Developing Pedagogical Content Knowledge Through Remote Instruction: Embedding Environmental Education in a Science Methods Course

Cynthia E. Lima
University of Texas at San Antonio

Lucinda N. Sohn
University of Texas at San Antonio

Abstract

This article presents an action research approach to adapting the traditional face-to-face Project Wild workshop to a four-week online experience. As a result of the ongoing COVID-19 pandemic, the shift to online courses presented the Science Methods faculty with the opportunity to maximize the use of Growing Up Wild (GUW), an early childhood Project Wild resource, to support the preparation of teacher candidates to teach science. The online workshop design addressed the instructional challenges of using technology to create and deliver a course focused on environmental science inquiry while fostering community. Four sections of the Science Methods participated in the GUW online workshop, totaling 82 teacher candidates. Data from various sources were collected to analyze the teacher candidates' experiences and inform the workshop improvement. This article examines teachers' weekly reflections on the perceived value and future application of the instructional resources explored during the workshop. Results show that the workshop components successfully supplied rich opportunities to develop pedagogical content knowledge to teach science inquiry. Nevertheless, there is an opportunity to include more self-regulated opportunities to engage in scientific investigations.

Keywords: education technology, remote learning, outdoor education, teacher preparation, science education

---

The instructors at a Hispanic-serving institution in south-central Texas embedded Project WILD (PW) resources in the Science Methods course to "engage students in the conceptually rich, intellectually ambitious, and meaningful experience" (NASEM, 2020, p. 91); develop inquiry skills and early childhood strategies (Council for Environmental Education, 2011). Prior to the Spring 2021 semester, teacher candidates attended the single-day workshop at a nature center located at a large city park to participate in a series of planned environmental activities. The shift to online instruction resulting from the ongoing COVID-19 pandemic presented the lead faculty with the opportunity to maximize the online use of Growing Up WILD. Guided by the Quality Matters standards (2018), the PW facilitators and faculty re-designed the workshop to provide teacher candidates with tools, skills, and knowledge to engage future pupils in doing environmental science. However, this opportunity came with some challenges. The first challenge was adapting a nature-based outdoor education curriculum for online delivery while maintaining outdoor learning and scientific inquiry opportunities. The second challenge was to minimize the disruption of instruction delivery due to internet accessibility and connectivity for both instructors and teacher candidates. The third challenge was to ensure rigor in creating quality materials relevant to the Science Methods curriculum. Finally, fostering community was a priority across the four-course sections by establishing communication channels between instructors and teacher candidates. This article presents an action research approach to adapting the traditional face-to-face PW to an online four-week workshop to address the recognized challenges using technology to create and deliver the course. Multiple data sources were used to examine

ISSN: 2166-0190 online

teacher candidates' learning experiences, including posts, reflections, and surveys. The analysis presented here examines the teacher candidates' weekly reflections to identify their experiences in learning to teach inquiry-based environmental science.

Embedding Project WILD in the Science Methods Course

Project WILD is a collection of activities organized into a conceptual framework focused on fostering an understanding of wildlife and habitat to make responsible and wise decisions about natural resources (AFWA, n.d.). PW encompasses resources related to terrestrial, aquatic, and birdlife. One of the components, Growing Up WILD (GUW), is an early childhood set of activities with a focus on field exploration, music, dance, investigation, and art for children ages 3-7. The guide incorporates play, content, literacy, and healthy eating habits while connecting children to nature. The GUW curricular materials are recognized by the Texas Education Agency and aligned to the Texas Essential Knowledge and Skills, i.e., the standards that teacher candidates will use to guide their future teaching practice.

For many years, instructors at a prominent urban Hispanic-serving institution in south-central Texas have embedded PW in the Science Methods course. Before COVID-19, the university teaching program collaborated with Texas Parks and Wildlife Department to organize and hold a day-long learning event with teacher candidates each semester with an agenda focused on the Project WILD K-12 and Growing Up WILD curriculum teaching strategies and content throughout the years. Participants receive a combo set from the PW series in a combination workshop, such as Project WILD K-12, Aquatic Project WILD, and Growing Up WILD. During the transformation to an online course, the PW facilitators and faculty decided to embed one of the series, GUW, in the Science Methods course, limiting the PW series, however, continuing to promote multiple ways of teaching science in early childhood through sixth grade. The limited time available for the Science Methods as an online course during the COVID-19 pandemic was a factor in selecting one activity resource from the PW series.

The primary intention of planning for the face-to-face workshop was to provide rich hands-on learning opportunities for teacher candidates about one or more of the following concepts: awareness and appreciation of wildlife, ecological systems, and responsible human actions, environmental issues and trends, cultural and social interaction with wildlife, habitat, and environmental systems, and human values and the wildlife resource (Texas Parks & Wildlife, n.d.). Workshop participants were exposed to one or more of these concepts and the teaching skills to facilitate them in early childhood and elementary classrooms. An example of this is teacher candidates engaging in the Oh Deer! PW activity (Council for Environmental Education, 2014) to learn about the elements of habitat and how the availability of shelter, water, food, and space impact the deer population. At the same time, they develop strategies to foster social-emotional, cognitive learning, and physical activity to learn science and math. After the workshop, teacher candidates plan and deliver a lesson based on GUW and the 5E approach (Bybee, 2015).

Relevant Literature

COVID-19 impacted how the teaching program faculty plans and delivers instruction in the Science Methods course. As a result of the health and safety mandates put in place at the university, all courses were migrated online. Course planning took into consideration multiple variables, including available technology and reliance on students-regulated learning. Remote learning was the only instructional delivery approach to accommodate all students enrolled in the early childhood to upper elementary Science Methods course. Transitioning to remote learning required extensive planning, preparation, and identifying appropriate education technologies to facilitate the knowledge and skills teacher candidates need for clinical teaching. In addition, the instructors had to maintain the focus on teaching and learning inquiry while creating a learning community.

Technology introduces the advantage of increasing access to education for all students. A traditional classroom may incorporate technology to support instruction and learning within the physical learning space. However, due to the COVID-19 pandemic shift, educators were revisiting questions and concerns about virtual and remote learning. As more

ISSN: 2166-0190 online

online universities and education programs have become available in recent years, higher education institutions have examined the effectiveness of teaching online (Pokhrel & Chhetri, 2021). Common challenges to remote learning include access to technology, the proper software, and applications to guide learning and connectivity for everyone to access the lessons and the materials (Pokhrel & Chhetri, 2021). Individual institutions leverage their resources to ameliorate the impact of technology access on students. For example, students rely on the information technologies supported through their campus to address connectivity issues and access computers.

The lockdown because of COVID-19 exacerbated the existing limitations on students' access to technological resources (Teräs et al., 2020). Universities and colleges worked with faculty to provide remote learning resources for students taking their courses from diverse US locations and abroad.

Traditionally, instructors have used course management tools to communicate with the students, share documents, and encourage academic exchanges outside the classroom. After lockdown, course management tools, such as Blackboard became more prominent to support all levels of student-to-student and student-to-teacher interaction and accomplish learning. Nevertheless, Blackboard has limitations to support collaborative work, and access is granted only to students enrolled in the same class. In the case of Project Wild, the facilitators provided access to the workshop to four sections of the Science Methods course. Instructors considered other online management tools, for instance, Slack, to include all the students and open communication and collaborative work opportunities. Being part of a community allows individuals to collaborate, share information, and learn from one another resulting in more robust learning experiences (Smith et al., 2016). Slack users can post tasks, collaborate, and connect with peers, thus *fostering an online community*. The digital platform includes tools to communicate the coursework expectations, allowing students to ask questions or seek direction and connect with the instructor (Prince, 2021). In the case of adapting the PW workshop, it supported aspects of the inquiry process.

Inquiry is a process grounded in reasoning through experience and research that encourages the formulation of questions based on observations and investigation to draw conclusions (NRC, 1996). Engaging in inquiry uses critical thinking skills such as questioning, thoughtful discussion, argumentation, and problem-solving through hands-on experience (Alvarado & Herr, 2003; Cusick, 2001). Inquiry processes can occur in formal school settings and daily life. Since the first implementations of distance learning, researchers have identified tensions between distance learning and outdoor education. Moseley et al. (2010) examined the impact of teachers' and students' interactions in nature and how learning virtually about the environment can conflict with the environmental education guidelines of direct experience through nature. According to the research by Moseley et al. (2010), teaching environmental education online may introduce barriers to interaction with nature, minimizing the effectiveness of the outdoor experience.

The concern is the drift from the guidelines in environmental education based on the historical goals outlined in international collaborations and agreements to increase awareness of the value and intersectionality of nature with humans and human influences (Mosely et al., 2010; Quay et al., 2020; Smith et al., 2016). To adapt Project Wild to an online environment, facilitators and faculty reimagined experiential learning to incorporate self-regulated learning experiences to alleviate the tension between virtual education and learning through nature.

Method

Context

The action research project (Saldaña, 2011) to adapt the Project Wild workshop included four sections of a Science Methods course. The course is a requirement of the Early Childhood-Sixth (EC-6) interdisciplinary degree teacher track. Each section averaged 22 teacher candidates, with a total of 82 students completing all the workshop requirements.

ISSN: 2166-0190 online

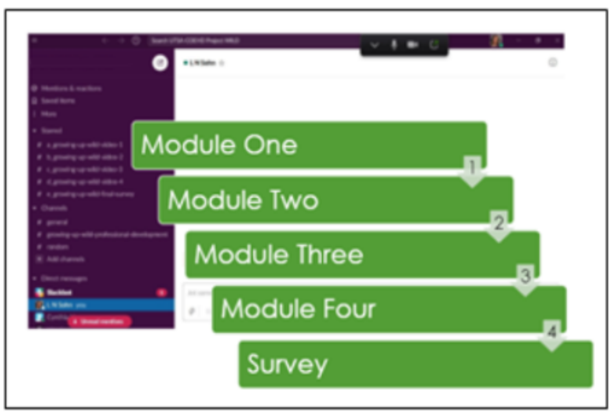
Transforming the Project WILD Workshop

The online GUW workshop design process considered the challenges of online instruction, including (1) minimizing disruption of instruction delivery due to internet accessibility and connectivity for both instructors and teacher candidates, (2) replacing instructor-led with self-guided opportunities for teacher candidates to experience learning outdoors, and (3) maintaining the integrity and learning expectations of the science methods curriculum.

The online GUW workshop was a series of four asynchronous modules that teacher candidates could complete at their own pace within a four-week time frame. The digital platform Slack minimized the disruption of instruction delivery for instructors and teacher candidates due to limited internet connectivity and accommodated students' schedules. At the same time, it opened communication channels between the instructors and teacher candidates. Slack served as a resource hub by providing a space to store all the workshop materials (Figure 1). Additional advantages of Slack are that it supports many users and provides a straightforward approach to organize materials, discussions, and collaborations through channels that serve as self-contained conversation spaces.

Another aspect that the workshop needed to address was the isolating conditions for teacher candidates created by COVID-19 and the need to build community among the participants and the PW facilitators. Even though the course was delivered asynchronously, the Slack platform fostered a learning community for teacher candidates across the four-course sections. Furthermore, the project management tool allowed users to message facilitators and participants to clarify and share information.

Figure 1
Growing Up WILD Slack Environment



Each week, teacher candidates completed (1) a 20-40 minute video, (2) a science or science teaching task, and (3) a reflection using Google forms. Table 1 presents an overview of the four modules. The Science Methods instructors used Panopto and Zoom video platforms to record four videos to introduce GUW activities and their alignment to the 5E lesson plan (Bybee, 2015). The GUW videos aimed to equip teacher candidates with ready-to-implement activities and instructional strategies to teach inquiry-based environmental science. Other objectives included making connections with young students' homes, communities and involving parents in doing science. Table 1 presents a concise description of the activities adapted and included in each of the modules.

ISSN: 2166-0190 online

Table 1
Growing Up Wild Workshop Modules

	Video content	Task
Module 1	Introduction to Texas Parks & Wildlife Overview of Growing up WILD resources GUW Activity: Adaptation as a factor in survival.	Post a photo of a local bird. What shape is the birds' beak? Based on your observations, what do you think they eat?
Module 2	GUW Activity: Observing changes in plants and animals over an extended period.	Conduct a nature walk, and describe the wildlife encountered. The objective is to learn to respect all the organisms and the environment.
Module 3	GUW Activity: Literacy and Math connections	Reflect on strategies to facilitate interdisciplinary approaches to science learning.
Module 4	GUW Activity: Making home connections by looking at leaves.	Reflect on the overall Project WILD workshop. Engage in discussions with peers and instructors.

The shift to remote learning impacted one of the tenets of GUW in that the program promotes the value of integrating play and outdoors to provide meaningful learning experiences, which needed to be at the forefront of the online workshop. Thus, the instructors needed to address the tension between virtual learning and experiential learning (Mosely et al., 2010; Quay et al., 2020; Smith et al., 2016) and position teacher candidates as active science learners (Loughran, 2014). The online workshop included two science tasks incorporating outdoor learning while also leveraging the Slack communication tools to share evidence and observations collected by teacher candidates. The first science task asked teacher candidates to record observations of a bird and predict the type of food it might eat based on its beak's shape. The second task was to conduct a nature walk and record wildlife sightings. Teacher candidates posted pictures of birds and their predictions about the foods they might eat based on their beaks' shape and descriptions of their wildlife observations.

The Google reflection form served a dual purpose. First, it allowed the instructors to monitor teachers' progress towards completing the workshop requirements to obtain the PW certificate. Second, the form was a reflection tool used by teacher candidates to identify the strategies, knowledge, and skills they considered most valuable to prepare them to teach science.

The course instructors used the Quality Matters (QM) standards (2018) to maintain the rigor of the online workshop. Specifically, the standards guided the integration of course elements, including the introduction, scaffolds to students' self-regulation process through reflection, quality curricular materials, and various technologies. Module 1 set up teacher candidates' expectations and provided an overview of the workshop and the curricular connection to the Science Methods course. Given the four-week timeframe to complete the workshop and its reliance on teacher candidates' self-regulation, it was essential to provide various approaches to allow students to monitor their learning. The Google reflections, Slack posts, and Q&A channels served the double purpose of scaffolding teacher candidates' self-regulated learning and collecting evidence of their learning experience. Table 2 presents the GUW workshop alignment

ISSN: 2166-0190 online

to the QM standards (2018). It is important to note that the facilitators did not use all the QM standards because PW is not a formal online course. Instead, it is a short four-week workshop. Nevertheless, the facilitators and faculty acknowledge that designing an online experience is not straightforward. Using QM standards can increase the rigor of the final product.

Table 2

Project WILD Workshop Alignment to Quality Matters Standards

General Standards	Specific Standards	Workshop Elements
Course overview and introduction	1.1 Instructions to get started and finding various components.	1.1 Week 1: Overview of the course and its components.
	1.2 Introduction to purpose and structure of the course	1.2 Week 1: Workshop purpose and its structure.
	1.3 Communication expectations for interactions	1.3 Use of email and direct messaging through Slack.
Assessment and measurement	3.5 The course provides learners with multiple opportunities to track their learning progress.	3.5 Weekly reflections and posts in the discussion space in Slack.
Instructional materials	4.1 The instructional materials contribute to achieving learning objectives.	4.1 All instructional materials are aligned to the Science standards and teacher preparation standards.
	4.4 The instructional materials represent up-to-date theory and practice in the discipline.	4.4 PW books are updated and reflect the most current research-based practice for science teaching and learning.
Learning activities and learner interaction	5.2 Learning activities provide opportunities for interaction that support active learning.	5.2 Inclusion of science and science tasks to provide learning opportunities.
Course technology	6.1 The tools used in the course support the learning objectives or competencies.	6.1 The GUW workshop included Slack to create a community of learners, Google forms to scaffold self-regulated learning, and data collected. Panopto to edit and store videos.
	6.3 A variety of technology is used in the course.	6.3 Use of Panopto, Google, and Slack to design the workshop.
Accessibility and Usability	8.1 Course navigation facilitates ease of use.	8.1 Slack provides a navigation panel for ease of access to the workshop components.

ISSN: 2166-0190 online

Data Collection and Analysis

Multiple sources of data were collected and used to explore the teacher candidates' perceived learning experience. The data collected includes teacher candidates' weekly Slack posts, reflections, workshop evaluations, and microteaching assignments. Data collected were coded for emergent themes. The following section presents the results obtained from the weekly reflections' analysis.

Results

The teacher candidates reported opportunities to develop various dimensions of pedagogical content knowledge (PCK) to teach science inquiry, including science content, interdisciplinary science, and knowledge of content and teaching. The post-workshop reflections indicate that teacher candidates learned the *scientific content* addressed in the weekly videos. Teacher candidates highlighted learning about adaptation and life cycle. One of the teacher candidates commented that "It was nice being reminded of how species evolve" during Module 1. Similarly, a teacher candidate focused on flowers when reflecting on Module 2: "What I enjoyed most of the video was the information that was given to us about flowers. I have not learned about them since I was in school." These statements demonstrate the opportunities to learn content offered throughout the workshop. Furthermore, it shows the effectiveness of the workshop to position teachers as active science learners.

The data further revealed that teacher candidates identified *interdisciplinary connections,* for instance, math and literacy. A teacher candidate expressed: "I like the idea of integrating topics in multiple content areas." Given the interdisciplinary nature of the teacher preparation program, embedding PW in the Science Methods course was vital in introducing interdisciplinary connections, keeping the workshop content relevant for our teacher candidates, and aligned to the overall course objectives.

Finally, teacher candidates developed knowledge of content and teaching. First, they established relationships between the activities and specific learning objectives. During Module 4, one of the teacher candidates noticed that "different type(s) of leaves allow for more understanding…". The teacher candidate recognized that presenting students with various leaves to explore shapes and colors supports understanding the natural world and developing observational skills. Second, teacher candidates identified approaches to data collection with young children and how to use them to identify patterns in nature.

> I really liked the idea about using cameras to take pictures… while the students are making observations. Then the pictures could be reviewed again during a different season, when the nature outside looks different… this would help children understand the changes and patterns that occur in our natural world.

The teacher candidate reflections demonstrate an articulation between the science activities, how to facilitate data collection, and the student learning elicited, in this case, changes and patterns in the natural world. Thus, the reflections constitute evidence of PCK development to create teaching opportunities to support young learners make sense of science. Another aspect relevant to the development of PCK is the knowledge of students. Data revealed that close to 10% of teacher candidates identified the benefits of outdoor learning experiences to teach about the environment. Moreover, they reflected on the relevance of building on students' prior experiences and linguistic resources to develop knowledge and scientific language, respectively.

Discussion

The action research project to adapt the GUW workshop for online asynchronous delivery enabled us to think critically about the student learning experiences and design process. Engaging in this project is vital to design a quality workshop that provides appropriate learning opportunities to prepare teacher candidates to teach science inquiry. Given

ISSN: 2166-0190 online

that action research is intended to discern problems and identify solutions for positive change, the lessons learned from this project can potentially shed light on other teacher educators' experiences with online learning, as it did for us.

The action research project revealed that the challenges related to technology access (Teräs et al., 2020) and the tensions between virtual learning and environmental education (Mosely et al., 2010; Quay et al., 2020; Smith et al., 2016) could be addressed leveraging various technologies and curricular design. The reflection on the design process indicated that following the Quality Matter standards guided us to articulate the different workshop components. The inclusion of self-regulated learning opportunities leveraging the Slack platform to communicate and share observations provided inquiry opportunities focused on the environment. Scientific inquiry was at the forefront of the workshop through models of teaching, strategies to promote inquiry with young children and engaging teacher candidates in scientific observation. The analysis of teacher candidates' weekly reflections demonstrated that the weekly videos and tasks successfully provided rich opportunities to develop pedagogical content knowledge to teach science inquiry, similar to the face-to-face workshop. Furthermore, they identified effective strategies to facilitate observations using the hula hoops to focus young learners' attention while exploring nature and a Venn Diagram to sort wild and domesticated animals.

Throughout the reflection process, the facilitators and faculty contemplated approaches to enhance students' learning opportunities of PCK to teach science inquiry. The learning experience analysis indicates that teacher candidates learned strategies to facilitate observation and data collection. Faculty and instructors consider that the workshop should engage teacher candidates in a complete inquiry cycle to collect data, discuss observations and seek emergent patterns. Teacher candidates need opportunities to be active science learners to develop a deeper understanding of scientific inquiry teaching and learning (Loughran, 2014). Similarly, the weekly tasks can incorporate more scaffolding of nature experiences to foster self-regulated opportunities to learn about science and science teaching.

Overall, the action research project has highlighted the relevance of engaging teacher candidates in the PW to develop their PCK to teach science inquiry. The findings have implications for future revisions of the workshop and for teacher educators who were required to design online courses due to the restrictions imposed by COVID-19 or want to improve

ISSN: 2166-0190 online

References

Alvarado, A. E., & Herr, P. R. (2003). *Inquiry-based learning using everyday objects: Hands-on instructional strategies that promote active learning in grades 3-8.* Corwin Press.

Association of Fish and Wildlife Agencies. (n.d.). *Teach WILD. Learn WILD, Be WILD*. https://www.fishwildlife.org/projectwild

Bybee, R. (2015). *The bscs 5e instructional model: Creating teachable moments*. National Science Teachers Association Press.

Cusick, J. (2001). *Practicing science: The investigative approach in college science teaching*. National Science Teachers Association Press.

Council for Environmental Education. (2014). *Growing up WILD: Exploring nature with young children*. https://www.fishwildlife.org/projectwild

Loughran, J. J. (2014). Developing understandings of practice. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education: Volume II* (pp. 811–829). Routledge.

Moseley, C., Herber, R., Brooks, J., & Schwarz, L. (2010). "Where are the field investigations?" An investigation of the (implied) paradox of learning about environmental education in a virtual classroom. *Canadian Journal of Science, Mathematics and Technology Education,10*(1), 27-39. https://doi.org/10.1080/14926150903574262

National Academies of Sciences and Medicine. (2020). *Changing expectations for the K-12 teacher workforce: Policies, preservice education, professional development, and the workplace*. National Academies Press. https://doi.org/10.17226/25603

National Research Council. (1996). *National science education standards*. National Academies Press.

Prince, N. (2021). Communicating to improve the lived experiences of learning during COVID-19. *The Christian Librarian*, *64*(1), 17-19. Retrieved from https://digitalcommons.georgefox.edu/cgi/viewcontent.cgi?article=2250&context=tcl

Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future*, *8*(1), 133–141. https://doi.org/10.1177/2347631120983481

Texas Wildlife and Parks Department. (n.d.). Texas Project WILD Suite. https://tpwd.texas.gov/education/project-wild

Quality Matters. (2018). *Standards from the Quality Matters Higher Education Rubric*. https://www.qualitymatters.org

Quay, J., Gray, T., Thomas, G., Allen-Craig, S., Asfeldt, S., Beames, S., Cosgriff, M., Dyment, J., Higgins, P., Ho, S., Leather, M., Mitten, D., Morse, M., Neill, J., North, C., Passy, R., Pedersen-Gurholt, K., Polley, S., Stewart, A., Takano, T, Waite, S., & Foley, D. (2020). What future/s for outdoor and environmental education in a world that has contended with COVID-19? *Journal of Outdoor and Environmental Education, 23*, 93–117. https://doi.org/10.1007/s42322-020-00059-2

Saldaña, J. (2011). *Fundamentals of qualitative research*. Oxford University Press.

Smith, H. A., Dyment, J. E., Hill, A., & Downing, J. (2016). 'You want us to teach outdoor education where?' Reflections on teaching outdoor education online. *Journal of Adventure Education and Outdoor Learning*, *16*(4), 303–317. https://doi.org/10.1080/14729679.2016.1147966

Teräs, M., Suoranta, J., Teräs, H., & Curcher, M. (2020). Post-Covid-19 Education and Education Technology 'Solutionism': a Seller's Market. *Postdigital Science and Education*, *2*, 863–878. https://doi.org/10.1007/s42438-020-00164-x

ISSN: 2166-0190 online