

# Building a Virtual STEM Professional Learning Network for Rural Teachers

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This study explored the experiences of rural and suburban teachers as they engaged in virtual and hybrid STEM professional learning opportunities, analyzed through an ethnographic case study. Provided are two lenses through which to view the findings. First, from the rural teachers' perspective, an exploration of the experiences while engaging in virtual and hybrid STEM professional learning, with findings indicating three major themes: 1) increased collaborations, 2) equitable access to resources and learning and 3) increased content and pedagogical content knowledge. The second perspective, from the project leadership, as collaborations across two IHE's and with multiple district teachers and administrators, led to the design of a professional development model that was successful at initiating a network for rural teachers to engage in STEM learning through investigations, collaborations within and between districts, and coaching activities, aimed at increasing STEM content knowledge and pedagogical content knowledge.

**Keywords:** rural teacher development, professional development model, science education, STEM education, online professional learning communities

In terms of professional development, this project is a testament that we do not have to be alone, nor do we need to reinvent the wheel. We have such talented and knowledgeable people within all districts and universities, small and large, across the state and with projects like this, we can virtually connect and learn from one another. State and district initiatives tend to dictate a building's professional development agenda; however, I feel the quality of experiences provided to teachers would be stronger if we were to collaborate when it comes to planning, preparing, and delivering professional development opportunities. - Rural STEM Teacher Participant

Teachers and administrators from districts, rural and suburban, collaborated with professors and instructors from institutes of higher education (IHE) to participate in two summers of a 2-week professional learning and 1 school year of instructional coaching, through hybrid and virtual participation. A case study research design was foundational to the research-based approaches employed including: (a) intensive summer institutes during which content and pedagogy were directly addressed through book studies, investigations, and discussions, and participants were also charged to design and establish an action plan with input and support from their building/district administrators; and (b) follow up activities, including classroom-based coaching experiences, progress monitoring of actions plans, staying connected with grade level and content specific teachers, along with planning and leading professional learning for their districts.

This project was conducted through collaborative partnerships of two IHEs, a large public land-grant university and a small private Catholic university, along with 10 school districts from across the state of Kansas representing rural and suburban districts and isolated STEM teachers to assess effective ways of providing equitable access in STEM professional learning opportunities for rural and isolated educators. Two of the districts were classified as high needs, all received title one funding, and all the districts fell into one of the following categories: single building rural district, multiple building rural district, multi-town rural district, single campus rural district, suburban district, and private religion-based district. The study was funded through a Mathematics and Science Partnerships (MSP) grant award (KS 84.366B from the S366B150017 federal award) funded through the U.S. Department of Education and was composed of K-8 grade teachers and administrators.

### **Literature Review**

As STEM exploration and career fields continue to grow in interest, there is a looming gap between urban and rural opportunities for STEM learning in the classroom. Lakin et al. (2021) share potential reasons for rural students' lack of interest or enrollment in STEM fields, including lack of familiarity with STEM occupations, less industry outreach, fewer college STEM prerequisites offered in high school, and lack of job potentials in their rural area. Yettick et al. (2014) describes five major areas of challenges for rural districts to engage in STEM learning, including funding, staffing, flexibility, local services, and professional development. With these many challenges comes the call for IHEs to collaborate with districts, of all types and sizes, to engage in high-quality STEM professional learning.

Subotnik et al. (2011) found that the sooner children can be provided with STEM learning opportunities, the more likely they are to pursue a STEM career, which identifies the need to train elementary and middle school teachers. Rather than attempt to train STEM teachers and import them into rural districts, Barret et al. (2015) described the benefits of utilizing partnerships to provide specific and STEM targeted training to teachers already positioned in rural districts. Lavalley (2018) reiterated the importance of training teachers in their rural locales but extended this idea to describe the challenges of attaining access to universities or other training providers to develop and implement these trainings as fewer rural teachers participate in STEM professional learning than their urban counterparts. In their study of teachers' perceptions of STEM in rural settings, Goodpaster et al. (2012) found teacher professional growth as a major barrier in terms of the lack of access to and affordability of high-quality STEM professional learning opportunities.

This inequitable access to STEM professional learning opportunities has led to the utilization of virtual learning platforms to engage rural and otherwise isolated teachers, including teachers who may not have a content or grade-like colleague within their district or geographical region (Duncan-Howeel, 2010). These virtual platforms allow teachers to remain in their rural locations, without the added financial and familial stressors of leaving their school community, or even their personal homes for professional learning, but these virtual platforms must be utilized effectively. Herbert et al. (2016) note multiple studies have shown important factors that increase the effectiveness of online professional learning, including content specificity, hands-on features, extended length of time, and cycles of feedback and reflection. Durr et al. (2020) concluded at the culmination of their professional learning community study with rural districts that online professional learning led to higher teacher efficacy and the desire for continued networking and

growth. The project overview will describe how researchers utilized hybrid and virtual attendance platforms to form a network of teachers, rural and suburban, throughout the state and engage teachers in high-quality STEM professional learning.

### **Project Overview**

The planning team who brought the vision of this project to fruition consisted of IHE STEM content faculty, education pedagogical faculty, instructional coaches, and administration from three of the participating districts. This team collaborated to maximize their internal and external assets to overcome the challenges facing rural schools in receiving quality STEM professional learning and to address the three grant project goals: 1) Increase teacher content knowledge in mathematics and science instruction, 2) Increase student achievement in mathematics and science, and 3) Increase IHE and LEA collaboration to develop a statewide MSP model. This article is focusing on the third goal from the grant project. Using grant funds, Swivl robots were purchased and distributed to each site location based on need. Each site was responsible for having a compatible iPad or phone to use in the Swivl. The tracking and multiple microphone ability of the Swivls allowed for better video tracking of the lead presenter and multiple small group audio captures, when small group discussions or investigations occurred. All sites kept their Swivl microphones off during presentations until they had questions, in which case they turned on their Swivl microphones to pose their questions. For year two, the presenters used inexpensive Bluetooth headsets that provided better audio quality for broadcasting to all the virtual sites. Virtual sites continued using the Swivls and their audio microphones to capture activity and audio. The only drawback when using the Bluetooth microphones was capturing teachers' questions or dialogue in small group work. When face-to-face participants asked a question, the headset was handed to them to talk so all the virtual locations could hear or the facilitator simply repeated the question.

Purchasing expensive technology is not necessary to deliver high-quality virtual and hybrid professional learning. Using existing technology resources within the schools and universities, and a minimal investment in peripheral devices, such as Bluetooth microphones, may be all that is required for each hybrid and virtual location. Using a Bluetooth microphone connected to desktop computers with an attached camera or existing tablets or laptops would be sufficient. Using more mobile camera devices provides easier movement to provide up close views of what presenters are demonstrating or small virtual groups providing close views of their progression through the investigations. Professional Zoom accounts were necessary, but the universities already had this technology resource, so there was no additional cost for Zoom accounts.

Well in advance of the summer institute start date, dedicated time was necessary for extensive and thorough logistical and content planning if equitable access to high quality/high rigor professional learning was to be achieved for these rural and isolated STEM teachers. While working with the planning team and synthesizing the results of the teacher application forms, IHE principal investigators directed talent and resources to best meet these rural and isolated teachers and their district/school needs. All lessons and investigations had to be identified or written up with a complete list of materials and supplies needed to carry them out, allowing enough time for purchasing and delivery of supplies and materials to all virtual and hybrid sites. The number of teachers in each book study breakout session also had to be identified, allowing time to receive and disseminate to the correct teacher location for the summer institute.

Five major components comprised the summer institute: book studies, content presentations, investigations, pedagogy presentations, and networking/collaborative team action planning time. In addition, this project included school year coaching for all participants. The coaching was delivered face-to-face, virtual, or a combination of these modes. Each IHE region had an instructional coach to support the teachers and administrators in implementing their district action plan and reinforcing the content and pedagogy for individual teachers.

### **Planning and Set-up Phase**

#### ***Using Good Pedagogy for Deep Content Delivery: IHE Science and Math Departments Working with Education Departments Pedagogy Experts***

When working with the IHE content faculty, care was taken to ensure all were using best STEM pedagogical practices. Faculty specializing in science and math pedagogy and instructional coaches were paired with content faculty to work as a team to create the needed delivery components. The program began with a whole group meeting designed to ensure everyone understood the project expectations so as to maintain a non-threatening team atmosphere and minimize the potential for bruised egos. Paired group meetings followed to gently guide and support the use of desired pedagogical practices when teaching content at the summer institutes. For instance, the researchers needed to ensure the STEM professors embed the Science and Engineering Practices and Standards of Mathematical Practices in their presentations and that they were well aligned to the goal of a particular session. If the STEM professors were struggling with how to dig deeper into the day's assigned content by avoiding using lectures and instead incorporating interaction with the hybrid and virtual groups, the pedagogy professors and instructional coaches were available to help brainstorm.

#### ***Ensuring District Administrative Buy-in and Follow Through***

For teachers and districts to participate in this study, administration support had to be secured. Prior to the summer institutes, the principal investigators met face-to-face or virtually with district superintendents to secure their support for their teachers implementing the action plans for the building/district and identifying the appropriate administrator to participate in the required summer institute administrator meetings to help guide the design of their school year action plan. District administrations were also requested to meet with participating teachers to create a working list of possible action plan district and/or building needs so district groups would have a place to start during team meeting time.

#### ***Virtual and Hybrid Physical Site set-ups***

Prior to the start of the summer institute, each location was delivered the correct book study materials for the site and received identical tubs of required supplies for each session and necessary paperwork. In addition, for each site, rooms were identified for whole group sessions; 2 content specific sessions (set up for small group interactive investigations and hands-on learning with manipulatives or models); and multiple book study rooms (depending on how many rooms were needed.)

For the larger gatherings, whole site groups, or large content groups, rooms already equipped with overhead projectors were selected. Depending on the number of teachers at a given site in the same book study, breakout rooms might vary from those already equipped with

overhead projectors, or smaller rooms with a television, or a small room where a site singleton in a specific book study could use their own laptop for audio and video. All other rooms were equipped with at least one video camera and audio set-up. Rooms in which content or pedagogy were being presented had a two-camera set-up, one toward the front capturing the “instructor’s view” and one towards the back capturing the participant’s view. Only the front camera set-up was activated for audio and video in Zoom. The second camera was video only.











There were many options of how to handle technology logistics. First, we ensured every site had a tech knowledgeable participant, or on-site tech support should there be a glitch. The following are low and higher budget options for setting up the hybrid and 100% virtual locations. For the summer institute, the face-to-face rooms were set up with at least three screens: 1 to broadcast the presenter and their face-to-face group, 1 to broadcast the computer of the presenter, and 1 to broadcast the virtual groups joining the presentation. The virtual locations also had a 3-screen set-up to broadcast the presenter, their computer, and the third screen to show the virtual groups participating. The face-to-face and virtual sites had all the hands-on materials on site to complete all activities. A site facilitator was present to assist in delivery and dissemination for all presenters.

### **Delivery and Interactions**

As can be seen in the sample schedule in Figure 1, Monday through Thursday morning sessions, included the science and math groups having independent deep content sessions hosted by IHE faculty. Virtual sites along with the hybrid sites moved to assigned physical rooms where the respective Zoom room was set up to deliver either the ‘deep content dive’ broadcasts. Throughout the day, teachers at the hybrid sites hosting their content area sessions/book study were face to face with the instructor as the broadcast being virtually transmitted to all other sites across the state of Kansas. Following a short break, teachers went to their assigned physical room where their book study (STEM/math/science) would be received virtually or face to face. This same practice was followed throughout the day for the investigation and pedagogy blocks. The morning welcomes/check-ins and afternoon wrap-ups/closure were a simultaneous broadcast from hybrid site one or two or tag teamed between the two sites at times.

Coordination of the content delivered in these sessions occurred through the lead planning team and the summer institute planning team. Hybrid site 1 took the lead with mathematics, and hybrid site 2 took the lead with science content. Both institutions worked collaboratively on all content and pedagogy delivered. To assist in building the learning relationships between concepts and procedures during the summer institute, IHE Math and Science faculty co-developed and delivered content with education staff to better model best practices and look at the bi-directional, causal links between conceptual and procedural knowledge. Most IHE content faculty have limited familiarity with K-12 content and practice standards. Through co-developing and delivering in the summer institute, not only did teacher participants experience better modeling of teaching best practices, but IHE faculty also enriched their teaching methods repertoire.

**Figure 1**  
*Sample Day's Schedule with Five Components*

<b>Check-in/Welcome</b>			
<b>simultaneous</b>	<b>Science Content Presentation</b>	Motion and Energy Transfer relating it to yesterday's investigation: Crooked Swing Pendulums investigation	
	<b>Math Content Presentation</b>	Binary & Place Conversion	
<b>simultaneous</b>	<b>Book Study</b> K-5 science & STEM	Science: Foundations of 3-Dimensions	
	<b>Book Study</b> 6-8 Science	Video link on using Models	
	<b>Book Study</b> Math breakout groups varying by grade or topic	Math K-2 Book Study Math 3-5 Book Study Math 6-8 Book Study	
<b>simultaneous</b>	<b>Science Investigation</b>	Investigation Sink or Float	
	<b>Math Investigation</b>	Kodable & Scratch Setup	
<b>Lunch Break</b>			
<b>simultaneous</b>	<b>Pedagogy /SEP's</b>	Conducting Investigations and Transforming Your Classroom <ul style="list-style-type: none"> <li>• Asking Questions</li> <li>• Developing and Using Models</li> <li>• Constructing a Mental Model</li> <li>• Developing a Predictive Physical Model</li> </ul>	
	<b>Pedagogy /SMP's</b>	Teacher Practices: Elicit & Make Use of Student Thinking	
<b>Groups</b>	<b>Vertical/Content Team Meetings or Team Action Planning</b>	<u>Some days could be all one/other, or split 50/50 between:</u> Vertical team meetings e.g., all 5 <sup>th</sup> grade teachers meet in same Zoom room, or breaking into specific science content rooms, <i>and/or</i> Team Action Planning time	
<b>Wrap-up/Closure</b>			



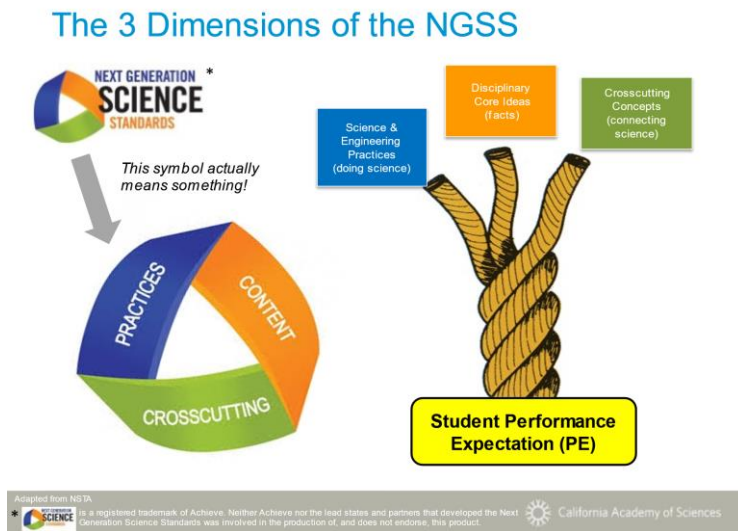
Monday through Thursday afternoons included the pedagogical block, allowing teachers opportunities to reflect on how their morning content and investigations integrate with pedagogical best practices. In preparation for both Fridays of the institute, Monday through Thursday afternoons included dedicated time for each district/school team to work on their sustainability plan to further professional learning for their peers/school/district. On Fridays, school teams met with their school/district administrator(s) who attended the institutes for the day. During this time the teacher teams worked with their respective administrators to finish building and gaining approval for the implementation of their plan. It was expected each district team would build professional development appropriate for their setting and deliver it during the school year. The IHE instructional coaches as well as the IHE pedagogy faculty played an integral part in following through on this component. Friday sessions of the summer institute helped lay the groundwork to accomplish grant goal 3, to build networks of teachers within and between districts throughout the state, specifically continuing to build relationships between rural isolated teachers and their colleagues teaching similar grade levels and content.

When looking at Project Excel's success of creating high-quality professional learning using technology as well as building a virtual STEM professional learning network for rural teachers, 4 cornerstones underpin its strength: (1) delivering pedagogical content knowledge to ensure best pedagogical practices are being used when delivering content; (2) using investigations to reinforce STEM content through hands-on activities and anticipate student thinking, including misconceptions; (3) coaching during the summer institutes and throughout the school year to support individual teacher growth as well as support the implementation of their action plans; and (4) collaboration among the teachers, building a virtual STEM professional learning network for collegial support and access to content and pedagogical professors striving to bring equity to Kansas's rural and isolated teachers.

### ***Pedagogical Content Knowledge***

STEM faculty and instructional coaches provided learning opportunities using a mix of grade level standards from Next Generation Science Standards (NGSS) and or Common Core Math Standards. The science content area will be further explored as we continue outlining delivery and interactions. From a pedagogical viewpoint for science, we chose to focus on the Three Dimensions (3D's) of the NGSS. "Within the Next Generation Science Standards (NGSS), there are three distinct and equally important dimensions to learning science. These dimensions are combined to form each standard—or performance expectation—and each dimension works with the other two to help students build a cohesive understanding of science over time." (NGSS Lead States, 2013). Figure 2 provides additional details on the 3D's that were explored and embedded throughout the project.

When teachers completed their applications to participate, they indicated their familiarity with the 3D's. Teachers entered the summer institute with a significant gap of knowledge and understanding. Experiences ranged from never having heard of the 3D's, to a solid cluster who had heard of the 3D's but had no idea of their use, and only a single teacher already teaching students with the 3D's embedded into her teaching. These were not surprising findings given the isolation and challenges rural districts face in trying to stay current within their discipline (Yettic, et al., 2014).

**Figure 2***The 3 Dimensions of the NGSS*

The primary goal of the pedagogical content knowledge component was to help teachers understand and use science progressions effectively for grade levels before and after the grade they teach. To facilitate learning these necessary content and pedagogical teaching skills, teachers would engage in an investigation facilitated by an instructional coach or professor specializing in pedagogical

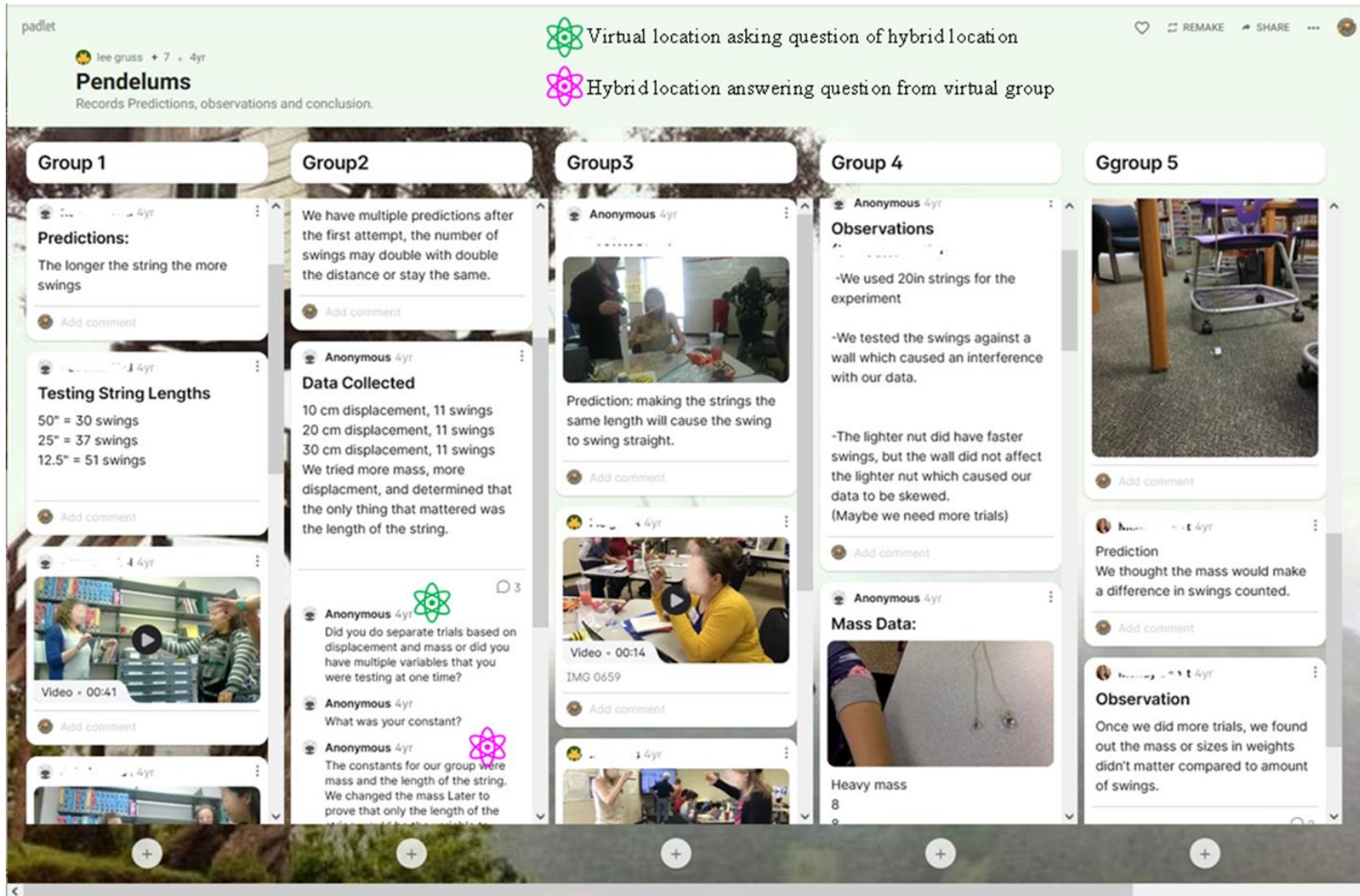
methods. The university science professor would also attend and observe the teachers doing the investigation, noting any misconceptions, and gaining insights into their thinking about the concept. The following morning, the science professor used discussions and demonstrations to correct misconceptions noted and then expanded and dug deeper into the investigation content from the previous day. Using the matrix of progressions for DCI's, SEP's, and CCC's (NGSS Lead States, 2013) helped build consistency in content delivery and guided their own preparation and discussions with teachers. For example, in the Crooked Swing investigation, scientists presented Motion and Energy Transfer content from the investigation that teachers previously explored and then provided time for participants to ask clarification questions to increase science content understanding and dig deeper into the concepts the investigation afforded. Figure 3 shows teachers interacting virtually, through the use of Padlet, with scientists regarding the investigation, with a focus on Life Science and SEP's.

The book study also proved useful in developing pedagogical content knowledge. When teachers applied to participate, they selected one of several STEM book study options in which to participate. Each day's book study block started with a short presentation from the group leader, either an instructional coach or professor or in summer 2 from teachers taking a leadership role and leading book studies. The presentation was followed by a whole group discussion and ended with group work and/or additional reading assignments for the next day. With several book study options and multiple teacher locations, having a master schedule for all presenters, a master schedule for all locations, then individual locations increased time efficiency. Figure 4 outlines how the hybrid and virtual teachers navigated in Zoom rooms and physical rooms at their sites and who was responsible for facilitating each session.











Figure 3

Padlet Virtual Collaborations



**Figure 4***Planning Responsibilities and Content Delivery Locations*

Activity Description	Planners	Facilitators			
	Planning Staff	Hybrid Location #1 Math	Hybrid Location #2 Science & Engineering	100% Virtual #1 Site*	100% Virtual #2 Site*
Check-in/Welcome	All	Grant PI's-Live Feed			
Dig Deeper Content/Concept Presentation	IHE professors & Instructional Coaches	 Math content & concepts	 Science content & concepts		
Book Studies	All	 See Breakout Schedule		Science 6-8 (2 <sup>nd</sup> year)	
Investigations-new content/concept	IHE professors & Instructional Coaches	 Math content & concepts	 Science content & concepts		
Closure		No Live Feed - Facilitators discuss morning debrief and afternoon schedule then dismiss to lunch			
Lunch		Everyone on their own			
Pedagogy Presentation	All	 IHE professors and/or Instructional Coaches	 IHE professors and/or Instructional Coaches		
PLC/Team Time	All	Grade Level Teams - All Facilitators - Live Feeds for Each Grade Level/Content Area			
Wrap-up/Closure	All	Grant PI's			

\* Blank spaces indicate live feed participation, no facilitation roles at site.

**Investigations**

We will use science to illustrate project procedures as we move forward. The day prior to each science investigation, teachers were provided grade specific content reading to review in preparation for the investigation. Specific DCI performance events for investigation content were also included for the teachers. Many of the investigations used during the summer institute were adapted from the *Learning Science by Doing Science* book, allowing a take home reference to encourage their deepening of understanding the NGSS. Each location, whether 100% virtual or hybrid, were provided identical materials for each investigation. Participants from across the state would listen virtually to instructions provided by the facilitator, then all sites would begin their investigation. While all sites were engaged in the investigation, they muted their mikes to allow other sites chatter not to distract them. The IHE site facilitator continuously checked in with all the

virtual groups and their face-to-face group to ensure all were proceeding well or to ask a probing question to a particular site to help nudge them in a better direction. When a site had a question, they would simply unmute their mike and pose their question to the facilitator.

Small site-based groups of teachers were formed to complete investigations. They used traditional hard copy notebooking practices to log all aspects of the investigation as well as make note of arising questions. A virtual cloud-based application, Padlet, was set up for each group to use simultaneously with their traditional hard copy notebook. Using Padlet allowed simultaneous sharing from all teachers across the state of Kansas. Teachers might post text descriptions, pictures, or even upload video clips as they progressed through the investigation. Padlet also enabled teachers to pose questions or leave a comment on what their distant colleagues posted as shown in Figure 3 above. Facilitators encouraged using this resource as a form of digital notebooking to promote site to site collaboration and sharing of teacher thinking, their own Ah-ha moments, and even their corrected misconceptions which their students may also embrace.

Time was always dedicated at the conclusion of the investigation for sites to share their observations and findings and then discuss misconceptions or anticipated challenges with their students. All sites shared and offered opinions. Each site had poster-size descriptions of all the SEP's from the NGSS. Using the Post-It notes on their tables at each site, teachers were asked to identify which practices "could work with the investigation they just completed, and which one practice was the strongest for the investigation they just completed." The sticky notes were then placed on the respective SEP posters. A collegial discussion usually ensued as teachers throughout the sites turned on their microphones when it was their turn to share. The process on day one of the institute when SEP's were introduced for some and reviewed for others and teachers discussed in depth what skills of doing science were revealed in each SEP set the stage for these later discussions. The first thing the following morning, STEM professors would reflect on their observation of the teachers completing the investigation from the day before and then move into digging deeper with the major science concepts and relevant DCI's across grade levels for the investigation

### ***Coaching***

An instructional coach from each of the IHE regions collaborated with the IHE faculty to provide ongoing support to teachers throughout the school year. These coaches worked closely with their designated teachers throughout the summer institute to begin forming a bond. Ongoing job-embedded training has significant impacts on teachers' efficacy and improving implementation of learned effective teaching strategies (Cobb & Jackson, 2011). Glover et al. (2016) further elaborated on the effectiveness of sustained professional learning with rural teachers. Providing this year-long coaching afforded the teachers to further integrate the summer professional learning with school-year application. Coaches collaborated with building or district administration to assist the implementation of action plans for the project participants, collaborated with participants and administrators to provide professional learning within each building or district and build relationships with building or district teachers outside the project.

Teachers from virtual sites used recording technology and Zoom video conferencing and recording to conduct lesson observations and have follow-up feedback sessions when in-person communications were not possible. Enacting a cycle of joint planning sessions, building on their

plans generated during the summer institute, enhanced coaches, face-to-face or virtual, preparedness for observing throughout the school year as teachers implemented their lessons. Special care was taken by the coaches to analyze along with the teacher and how their NGSS-DCI performance event from their lesson was supported through a purposeful relationship to the selected SEP's and CCC's.

### ***Collaboration***

**Within District.** School/District Professional Learning was designed to complement summer institute content and address concerns identified through ongoing evaluation of coaching sessions with the teachers. "Various platforms were utilized by PD leaders and teachers to form networks of teachers by school, district, content area, and grade level. In many cases, the teachers in this project, from rural and geographically isolated areas, may be the only teacher that is accountable for specific content in their building or district" (Thiele & Bogdon, 2020).

Details of what this professional learning looked like varied depending on individual school/district needs. Instructional coaches assisted, virtually or face-to-face, in the development and delivery of these opportunities as needed. Teachers were encouraged to lead these opportunities by themselves, with their school institute team, or co-teach with teachers from other districts based on readings from DuFour & Reason (2016) on the effective principles of virtual professional learning communities (PLC) and the development of these collaborations. Depending on a district's culture, some teams were better received if led by a teacher outside the district rather than an in-district leading the team. School/district professional learning included learning the relationship between concepts and procedures as experienced during the summer institute and center around appropriate performance expectations. When teachers better recognize and understand the conceptual understandings and procedural fluencies in the standards they teach, they will be better prepared to establish goals to focus learning on the standards, to support students by identifying their deficiencies, and using discourse to make explicit how students can build procedural fluency from conceptual understanding.

**Across State.** The afternoon meetings during the summer institute included time for teachers to not only meet in their district groups but also to meet in grade and content groups. These groups began developing a network and framework for a grade/content PLC network across the state to help support the singleton/isolated teachers and schools. While district teams could also dialogue through this same system, the importance of providing a professional support network for the singleton/isolated teachers and schools was the driving force. This grade/content state-wide PLC dedicated support time during the Summer Institute's was also complimented through introducing the science teachers to the National Science Teaching Association (NSTA) virtual learning community. Only 2 of the participants were aware of this resource, and only 1 was an active user. While many of the resources on the NSTA site can be used for free, having a membership opens even more doors to free resources, and other resources at a discount. Not only did the science teachers indulge in the myriad of three-dimensional resources, grade specific lessons, and journal articles, but they were also introduced to the Forum section. Here teachers can interact with science teachers from all disciplines, and all grade levels, but also pre-service through well-seasoned teachers in the field. There are many established and long running strands, including ones for rural and isolated science teachers, and if a teacher can't find a relevant strand for what they are seeking information/input on, they can start a new strand. The



Forums in and of themselves serve as a wealth of information, but most importantly, they provide a means for teachers across the nation to connect. Teachers continued to meet in grade and content groups throughout the school year using virtual techniques they practiced during the summer institute.

### **Research Methodology and Design**

As described in the project overview, this project implemented two platforms of professional learning, hybrid and virtual. This study explored the experiences of teacher participants and their perceptions of the effectiveness of both types of connections, being that two sites were hybrid while another two sites were virtually connected during all presentations, break-out, and work sessions. Participants were engaged locally in district and building PLC conversations and worked across districts in grade level and content collaborations utilizing Zoom to host conversations between multiple sites.

### **Methodological Framework**

Through the ethnographic lens, the case study design was the data collection methodology that framed this study. Ethnography has its roots in the field of anthropology, but many adaptations and interpretations have taken place throughout the course of the last century. Hammersly and Atkinson (2007) state, “the origins of the term [ethnography] lie in nineteenth-century Western anthropology, where an ethnography was a descriptive account of a community or culture, usually one located outside the West” (p.1). By the 1950s, ethnographies were being conducted in rural and urban settings and were exploring the cultures of unique groups of individuals as they lived through a phenomenon (Hammersly & Atkinson, 2007). This study used ethnographic methods to develop relationships between the researchers and the teacher participants to gain a deeper understanding of their experiences during the two-week summer institutes as well as school year coaching through the lens of face-to-face, hybrid, or virtual learning opportunities in rural and suburban locations.

Merriam (1998) suggests that case study design provides a rich account of social phenomena because it is “anchored in real life situations” (p. 41). Case study design has become useful for studying current educational processes, which aims to affect and improve future practices. Bhattacharya (2007) confirms this idea by noting, “Case studies are also targeted at information-rich sources for in-depth understanding and can also be used to inform policies or to uncover contributing reasons for cause-and-effect relationships” (p. 206). As the aim of this study is to explore the experiences of the rural teacher participants as they engage in virtual and hybrid professional learning, case study will be used because it “afford(s) researchers’ opportunities to explore or describe a phenomenon in context using a variety of data sources” (Baxter & Jack, 2008, p.544). For the purposes of this study, the ethnographic case study design allowed the researchers to explore each case, hybrid and virtual, in rural and suburban settings, on an individual basis using multiple data sources.

The ethnographic case study design allowed the researcher to explore the teacher participants’ ways of behaving, thinking, feeling, and understanding within the context of their school culture, especially of the rural districts as their cultural contexts each differ significantly from one another and their suburban counterparts. By bringing a team of teachers from each district together, either physically or virtually, through interviewing, observing, and surveying, the



researchers were able to gain a better understanding of the cultural and social contexts of each district regarding professional learning. Baxter and Jack (2008) state, the “potential data sources may include, but are not limited to: documentation, archival records, interviews, physical artifacts, direct observations, and participant-observation” (p.554). Creswell (2013) reiterates this notion by suggesting, in case studies, the researcher explores cases or a case over time, through in-depth data collection procedures involving multiple sources of information such as observations, interviews, audiovisual material, documents, and reports. Aligning with these approaches, the researchers employed numerous forms of data sources, including observations, interviews, and document analysis.

## Research Design

This is an ethnographic case study, designed to explore the experiences of teachers as they engage in face-to-face, hybrid, and virtual learning aimed at engaging rural and otherwise isolated teachers in high-quality professional learning from the comfort of their own school, without the additional travel and financial burdens. This study is situated within the scope of an ethnographic case study, including participant selection, research site, and researcher role. Creswell (2013) states, “the process of designing a qualitative study emerges during inquiry, but it generally follows the pattern of scientific research. It starts with broad assumptions central to qualitative inquiry, and an interpretive/theoretical lens and a topic of inquiry” (p. 65). Some of these characteristics have been laid out in the methodological framework; the remainder will be discussed in this section.

After setting the goals, project staff determined multiple districts throughout the state, located in rural, geographically isolated regions as well as districts close to the host universities as the main focus of the project goal was to engage rural teachers in professional learning opportunities alongside their suburban colleagues throughout the state. District administration e-mailed all of their K-8 teachers the opportunity to participate in a needs assessment survey prior to the start of the project. As part of this survey, teachers were asked if they were interested in participating in this grant opportunity. Eighty teachers responded as being interested. Schools as well as districts then assembled their ideal team of interested and available teachers to participate. We provided the following criteria to help them assemble and present their team to the project staff for selection: 2 to 4 teachers from elementary buildings and 2 to 4 teachers from respective feeder middle schools, for a total team of 6 to 8 teachers from each site as well as 1 to 2 building and district administrators.

As an incentive for teachers, they received a \$1250 stipend for participation and leadership in the summer institute as well as follow-up continuing school-year coaching activities. Graduate credit in mathematics, science, or education was also available for all participants. Upon grant award and district team acceptance into the grant project, all participating teachers and administrators were asked to sign a statement of commitment. Districts either chose to remain fully virtual, hosting the professional learning in their own district buildings or to drive to a host university and attending some sessions face-to-face and others virtual for a hybrid experience. The following table includes a brief synopsis of each district team based on their hybrid or virtual attendance.

**Table 1***District and Participant Descriptions*

District Type	Attendance Type	Number of Buildings	Teacher Attendance	Administrator Attendance	Distance (in miles) from a host University
Suburban	Hybrid	3	4 elementary	1	40
Rural	Virtual	1	5 elementary 2 middle	1	220
Rural	Hybrid	2	6 elementary	1	25
Rural	Hybrid	4	17 elementary	3	25
Rural	Hybrid	5	6 elementary 4 middle	2	45
Suburban	Hybrid	1	2 elementary	1	75
Rural	Virtual	1	2 elementary	1	108
Suburban	Virtual	51	5 elementary	1	85
Rural	Hybrid	2	3 elementary	1	50

As noted above, interviews, observations, and qualitative survey data were collected from participants and analyzed based on their attendance type. The qualitative data was categorized for major themes that could be crucial in understanding the experiences of rural teachers, identifying perceptions of effectiveness of virtual/hybrid collaborations, and developing specific components of effective virtual professional learning based on these experiences and collaborations.

There were three goals as described in the project overview. Our ethnographic case study focused on goal three: to increase IHE and district collaborations with a focus on rural connection to suburban districts as well as IHEs. Our secondary aim of this goal was to develop a model of effective professional learning delivery that could sustain a statewide network of teachers, including rural and suburban districts, not bound by geographic regions.

### Findings and Discussion

The data from this ethnographic case study will be shared through two lenses, first, the analysis of the teachers involved in the case study project, virtually and through hybrid interactions; and second, from the researcher's perspective on the design of virtual professional learning model to increase rural district access to resources and learning, which was a theme of the teacher findings. These two lenses are reciprocal in nature, one leading to the other and vice versa, as the model unfolded based on teacher needs collected throughout the study.

Prior to the summer institute, there were no inter-district communications among participants and little intra-district communication with peers teaching the same grade/subject.

The virtual sites were primarily rural/isolated teachers while the hybrid sites had a combination of rural and suburban teachers. Teachers who attended, whether virtually and hybrid, showed increased collaborations with their peers, both within and between districts, during the school year as well as demonstrated increased application of effective teaching practices based on responses from open format interviews and survey questions. Through the instructional coach observations and coaching activities along with survey and interview responses from teacher participants, the digging deep in content with the IHE faculty and mixed mode of engagement in content and pedagogy during the institute, it was evident that teachers were applying their increased content knowledge and beginning to embed the three dimensions into their teaching of science in their classrooms. Three major themes that were identified based on overwhelming recurrence in teacher and administrator open-response questions, categorized by type of experiences, virtual or hybrid.

The first major theme that was identified in the data by using axial coding, was the need for and appreciation of the explicitly designated collaboration time. As noted in the project overview, this time became progressively more teacher led and directed throughout the project. Teachers had set time to collaborate with their grade level, content specific counterparts between districts, rural and suburban, as well as time to collaborate with their building and district. There were also opportunities to cooperate and collaborate during the investigations and book studies. Table 2 shows teacher and administrator quotes that exemplify the need for collaboration within and between districts to enhance professional learning and sustained growth.

The second major theme that was extrapolated from the data was the lack of equitable access that many rural and isolated but also suburban teachers and administrators noted. Although their experiences were different, virtual or hybrid, it was evident that many participants from both groups had not previously had access to the resources and high-quality professional learning that they experienced throughout the project. In Table 3 below, teacher and administrator quotes are provided that focus on the project's ability to increase equitable access.

The final major theme detailed in the data included the teachers' increase in confidence in their STEM content knowledge and specific pedagogical content knowledge based on their experiences throughout the project, including summer institutes and school year coaching and subsequent professional learning. Table 4 showcases specific quotes from rural and suburban teachers, shedding light on the impact of their experiences related to their knowledge growth.

**Table 2***Theme 1 Collaboration: Quotes from Virtual and Hybrid Teacher Participants*

<b>Theme 1: Need for Collaborations, within district and between districts</b>	
<b>Virtual Teacher Quotes</b>	<b>Hybrid Teacher Quotes</b>
<p>“We were very fortunate to have the opportunity to be a virtual site for this project, which allowed our teachers the convenience of staying home while participating in this PD.”</p> <p>“Even though I was 100% virtual, I never felt left out, and it was great to be doing the investigations along with all the others. I loved using Padlet and seeing what my peers were doing and how they were thinking. The discussions during the book study were invigorating and enlightening and digging deep into the content was an amazing experience.”</p> <p>“Out of a PK-12 building we were represented by the following grade levels: kindergarten, first, second, third, fifth, sixth, seventh/eighth, and high school, which allowed us to collaborate across the grade levels.”</p> <p>“The network we built across the state has proven extremely helpful in maintaining access to my ever so helpful project peers.”</p> <p>“I took full advantage of networking with my peers and having virtual discussions with my peers about their adoptions and the pros and cons they saw in the available options.”</p> <p>“It was a good feeling to be able to put some of my colleagues in touch with other teachers across the state who taught the same thing so they could learn.”</p>	<p>“The networking we did and the book study, investigations were fantastic springboards to help bring me up to speed. I am looking forward to staying in touch with my peers from the summer institute to support each other and steal their ideas.”</p> <p>“Foremost was the chance for elementary teachers from two different buildings within the district to attend and bond together for two weeks. Collaboration like this is often thought of theoretically, but rarely does the time present itself to make it happen.”</p> <p>“Building this state-wide network of peers during the project was such a comfort to have access to.”</p> <p>“Building these connections over the past year has been great for me to stay in touch with others to get ideas or troubleshoot when I get stuck. I have no other teachers in my district that teach the same grade /content level, so this has been a blessing!”</p> <p>“Now, along with learning with my peers across the state from this project to support my teaching, I also can use the NSTA forums if my state peers are also at a loss to help me. It is hard being the only science teacher for your grade in the building, and it’s almost impossible to find time to work with the other science teacher in our other elementary school.”</p>

**Table 3***Theme 2 Equitable Access: Quotes from Virtual and Hybrid Teacher Participants*

<b>Theme 2: Equitable access to resources and learning</b>	
<b>Virtual Teacher Quotes</b>	<b>Hybrid Teacher Quotes</b>
<p>“Another benefit from the project were the resources and connections that we were able to make use of during the investigations and book study I learned about and feel ready to implement the 3-dimensions of NGSS in my classroom.”</p> <p>“Having lacked access to adequate resources and PD opportunities for years, the gift of this project provided my growth in increasing my content and pedagogy by leaps and bounds.”</p> <p>“Coming from a small rural district, access to such high-quality resources and little access to PD, or any content or pedagogical support was never available.”</p> <p>“Never having had any pedagogy training in my district, I soaked up every ounce of information from the summer to help provide me confidence and knowledge.</p> <p>“Access to this kind of quality PD was never an option in my old district because it was so small and removed from any population center.”</p>	<p>“Living and teaching out in the boondocks, I never thought I’d see an opportunity like this to have meaningful professional development.”</p> <p>“The resources at NSTA are amazing. I can’t believe I’ve been teaching for 5 years and never found these before. I will continue to use the NSTA content resources to find ready-made and tested lessons, and even more importantly do a better job of staying on top of current pedagogy best practices.”</p> <p>“The biggest benefit from the project were the resources and connections to districts throughout the state.”</p> <p>“I have been teaching for over 30 years but have never had this type of opportunity for professional development, nor any colleagues I could talk with about science content or best practices for teaching it.”</p>



**Table 4***Theme 3 Increased Knowledge: Quotes from Virtual and Hybrid Teacher Participants*

<b>Theme 3: Increase in content and pedagogical content knowledge (coaching)</b>	
<b>Virtual Teacher Quotes</b>	<b>Hybrid Teacher Quotes</b>
<p>“We were able to have the tough conversations about aligning content across grade levels, common vocabulary, and goals that we would like to meet as a building in science.”</p> <p>“My experience of the year-long coaching was of tremendous value and reinforced much of my learning during the summer.”</p> <p>“Having been part of the project I now feel more confident in my instruction, especially when it comes to preparing engaging and rigorous content for students. In addition, being part of this project has pushed me to want to be part of more committees and experiences, all of which has contributed to keeping me up to date and knowledgeable of what is best practice for students.”</p> <p>“When I had the opportunity to work with my coach and deliver very needed information and made it “fun and engaging” for my colleagues to learn, it was amazing how much more respect they had for what I had gained from the summer institute. After the PD, when I would be working with my instructional coach, if one of my peers found out they jumped in front of the camera and started asking questions of my coach.”</p>	<p>“I have to admit the first few days I was scared and a little intimidated and wondered what I was doing here. I had never heard of the 3 dimensions and how they drive the teaching of science to all grades. By the second day I was relieved to know I was not alone in my ignorance.”</p> <p>“I wish my college professors taught like the ones I had here. They never made me feel guilty about what I did not know, but just opened the doors to more content in a way that was very easy to grasp.”</p> <p>“This project provided me with much needed exposure and learning of science and pedagogical content knowledge. I was a little concerned at the beginning of the grant that I was going to be the only one ‘who knew so little’ but it turned out that my peers from across the state were in the same situation as me! Gaining access to the resources and learning opportunities through this grant and knowledge of how to effectively use professional organizations like NSTA was a goldmine for me.”</p>

The identified growth of teachers as they engaged in high-quality virtual and hybrid professional learning, as they collaborated within a virtual STEM learning network, led to the development of the effective professional learning model with four integrated components. By collaborating with peers, both within and outside of their district during the pedagogical content knowledge learning investigations to reinforce STEM content and through teacher engagement in coaching activities during the training, the project was able to support individual teachers, as well as district and state level networks, to bring equity to rural and isolated teachers. Figure 5 (Thiele & Bogdon, 2020) showcases the effective science professional learning model that was derived from this project, based on teacher strengths, needs, and wants, as well as feedback on the success of the integration of each aspect, rather than training on each individual component in isolation.

**Figure 5***Effective Science Professional Development Model*

(Thiele & Bogdon, 2020)

The individual components of the model were identified during the planning phase and year one of the project, however, based on teacher and administrator input as well as the major themes that were identified in the participant responses, the integration of each component of the model, specifically the collaboration and networking that takes place throughout each aspect, is vital to the effectiveness.

From the perspective of the IHE content and pedagogy faculty, an improvement in IHE interdepartmental relationship was an additional finding of this project related to developing a statewide network. A STEM content faculty member who led content sessions stated, “Even though I teach mostly undergraduate science majors going on to med school or further degrees for research, I was humbled in participating in this project. I learned a lot from working with my pedagogy partner as I prepared for my deep content dive after the teachers finished their investigations. The pedagogy used for teachers to teach their students, can easily be applied into my teachings of science majors. I am excited to see the impact with my college students’ growth as I begin to work these practices into my teaching.” This level of collaboration is an additional perk of the integrated professional development model, to encompass content faculty in the development and implementation of professional learning, simultaneously increasing content knowledge of K-8 teachers and education faculty and increasing pedagogical knowledge of content faculty. This open sharing of skills, resources, and knowledge is a continued area, ripe for future research.

### Future Considerations

The ethnographic case study provided evidence of increased collaborations, content knowledge, pedagogical content knowledge, and efficacy in using the knowledge and skills acquired during the project. The follow through of the instructional coaches with their assigned teachers, whether face-to-face or virtual, played a significant role in the success of teachers embedding their gains successfully in their daily routine. These rural and isolated teachers were thankful for the quality and opportunity to participate in such a rigorous project. The case study lens allowed the researchers and participants to simultaneously engage in and create an integrated professional development model to provide high-quality learning opportunities to teachers in rural and otherwise isolated districts. This project moved forward in identifying key components necessary for bringing equity in professional learning to our rural and isolated educators; however, further work is needed to identify steps to sustain this level of statewide professional network for years after the summation of a project and continue studying the long-term impacts of individual teacher and district participation. The development of a mechanism to assist with teacher transitions between districts as well as IHE access to districts would allow for more succinct collaborations to be maintained. Many rural district administrators were unsure how to reach out to IHEs to collaborate, so although both institutions were willing and had a desire to collaborate, the development of a sustained pathway to increase the frequency and ongoing nature of professional learning would increase efficiency and accessibility, specifically for rural and otherwise isolated districts.

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