Online Professional Development for Elementary Science Teachers

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Traditional professional development (PD) seldom provides teachers with the science content knowledge and pedagogical skills necessary to teach in ways called for in current reforms (Wilson, 2013). In a review of the literature, Darling-Hammond et al (2017) specified that quality PD is content-focused, incorporates active learning, supports collaboration, uses models of effective practice, offers feedback and reflection, and is of sustained duration. Few PD programs meet these quality criteria, indeed most PD in the United States uses a short-term approach. The challenges are to (1) provide high quality PD (2) in a flexible, cost-effective format accessible to a wide audience of teachers. The first challenge is to "design effective professional learning programs based on the best theories of learning and employing the most effective media and technology available (Fishman, 2016, p. 47)." The second challenge may be addressed through online PD. Online PD has emerged as a viable means to provide the necessary accessibility and flexibility for teachers and to reach larger numbers of teachers (Nese et al, 2020). One clear strategy for designing **effective online PD** is to start from a high-quality in-person PD grounded in research and learning theory.

While there are a growing number of online learning opportunities for science teachers, such as MOOCs (Kleiman & Wolf, 2016), access to online resources (Byers & Mendez, 2016), access to science webinars (Stiener et al, 2016), and just-in-time PD related to curriculum initiatives (Levy et al, 2016), these existing opportunities do not meet the criteria for effective PD. Thus, this paper set explores the development of *Online Elementary Science PD* (*OESPD),* a pseudonym, to understand how to effectively translate an effective in-person PD for science teachers into an online environment. Each of the three papers explores critical design features for

quality online PD drawing on data from an overarching design-based research study that describes the iterative development of *OESPD*.

Paper 1: Iterative Development of an Online Professional Development for Elementary Science Teachers

Design-based research (DBR) is an appropriate framework for constructing and testing educational interventions, it is not a single approach but rather a series of approaches intended to advance design, research, and practice concurrently through iterative design cycles (Anderson & Shattuck, 2012). Specifically, a DBR approach was used to explore the translation of a successful in-person PD into an online PD, while maintaining mechanisms for facilitating teacher learning within *OESPD*. The overarching research question was:

How can an effective in-person PD be translated into an online environment?

In-Person PD Program

The development of *OESPD* started from a successful in-person PD for elementary science teachers that was aligned with features of quality PD and had empirical evidence of impact on teacher practice and student learning. *In-person Elementary Science PD* (*IESPD*), a pseudonym, is one of few PD programs that has been studied using an experimental research design to determine impact on teaching practice and student learning (Darling-Hammond et al, 2017). *IESPD* has been shown to have a statistically significant impact on elementary teachers' science content knowledge, teachers' pedagogical content knowledge, teachers' instructional practices and student achievement in science as compared to a control group (Roth et al, 2011; Taylor et al, 2017).

IESPD is a year-long PD program, beginning with an intensive two-week summer institute for science teachers with academic year follow-up through a series of small study

groups. Teacher learning is guided by a conceptual framework that consists of nine strategies to support teachers in making student thinking visible and nine strategies to support the development of a science content storyline that is coherent from the students' perspective. During the summer, teachers engage in content deepening and analysis of practice activities supported through video cases of the 18 strategies and educative classroom science curricula. These curricula were designed to model and scaffold the teachers' use of the strategies and support teachers in deepening their science content knowledge.

While *IESPD* aligns with the consensus model of quality PD, more specifically, it is grounded in several design principles (Authors, 2017). While all design principles were considered in translating *IESPD* into an online environment, the most critical design principles to consider as part of the translation were related to the design of program learning experiences and the structure (or form) of the program (see Table 1). Some of the design challenges were mechanical or technological in nature, while others were based in generating high-quality interactions through a carefully designed sequence of asynchronous and synchronous experiences.

Table 1

Design principles central to the DBR study

Program learning experiences	
● Video-based analysis of practice	Analysis of teaching and learning using classroom video is a core learning activity.
● Science content learning experiences	Science content learning is closely linked to analysis-of-practice work using a common classroom curriculum.
● Scaffolded teaching practice	Teachers have scaffolded opportunities to practice using the guiding *IESPD* strategies.
Program form	
● Duration and intensity	PD is of significant duration.

Methodology

This DBR study used three rapid, iterative development cycles over a nine-month period to test key features associated with translating *IESPD* into an online environment. Pilots overlapped in time but still allowed for modifications to each module in-between pilots. Each iterative cycle included a small number of elementary teachers (3 -5 teachers per pilot group) who were recruited from previous PD projects. Three developers of the PD facilitated all synchronous sessions. The project team also included two researchers who gathered and analyzed participant data but did not directly facilitate the PD, and one participant-researcher - taking part in all PD activities and studying the learning experience from a participants' perspective.

Data Collection and Analysis

Data sources included surveys completed by participants at the end of each online module, interviews with participants collected three times during each pilot, participants' asynchronous posts, developers/facilitators' notes about sessions, and recordings of synchronous meetings.

Each weekly project meeting included time for the developers/facilitators to share their observations from both asynchronous and synchronous work, make suggestions for changes to the PD,

and discuss challenges with module implementation. When survey or interview data were available, participant data were presented by a researcher on the project team. The entire project team then discussed possible modifications to modules, with modifications ranging from small changes in wording or reflection questions to complete redesign of activities within a module.

Findings

Findings from this DBR take the form of our decisions for translating three design principles into an online environment, and are provided in Table 2.

Table 2.

Summary of translation from IESPD to OESPD

Principle	**Face-to-face experience**	**Decisions for translating to an online environment**
Video-based analysis of practice	Opportunity for analysis and reflection on classroom video	Analysis of video done asynchronously in preparation for whole-group exploration of strategies in a synchronous session. Crux questions embedded in asynchronous work to surface teachers' challenges. Video annotation tools used to support asynchronous work.
Science content learning experiences	Discussions in which teachers' ideas emerge through engaging in science activities and analysis of student thinking through classroom video	Asynchronous learning experiences that uncover and challenge teachers' current thinking about science content (content learning and analysis of classroom video). Synchronous discussions in which teachers' ideas from asynchronous sessions can be developed further .
Duration and intensity	90 hours of PD - an intensive 2-week summer institute and study group discussions during the school year	90 hours of PD - 10 weeks in summer, each week including a 2-hour synchronous session and 4-6 hours of asynchronous work plus 30 hours of study group discussions during the school year

Paper 2 : The use of technology tools to promote teacher learning in an online professional development

The effectiveness of online learning depends on the interactions that take place among students, instructors, and content in online learning communities (Schullo et al,2007). Technology tools that support online learning continue to evolve, and it is now possible to engage teachers in online PD using effective practices from the PD literature such as

collaborative and active learning approaches (Darling-Hammond et al, 2017). This paper focuses on the tools used to engage elementary science teachers in collaborative learning within *OESPD*. The study was guided by the following research question:

> In what ways do the selected tools create an opportunity for collaborative learning in an online PD?

Literature Review

Research shows that online instruction is effective when "the technologies are appropriate for the instructional tasks, instructors provide timely feedback to students, and levels of student interactivity are high (Durrington et al., 2006, p. 190)." Most Learning Management Systems include tools for collaboration and interactive communication, such as asynchronous discussion boards. Tools that allow teachers to post and share their ideas, such as Padlet and VoiceThread, offer additional mechanisms to develop and explore scientific ideas. These tools support internal dialogue where participants can think, discuss, and examine the content individually (Moore, 1989), as well as collaboratively. The primary benefit these asynchronous tools is flexibility for anytime-anywhere learning (Hrastinski, 2008) and the affordance of "time to consider their thoughts, engage with the content more deeply, feel a part of the learning community, and post more reflective comments in discussion boards (Watts, 2016, p. 27)." Selecting a technology tool requires that instructors first determine the types of interactions necessary to support learning of the specified learning outcomes (Watts, 2016).

Methodology

This study employs a single case study design (Yin, 2014). The case is the third pilot from the larger DBR study (described in paper 1). The third case represents a more established

learning environment where issues and challenges supporting collaborative learning within an online setting had been addressed. Data sources included the *OESPD* modules (activities, assignments, resources etc.) and participant interactions and artifacts. Data analysis considered the ways in which technology tools supported the intended learning outcomes and participant interactions in the asynchronous components of *OESPD*.

Findings

Content deepening activities are used here to illustrate how the asynchronous space was used in *OESPD* to maximize learning. Content deepening was developed through direct interactions with the content and through opportunities that emerged from analysis of classroom video and understanding student thinking. In the in-person PD, teachers engage in small groups in inquiry-based science learning using the activities from the IESPD curriculum. In the online setting, it is not possible to directly translate small groups working with hands-on science activities in either the asynchronous or synchronous space. Thus, use of selected tools aligned with the learning goals was necessary to create an opportunity for specific interactions with content and peers. It was important for the teachers to still have opportunities to engage individually and collaboratively in content learning. In some cases, materials were mailed to teachers so they had opportunities to engage individually with the hands-on activities before sharing ideas and explanations of phenomena with their peers. Teachers used Flipgrid to record themselves engaging in hands-on activities as part of sharing their ideas and explanations with peers asynchronously.

More vital, however, was teachers' use of VoiceThread. It was possible to use online resources such as images or videos of demonstrations of phenomena that teachers were able to annotate while describing what they saw in the image or video and sharing their interpretations

of what they saw using VoiceThread. Another tool, used primarily by the facilitator to collate teachers' ideas from the asynchronous session, was Padlet. Facilitators used Padlet in synchronous sessions to highlight areas of confusion or disagreement that emerged asynchronously and focus teachers' attention on key takeaways from the asynchronous work. Padlet was also used directly by participants as a shared space to post questions about phenomena. Teachers needed to overcome the desire to post correct scientific ideas (which sometimes led to Googling answers and "cut and pasting" responses). Padlet was used as a shared place to post questions about a phenomena instead of explanations. Teachers organized their questions in Padlet and revisited it throughout the module to decide which questions had been answered, as well as to add new questions.

Another critical mechanism for content deepening was the use of classroom video to understand student thinking. In *OESPD*, carefully selected classroom video was frequently used where teachers were asked to analyze student thinking from the video, as by understanding student thinking, teachers also have to reflect on their own understanding of the content (Roth et al., 2011). While the primary technology tools were the electronic resources of video and accompanying transcripts, VideoANT (video annotation) tools were also used to elicit teachers' thinking and share their video annotations with their peers.

Conclusion

Tools that were used in the asynchronous space provided the opportunity for teachers to make their thinking visible and share their initial ideas and reflections asynchronously in a shared space. Asynchronous work helped teachers and facilitators prepare for synchronous

sessions, for example, facilitators were able to pull ideas from asynchronous work and plan for rich discussions in synchronous sessions.

Paper 3: Establishing and Maintaining Community in Online Professional Development

As online PD increases in popularity due to its many affordances (Nese et al., 2020), it is important to also consider common pitfalls present in online learning. The most critical being learners sensing a lack of community. A weakened sense of community can have a detrimental effect on the overall online learning experience if participants feel isolated and devalued and lead to participants withdrawing from the learning opportunities, both figuratively and literally (Phirangee, 2016). As a result, there is a need for teacher educators to develop and facilitate online PD that cultivates a sense of community in order for rich and collaborative learning experiences to take place. The study was guided by the following research question:

How do facilitators cultivate and maintain a sense of community in an online space?

Literature Review

Research shows that design and facilitation decisions in online learning environments influence the development of community (Ouyang & Scharber, 2017). These decisions range from using technology tools that allow participants to connect with one another (Delmas, 2017), to creating a culture and structure that is responsive to the needs of teachers, allows them to take ownership of their learning, and honors the voices and experiences of the learners (Lock, 2006).

One of the biggest factors that interferes with peoples' ability to connect with others is a feeling of shame, whether it stems from fear of being wrong or ridiculed or simply feeling exposed and open to critique. In order to overcome these concerns, facilitators must balance speaking and listening to bridge understanding across different experiences and ideas (Brown et al., 2011) leading to a sense of empathy. A sense of connection is enhanced when facilitators

allow space for participants' identities to be included in interactions (Delahunty et al., 2014). For example, having participants interact with one other about science content can be elevated to richer learning experiences if they are also able to share their own ideas and questions about the science content.

Methodology

A single case study approach (Yin, 2014) was used to examine how a sense of community was established throughout *OESPD*. The case is bound by the first pilot of the larger DBR study. Pilot 1 was chosen as this was the only pilot to experience all modules. This is particularly critical for understanding the sense of community as the final modules required participants to begin sharing video from their own classrooms.

Data Collection and Analysis

Primary data sources include a purposeful sample of 10 video recordings from the synchronous sessions, transcripts of those synchronous session recordings, and relevant asynchronous module pages. Secondary data sources to understand the participants' experience within the community include participant survey and interview responses, narrowing in specifically on questions about the community.

Data sources were inductively coded and then sorted into categories and used to develop focus codes for further analysis (Saldaña, 2009). Once the focus coding was completed, the codes were examined to develop themes which served as the basis for the findings.

Findings and Discussion

There were several themes related to establishing and maintaining a sense of community. While parallel to building community during in-person PD, the themes include critical instructional design decisions that were necessary within an online space.

Vulnerability

Participation in PD requires a willingness to be vulnerable. This opens up teachers to sharing their ideas, better allowing facilitators to understand the teachers' prior knowledge and sense-making. It is important to note that this shared experience of vulnerability amongst teachers is at the heart of developing community. Facilitators created moments of vulnerability, at varying degrees, throughout *OESPD*. Early on, teachers experienced some low-risk moments of vulnerability. For example, teachers introduced themselves, their classroom, and their teaching philosophy in a FlipGrid video. These videos were then shared and discussed during the first synchronous session. This initial discomfort with sharing video was critical to establish a sense of community as it allowed teachers to become familiar with confronting vulnerability. Facilitators gradually built on this vulnerability by asking teachers to upload sketches of their science ideas, comparing and contrasting their contributed science ideas, watching videos of non-participants teaching, and finally having the teachers share a video of their own teaching. Building comfort with vulnerability over time was critical in leading up to highly vulnerable moments where teachers were asked to share video of themselves teaching.

Trust

Trust is built within those moments of vulnerability and is the driving force that maintains the sense of community. Once teachers work through any initial moments of discomfort, a sense of trust was established as they recognized *OESPD* is a safe place for them to grow and learn. The extra processing time in the asynchronous space allowed teachers to feel more prepared coming into the synchronous sessions, confident they had ideas and questions to contribute. Furthermore, teachers often noted that they felt a sense of accountability to one another to be prepared for the synchronous sessions. Through the building of trust in the

asynchronous space, teachers were able to engage in rich discussion in synchronous sessions. This allowed the facilitator and teachers to push their thinking forward throughout *OESPD*.

Challenge

The trust that was established from key instructional design elements and moments of vulnerability created the space for teachers to be open to challenging their own, and one another's thinking. For example, teachers were regularly asked to compare and contrast their ideas. As they had already worked through the vulnerability to share their true ideas, rather than looking up the correct answer, they were in a position to dig deeper and push their understanding further. Activities within *OESPD* normalized the reality that everyone has knowledge gaps, and teachers could tap into the collective knowledge generated from the *OESPD* community to help grow their content knowledge and practice.

Relevance of the Paperwork to ASTE

This paper set provides guidance to ASTE members engaged in teacher professional development. Particularly in the current COVID-19 situation, it is critical that we continue to engage teachers in professional learning opportunities and carefully crafted online PD that addresses the known features of quality PD have strong potential. Many of the research findings and pedagogical techniques are also relevant to teaching preservice courses online.

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