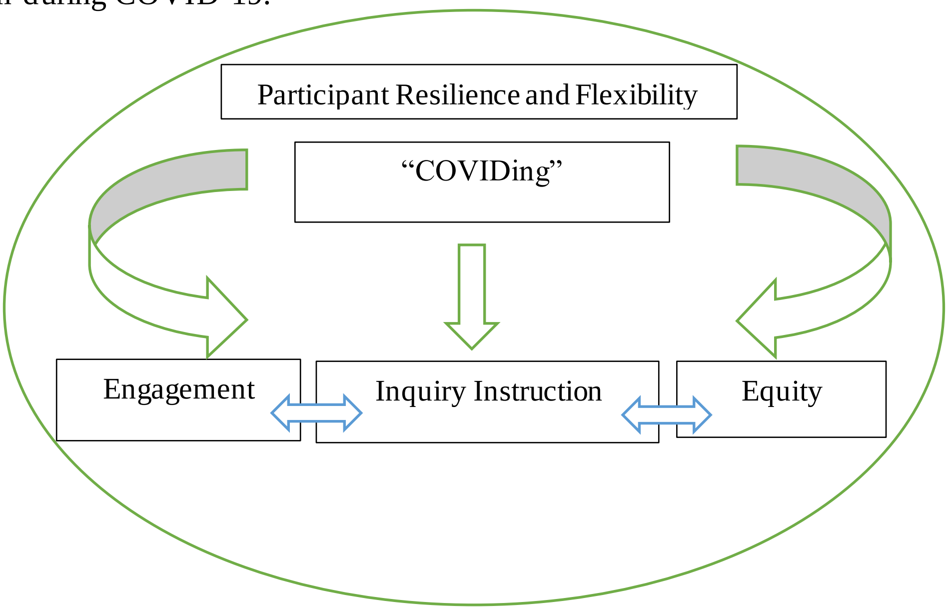

Figure 1
Themes

Engagement

Engagement showed up as a major theme for the "high flex" learning environments, virtual learning environments, and for families in general. Based on the observation data, students had minimal behavioral engagement during class. One student out of 24 had their camera on during synchronous instruction. In the inclusion classroom that the researcher observed, none of the online students had their cameras on. One high school teacher who has been teaching for twenty-five years shared, "I have students with zeros. For the year. I have never had a student with a zero. I have students who sit in my class with zeros. Some kids have completely just decided not to do anything. The lack of engagement and the policies that are supporting the kids who are not doing anything is amazing.”

For cognitive engagement, one teacher high school teacher shared, “I have not given a quiz or test the entire year. Because regardless, they can look it up it's all about open notes, everything is open notes on time use your resources, and so I haven't given a test or quiz.”

Teachers have been told to be highly flexible with student's time, but during asynchronous activity periods, teachers report that students are doing nothing. One teacher explained,

> In a normal year, we would be busy for an entire 90-minute block, and we would be learning the same things but just over a longer period and being able to work through problems and be curious and get their creativity out on paper or in a lab. Now they are not getting that. (High School teacher, April 2021)

According to teacher interviews, students were also not engaged emotionally. One elementary teacher shared,

> The extra attention from the teacher just was not there, either because if you did not have extra adults, you could not have breakout rooms. Or you would put each kid in an individual breakout room, and you would have to flop between them to check in on them, or you know you would have them do independent work, but it was less personable… it felt like very surface-level unfortunately... (a student) did not talk very much virtually but in person, she is like drawing pictures and asking me 99 questions. (Elementary teacher, April 2021)

Similar sentiments about general engagement were shared by an administrator from Freeburg.

> It has been hard trying to reach the completely virtual students. The reasons for why they are here (in virtual school) varied from family to family and that has been the most frustrating part of all this. Trying to reach out to those families and get these students involved they are just detached. They have not engaged at all and that is very worrisome. We know we have got to try to get them back into it. (Administrator, April 2021)

The family engagement was of great concern to this high school administrator. The detachment from these groups raised questions about the engagement of the students and the support from their families.

Vignette on Engagement

All the high school classrooms in this study (six) were being taught in a "high flex" fashion. Most of the students were at home video conferencing with the teacher who was in person with a few students. Below is a vignette from a classroom that the researcher observed.

> The researcher enters the Zoom call and waits patiently to be let into the "room." There is a "Welcome" banner displayed on the screen asking the students to scan a "QOTD" code to answer the question of the day. Some folksy music plays in the background and periodically gets scratched out by the bandwidth of the internet. The question of the day appears:
>
> "If you were stranded on a desert island, what food would you take."
>
> Chat messages start populating the screen with answers like "hot dogs;" a total of three students participate. The teacher's screen comes into view, and you can see her sitting at her desk with a face mask covering her nose and mouth. The

> chat goes wild again as students claim attendance by typing their names. She is sitting in her classroom with two other students in person, and nineteen others on the Zoom call. Most of her attention is directed into the virtual space. Only one student has their camera on, the rest appear as tiny black boxes with white names scrawled across the screen. The researcher introduces herself and states her intention of just watching the interactions that are taking place online.
>
> The lesson continues with a short lecture and power point about the conditions necessary for life. This is a high school Astronomy class for upperclassmen, and the search for extra-terrestrials is the hook for the learning today. The teacher asks a general question to the group to name a supercluster, eliciting a prior lesson. Only one student (the one with the camera on) responded to her prompt. If the students in person are responding, there is no way to hear them.
>
> Switching gears, the lesson moves to a synchronous activity online. In groups of eight, the students are answering questions on a Google Doc (an online document) that is linked to the county's website. The teacher wants to model where to go on the website, but it takes a while to load the document. Once it is loaded, she points to a table where they are to discuss Hollywood's portrayal of extraterrestrial life. She asks, how accurate are the movies' depictions of aliens?
>
> The researcher gets placed in one of the Zoom rooms. Only one student has their camera on, and the rest are on black screens with white names. The students seem to be collaborating, and the teacher drops in for a few moments to hear the discussion. One student excused himself because the county's lunch bus has arrived, and he must go. Two students do not say anything during the synchronous activity. Ten minutes go by, and then the teacher pulls us back into the "main room."
>
> The lesson continues as whole group instruction, with the teacher mostly focusing her attention on the computer screen. Some videos are linked to slides that she wants students to view later. The one student with the camera on is the only one who contributes to the conversation. She does not call on anyone else but moves on through the notes. Forty-five minutes go by, and she moves on to asynchronous work. For the remaining forty-five minutes (and the following day's classwork assignment to be completed at home), the students have a list of tasks that need to be completed. Most of the students drop the call at this point, and she focuses her attention on the two students that are in person.

Most of the teacher’s attention was on the students who were video conferencing into class. Her actions and responses were intended to meet the needs of these students. However, in terms of engagement, students were not showing their faces or even responding to her prompts. From the observation, students did not appear to be behaviorally engaged (cameras off) or cognitively engaged (minimal participation).

Inquiry Instruction

For inquiry instruction, according to the teachers, many lessons had moved away from hands-on experimentation to digital notebooks, vocab strategies, and videos. In an interview, a high school teacher shared, "I restructured the entire format of biology to be an online course, and then when they come into class, we maybe expand on that, or we play a game." Another high school teacher said, "It's been hard. I do use a lot of ED puzzles or online simulations." A chemistry teacher shared, "The other thing would be labs. We cannot do labs. We are doing a lot of PHET simulations. We are doing a lot of graphical analysis. They have learned how to make graphs." For some elementary classes, the impact of COVID-19 limitations left little time for science. One teacher reflected,

> Science was extremely impacted. Reading and math were the things that we had to spend most of our time on. We would do one unit on science and then we would switch to a unit on social studies, and we still do that, but it was, it was just a 30-minute chunk. The amount of planning and time it took just to get through the other parts of the day that we had to focus on math and reading left us barely any time and bandwidth to get to other things like science. (Elementary School Teacher, April 2021)

According to the interviews, other elementary classrooms collaboratively handled science instruction. From the interviews, one teacher tried to integrate science with math and reading. She shared that she helped the county and her team plan for science during the summer by creating common curriculum pacing guides and lessons. An administrator from the same county echoed this effort by highlighting her focus on helping to create professional learning communities that were led by teachers to support curriculum enactment. One teacher shared that he created take-home roller-coaster kits to keep his students engaged, and handed them out to parents to help their children build them at home

An administrator from one of the elementary schools shared that the achievement data from a mid-year school science assessment was higher than he expected, but that he thought the depth of inquiry was not being taught in his school.

> I looked at our science achievement in our mid-year data and science was the one area we're doing better in this year than we did last year. I'm a little concerned about that in that I when I look at the test it certainly is not promoting deep scientific thinking as much as it is promoting recall. With the limitations we've had the past year we've relied on some more traditional factory call. The teachers are focused on surface level science instruction really focusing on terminologies and basic concepts and have not been able to give kids the opportunity to really dive into deep investigations as much as we typically would. We've seen this before you know where you could score better on a test, but not necessarily be better in your content. I wouldn't be surprised if that's something that we're experiencing. (Elementary School Administrator, April 2021)

For high school science classes, some teachers shared that most of the inquiry experience moved to a virtual lab format. In response to the virtual labs, one teacher stated that she felt like the experience of the inquiry lab did not translate online.

> I feel that the virtual science labs kind of cheapen the experience, because they do not get to physically learn how to measure things. They do not quite understand density, and that is a huge thing in earth science to understand because it is in literally everything that we talked about so that is one of the first labs that we normally do and doing an online density gizmo just does not give you the feel of what density is. (High School Teacher, April 2021)

From the interview, she is stating that all the different learning experiences that give her students a feel and understanding of what density is are not translated well in virtual labs. Especially when the teachers cannot be in person to supplement the experience.

Equity

Issues of equity in science instruction bubbled up to the surface many times, especially for the "high flex" teaching model. Apple Blossom County was pushing for all lessons to be equitable. If an in-person student was having an experience that a virtual student was not able to access, that lesson had to be shifted. For example, one high school teacher shared,

> We are trying to focus on equity in this horrible time. I feel like we are hyper-focusing on something that cannot be achieved. In one month, five months, or within this year I think if we were to focus on just the meat of like getting the kids their computers or contacting parents… the school is supposed to be a family, and I feel like we are building a car, while also trying to drive it. (High School Teacher, April 2021)

A high school teacher from Freeburg County explained that her course is essentially an online course. All her notes, lectures, videos, and papers are virtual. She does not handle a single paper in person. In terms of equity, she uses the in-person lesson to reinforce the curriculum with games and interactions. Most of the core learning comes from the online material. She shared,

> It must be equitable for biology students at home versus here. You must assign it for the ones at home, first, and then the ones that come in here, you make it more interactive but ideally, they are turning in the same assignment online (so it is equitable). (High School Teacher, April 2021)

Similar stories about emphasizing equity were shared by the elementary teachers in their virtual classes. One teacher from Apple Blossom shared,

> A lot of the activities they would offer (Virtual Virginia the online curriculum) that could be hands-on we had, we made them available, but optional because it is not equitable to say every kid needs to go on a scavenger hunt and go find all these things in their house or outside. Some kids cannot go outside because they do not have a yard, or they do not have these objects at home, or it is not safe. So, it ended up becoming optional, and then when they would see optional after a day of online learning, they were like, Nope, I am too tired. I cannot even consider something optional. (High School Teacher, April 2021)

This teacher felt that the students who did not have equitable home situations would not be able to participate in the optional learning. When students saw optional, they became too tired to complete the task and opted not to.

Resilience and Flexibility

Teachers and administrators demonstrated a tremendous amount of resilience and flexibility in the spring of 2021. One administrator bravely shared, "I don't feel defeated you know. I keep going." A teacher reflected that a major theme for her entire year was the flexibility demonstrated by everyone at the school.

> This school year (2019 to 2020) has been unique and "one for the books." My main word to describe this school year would be "flexibility." Teachers and students have both been tasked with new challenges and flexibility has been paramount. Some highlights of this school year have been the resilience that has been created and developed in both students and teachers, the adaptability and flexibility that has been required by both students and teachers and the sense of community that we are all in this together. (High School Teacher, April 2021)

Community was also built by rewarding teacher flexibility. One administrator shared,

> All these things that teachers rely on as being predictable are suddenly not predictable, which makes it very difficult for them to do their job. One of the things it's been great for us is every month (it's a little cheesy): we hand out what's called the Gumby award, for a staff member who has demonstrated exceptional flexibility. Anyone who wins this prestigious award is then tasked with awarding the next teacher the next month, Really, more than anything else it's a way to remind us all to be grateful to others, as we need all to be flexible. (Elementary Administrator, April 2021)

The Gumby award allowed administrators to acknowledge teacher experiences in a creative, celebratory mood. Small celebrations created a feeling of community among participants and their colleagues. One teacher shared that her administration created a positive community through "special events for teachers from administration (i.e., ice cream social), support through positive encouragement with sticky notes and small acts of kindness around the building."

Despite the positive remarks about resilience and flexibility, there was also exhaustion in the participants voices. One administrator shared, "This has been the most exhausting year ever." Participants had to create virtual experiences, and then change those lessons for high flex classes. The amount of planning for each of those stages seemed astounding. A high school teacher shared, "Just when I think I have all my materials ready for a virtual experience, the kids are back in person, and I am reinventing the wheel again." The stress of intense flexibility was palpable in all the interview conversations.

Discussion

Participants were all "COVIDing" and handling the COVID-19 stress in different ways, but the anxiety of the context was ever present in their voices. The resilience and flexibility required to navigate the changing situation created audible exhaustion. Science teachers and administrators grappled with engagement, inquiry science curriculum and equity issues all within the strange context of COVID unpredictability. The key question that was posed as part of this research asked: what were science teachers' and administrators' meaning-making experiences when trying to implement inquiry science instruction during COVID-19?

For high school classes, the "high flex" learning environment is not conducive to inquiry education. Based on the teachers that were interviewed, virtual labs were challenging for the students and ineffective, despite the research supporting virtual lab experiences as a positive tool to teach abstract learning concepts. (Clark 1994; De Jong et al., 2013; Klahr et al., 2007; Pyatt et al., 2012). Some teachers reported that science instruction turned into a game, and for some teachers, this is how they engaged students without inquiry labs. The reported interactions between students and teachers did not include practicing science processing skills. Most of the interactions that teachers shared revolved around information recall.

For elementary classrooms, teachers reported that the pressures from math and English left little time for science. During interviews, teachers shared that lab activities were given as optional and optional activities were most often not completed. The researcher observed science processing skills being practiced during in-person instruction, but it had to be carefully scaffolded for distancing protocols by the teacher.

Other issues that were highlighted for teachers were issues of engagement. Behavioral, emotional, and cognitive engagement were all challenged and shared within the interviews. The observations into the "high" flex classrooms showed that most students were not engaged at all. Teachers reported giving students zeros on assignments and could not get students to plug back into school.

One interesting category from this work was that as teachers and administrators were “COVIDing,” a discussion of equity came to light. As both parties were trying to support student learning they noticed that the virtual environment is not equal to the in-person environment. To account for this, Apple Blossom County put limitations on what teachers could cover in their “high flex” high school classes. One teacher shared, “I was happy to go to high flex but unfortunately we're told that we can't do physical labs like we normally would because the kids at home won't get to experience it and therefore it's not equitable.” COVID-19 has disproportionately impacted poor communities exacerbating the economic and academic disparities across the United States (Donohue & Miller, 2020; Schwartz, 2020; Usak et al., 2020). Low-income students have difficulties accessing resources such as technological devices, the internet, individualized educational support, mental health services, and translations of communication from their schools (Dibner et al., 2020). Students from low-income households may lack internet and technology access to join synchronous virtual classes. These students' parents are more likely to be essential workers, leaving the kids at home without academic support (Schwartz, 2020). Virtually, schools struggle to support a broad range of students (Cavanaugh et al., 2009), and this highlights equity issues.

In conceptualizing equity in virtual instruction, the researcher associates equity with people receiving what they need. It seeks to advantage people that are the least well off, for example, marginalized communities including low-income families (Ericson, 1990). Equitable science instruction provides students opportunities to participate meaningfully in their communities (Holland & Correal, 2013; Lave & Wenger, 1980) and enables students to see themselves, their families, and their cultures as part of science (Agarwal & Sengupta-Irving, 2019). The barriers of COVID-19 provide additional challenges to achieving these goals.

The researcher contends that equity is not the same as equality. The county seemed to be confusing the two. To make science more equitable for marginalized communities (including families stuck on the digital divide of virtual instruction) teachers and administrators should provide students opportunities to participate meaningfully in their communities (Holland & Correal, 2013; Lave & Wenger, 1980) and create activities that enable students to see themselves, their families, and their cultures as part of learning science (Agarwal & Kaushik, 2020). Limiting opportunities for students who are in-person because you cannot provide an equal experience to a student online is limiting everyone; there is no equity there.

For the elementary classrooms, one teacher was told that her students could only complete a scavenger hunt outside if it was optional. The county felt it was inequitable to have city kids who might not have yards to go outside when a county kid might have more available for a scavenger hunt. Going outside and exploring your community is the very definition of equity. Connecting to your community and seeing yourself as a scientist is part of the scientific process. COVID-19 highlighted inequities and inequalities in our communities, but they have always been present in our school communities. Focusing on limiting interactions due to this agenda is limiting science education. There must be a more creative way to tackle this issue within science education.

One administrator voiced frustration with some families disappearing from the learning landscape completely. Most of their attention was directed towards supporting staff and students, and not directly related to science processing skills or education. More research should be conducted on how administrators supported staff and students during COVID-19.

Limitations

The pandemic limited opportunities to engage in fieldwork during this study. The researcher would have liked to broaden the scope of analysis by conducting multiple interviews with participant volunteers. A richer interpretation of the interactions would need a deeper time commitment to the context, which was not possible due to COVID-19 restrictions.

Additional limitations would be that all data was collected and analyzed by one researcher. If there had been more time and collaboration, this study might have highlighted different components of the participants' experiences. The participants also knew they were being observed, which might have changed their behaviors. The researcher chose convenience sampling to navigate participation during the pandemic but having a more purposeful sampling method, for example, only high school might paint a different picture about the experiences that educators had.

Finally, this study included the voices of teachers and administrators only. If the researcher had access to students for their perspectives and feedback, different results might have materialized.

Implications

The researcher hopes that this study will provide an insight into how science teachers and administrators created meaning from the unique context of the COVID-19 pandemic in the spring of 2021. This work highlights the challenges educators faced during this time. Understanding the limitations of these educators might pave the way for researchers to create virtual lab experiences that are community-based, easily navigated, and free for teachers and school districts. Another implication is to re-examine how our social systems support families through schools. Perhaps schools should consider adding social workers to the tiers of family support within schools. This work also highlights equity issues for science education. Limiting a student's potential should never be an outcome of equity. Re-defining equity in a virtual landscape is a topic that needs to be examined further.

An extension of this work would be to ask the students about engagement. What did they like about the learning supports they had, and what would they change? Future studies could also look more intensely at the differences between elementary school and high school contexts. How do variables change between these environments?

Appendix A: Observation Protocol
Time:
Date:
Location:

Observation Notes	Inferences

Appendix B: Teacher Interview Protocol

Interview Protocol:
Thank you for agreeing to participate in this study. My name is Lily Bentley, and I am a first-year Ph.D. student at UVA. The focus of this study is to make meaning of how teachers have been impacted in their science instruction during COVID-19. I will be recording the interview so that I can transcribe it later. If at any point you feel uncomfortable and you want to stop the interview, please let me know. You do not have to participate. I want to hear your viewpoint. You are the expert. I may be taking notes during the interview, but I want you to know that even if I am not looking at you, I am listening. I will try to remain quiet to hear your thoughts. Your responses will be kept confidential and once the interview is transcribed, I will have you read through it to make sure I got it correct. At that time, I will delete all recordings. Do you have any questions for me before we start?

Interview Questions Warming up:

1. How many years have you been at your school?

2. How many years have you taught?
3. Can you share with me one of your favorite science moments?

Topic: What patterns of impact do teachers report from their instruction and student learning?

Probe: In a general sense, how has the year been? Can you share some highlights and lowlights with COVID?
Probe: Explain a typical day and how that has changed under COVID

Topic: How have teachers created and implemented science instruction during COVID-19? how have they interacted with their students during this time?

Probe: Can you describe some strategies you have used to deliver science instruction given the new norms?
Probe: How have your interactions been with your kids?

Topic: How have teachers navigated the unique environmental limitations of COVID-19

Probe: What are the requirements for you and how has your role changed?

Topic: How are administrators supporting teachers? How are administrators interacting with teachers to support them?

Probe: What supports have been given to you to manage the pandemic?
Probe: What supports do you need or what supports do you think would have been helpful?
Probe: What has the COVID rollout been like?
Probe: What different stages were there and what issues came up at different stages?

Question: How did you decide to be online or in-person?

Closing: Is there anything else you would like to add that would help me understand how teachers have navigated science instruction during COVID

Appendix C: Administration Protocol:

Thank you for agreeing to participate in this study. My name is Lily Bentley, and I am a first year PHD student at UVA. The focus of this study to make meaning of how teachers have been impacted in their science instruction during COVID-19. I will be recording the interview so that I can transcribe it later. If at any point you feel uncomfortable and you want to stop the interview, please let me know. You do not have to participate. I want to hear your viewpoint. You are the expert. I may be taking notes during the interview, but I want you to know that even if I am not looking at you, I am listening. I will try to remain quiet to hear your thoughts. Your responses will be kept confidential and once the interview is transcribed, I will have you read through it to make sure I got it correct. At that time, I will delete all recordings. Do you have any questions for me before we start?

Discussion Topic One: Explain how has science education been affected through the different stages
Questions: Can you explain how teachers have navigated the pandemic with their science instruction?
Can you explain what science education look like through the different stages?
Probe: Which specific lessons do you think were impacted the most?

Discussion Topic Two: Support - Can you explain how you have supported teachers?

Questions: What types of supports did teachers need during the transitions and what were the differences among the teachers?
How did you specifically interact with teachers to support them? Can you explain what measures were in place, and how do you know teachers felt supported?
How did teachers decided to go in person or not?

Discussion Topic Three: Patterns of Impact
Questions: Can you explain any patterns of impact on teachers or yourself as you moved through stages?
Probe: What new challenges are there for teachers? How do you envision supporting them moving forward?

Is there anything I have left out that you want to add?
Any questions for me?

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