

STEM Teachers' Experiences With Different Modalities of Workshops

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Abstract. This study investigates the affordances and limitations of different modalities of professional development workshops for STEM teachers—specifically in-person, synchronous (Zoom), and asynchronous formats. Using post-workshop surveys and interviews, we analyzed the key learning factors distinguishing these formats. In-person workshops provided the highest levels of interaction, engagement, and collaboration, while synchronous participants appreciated the flexibility but experienced reduced interaction compared to in-person settings. Asynchronous participants reported challenges with engagement due to a lack of interaction and collaborative opportunities. The study highlights the importance of tailoring workshop formats to the needs of participants and suggests incorporating structured peer interaction and feedback in asynchronous settings to enhance engagement. A hybrid model that combines the strengths of different modalities may offer a more comprehensive approach to supporting teachers' growth in STEM education, particularly for those with time or location constraints. These findings contribute to understanding how professional development programs can be adapted to meet diverse needs and improve the learning process, especially for remote learners requiring flexibility.

Keywords: STEM Teacher, Professional Development, Workshop Modality, Face-to-Face, Virtual Live, Asynchronous

Introduction

Over decades, different forms of teacher professional development and training programs have been offered to provide opportunities for teachers to learn about innovative teaching practices and instructional strategies. As online education has expanded, exploring the outcomes, challenges, and limitations of online or hybrid modalities for professional development programs for teachers has also gained attention. The main forms of online professional development programs are asynchronous and synchronous, which differ in the methods of interactions. Although prior research indicated no clear significant differences between online and in-person or face-to-face programs regarding the impact on teachers' knowledge and beliefs, the affordances differed. For example, in an online synchronous form, learners can receive immediate feedback from peers or instructors and be more socially connected to them because of capturing social cues during communication (e.g., Peterson et al., 2018). In contrast, providing a flexible and self-paced learning opportunity, the online asynchronous form allows for deeper reflection, critical thinking, and productive and meaningful discussion because of the learners' response time (Morrison & Anglin, 2012). The affordances of in-person participation include greater collegiality, and emergent discussions among participants physically present in the same room for a prolonged time (Fishman et al., 2013). Comparing synchronous, asynchronous, and in-person forms of instruction, Wang and Wang (2021) found that synchronous

instruction is more beneficial in developing social and cognitive presence; whereas, asynchronous instruction resulted in deeper thinking and more thoughtful discussions. As research conducted on different forms of instruction delivery varied in content, context, discipline, and outcomes, it is imperative and informative to study different forms of professional development programs in the context of high-need schools. The following research questions were answered in this study:

- (1) What are the affordances and limitations of different types of workshops for STEM teachers?
- (2) How do these workshop types compare in terms of promoting active learning/engagement and expanding/sustaining teaching networks?

Literature Review

The growing popularity of online courses, whether synchronous or asynchronous, has encouraged researchers to study what distinguishes different delivery methods of instruction and the mechanisms that impact outcomes through these delivery methods. For example, Soffer and Nachmias (2018) studied the impacts of an online asynchronous course and a face-to-face course taught by the same instructors with identical assignments and grading criteria. They found that students in the online asynchronous course demonstrated a better understanding of course structure and better communication, engagement, and satisfaction. On the other hand, students in the face-to-face course reported better contributions to learning content. Students enrolled in the online asynchronous course achieved higher final grades compared to those in the face-to-face course, but students in both methods of delivery had similar completion rates (Soffer & Nachmias, 2018). Serhan (2020) examined how students viewed using Zoom in online synchronous instruction in their learning and engagement compared to those in face-to-face instruction. The results highlighted students' negative perceptions of Zoom with most students believing that Zoom negatively affected the learning process. However, students value the flexibility of Zoom and consider it a significant benefit of online learning (Serhan, 2020). In a meta-analysis by Bernard et al. (2004) comparing distance with in-class education, they reported high variability in different measures, leading to difficulties in interpreting the results. A recent systematic literature review by Joksimović et al. (2018) revealed that existing research lacks a unified framework to understand the outcomes, challenges, and limitations of online learning. Focusing on student engagement, Halverson and Graham (2019) offered a framework describing the correlation between academic achievement and different types of student engagement such as cognitive and emotional engagement.

Although these studies focus on students, their results align with research on different formats of professional development or training programs with teachers. For example, Wang and Wang (2021) found that synchronous instruction outperformed asynchronous instruction in social presence, cognitive presence, and science teaching. Although both online and face-to-face formats of professional development programs can improve teacher and student performance, the effectiveness of professional development programs may depend more on their underlying theories of action and strategies for helping teachers implement new ideas rather than on specific design features like duration or delivery mode (Kennedy, 2016). Thus, to better understand the role of delivery formats of professional development programs, we explored teachers' perspectives on the affordances and limitations of these formats as well as their levels of active learning and engagement and the contributions of these formats in the sustainability of their teaching networks.

Methods

Participants and Setting

In our study, we used a convenience sampling approach (Creswell & Creswell, 2022) to recruit nine science and mathematics in-service teachers who taught in high-need schools. These teachers participated in summer workshops during either 2023 or 2024. These workshops focused on language and equity in STEM education and academic language development in science and mathematics content classrooms. The workshop had a Hybrid-Flexible (Hy-Flex) course design (Beatty, 2019) and was offered in three formats; in-person, synchronous via Zoom, and asynchronous. After completing the workshop, they were invited to complete a post-workshop survey and a semi-structured interview via Zoom. Nine participants completed both the survey and the interview—five from 2023 and four from 2024.

The participant group consisted of nine teachers, with six of them specializing in science and the remaining three in mathematics. Most participants, five out of nine, chose to participate in person, while two joined via Zoom and the other two participated asynchronously. The majority of the participants taught at the high school level, while the remaining three were middle school educators. Teaching experience varied widely among the participants, ranging from new teachers to experienced teachers, with a maximum of 20 years of experience in teaching. The median teaching experience was one year, while the average was 4.5 years. The group included five females, three males, and one non-binary participant, and represented diverse ethnic backgrounds, including White, American Indian, and Hispanic/Latino. Geographically, most participants came from the Western U.S., with some from the Midwest and East, contributing to a diverse range of perspectives and experiences.

Study Design

The summer workshop was organized by faculty at a major public university in the Pacific Northwest. It was announced in early spring through the Western Regional Noyce Network—a regional network serving pre-service and in-service teachers in high-need schools across 14 western U.S. states—and took place in the summers of 2023 and 2024. The workshop participants received a \$300 stipend, and those who participated in both the study and interview received an additional \$25 in electronic gift cards.

In-person participants attended the workshop for three days while those who participated via Zoom joined the class simultaneously and these sessions were recorded. In-person participants also had opportunities to bond and socialize through excursions and group meals outside the workshop time. Asynchronous participants had access to these recorded sessions, along with additional notes, and were given two weeks to complete the workshop at their own pace.

Data Sources and Data Analysis

Our data comprises the survey responses and interview transcripts. We developed a majority of the categories within our codebook from prior research studies (as cited in Table 1) and some categories by theming the data using thematic analysis (Saldaña, 2021). We used this codebook to analyze these survey responses and interview transcripts. Two researchers coded the transcripts independently and then compared their codes to reach a consensus. Table 1 presents the codebook used in this study. When applicable, we noted either positive or negative references to the categories or subcategories.

Table 1: Codebook for coding the interview transcripts.

Categories		Descriptions & Reference
Interaction	Student-student interaction	Interactions among students or students working in small groups. Student-student interaction is desirable for both cognitive and motivational purposes (Bernard et al., 2009).
	Student-teacher interaction	Occurs when the teacher seeks to “simulate or at least maintain the student's interest in what is to be taught, to motivate the student to learn, to enhance and maintain the learner's interest, including self-direction and self-motivation” (Moore, 1989, p.2 as cited in Bernard et al., 2009).
Engagement	Cognitive engagement	Includes factors such as attention, effort/persistence, cognitive/metacognitive strategies, deep concentration and absorption, curiosity, or individual interest (Halverson & Graham, 2019).
	Emotional engagement	Includes positive factors such as enjoyment or situational interest, happiness, confidence, or self-efficacy and negative factors such as boredom, frustration, or anxiety (Halverson & Graham, 2019).
Motivation		The underlying source of energy, purpose, and durability, whereas engagement refers to their visible manifestation (Skinner & Pitzer, 2012).

Categories		Descriptions & Reference
Learning process	Active or passive learning	Any instructional method that engages students in the learning process. Active learning requires students to do meaningful learning activities and think about what they are doing. Passive learning happens in the absence of active engagement of students in their learning process (Freeman, et al., 2014).
	Collaborative learning	A student-centered educational approach that involves working in groups of two or more on different learning activities (Sawyer, 2006).
Learning outcome		Knowledge and skills that learners should be able to demonstrate, produce, and know as a result of participation in any form of learning activity (Suskie, 2009).
Flexibility	Time or schedule	Learning at one's own pace, regardless of the physical location, with access to materials and resources anytime, with physical comfort, and accommodating for personal difficulties that may prevent face-to-face participation such as family, work, and travel (e.g., Bernard et al., 2009; Regmi, & Jones, 2020).
	Money or cost	
	Family	
	Travel or comfort	
	Pace of learning	
	Access to materials, content, or resources	
Networking opportunity		Meeting with new people with whom you plan to interact is related to teaching and/or education (Polizzi et al., 2019).

Results

Overall, participants' responses to the survey questions aligned with their experiences shared during the interviews. Both in-person and Zoom participants reported positive experiences, with in-person participants describing their experiences as more positive than those of Zoom participants. All in-person participants indicated that the format met their expectations. They provided positive feedback, emphasizing interaction, collaborative and active learning experiences, and networking opportunities as key advantages and primary reasons for attending in person. The majority of Zoom participants also felt their expectations were met. Zoom and asynchronous participants appreciated the flexibility of their workshop formats, though their experiences did not fully match those of the in-person participants. Zoom participants benefited from real-time participation, which allowed them to follow the workshop more efficiently, and breakout rooms gave them some opportunity to interact, collaborate, and receive feedback. For the asynchronous participants, the flexibility—particularly the ability to set their own learning schedule and pace—was the main benefit. However, not being able to interact and collaborate during the workshop resulted in negative experiences with one stating that their expectations were not met, and another saying the format did not fully meet their expectations. In fact, some Zoom and asynchronous participants indicated that they wished they had signed up for a different format in their survey responses, while none of the in-person participants preferred another format over in-person. When asked to explain why they would choose another format, Zoom participants highlighted easier communication and greater networking opportunities and the asynchronous participants highlighted a desire for more interaction with the instructor.

Interaction

In-person participants benefited greatly from student-student and student-teacher interactions. In their survey responses, in-person participants listed group discussions and interaction with others as advantages of the format. They stated that discussion and feedback were among the most valuable parts of the workshop. For example, an in-person participant said,

“So the in-person component works better for my learning style. I feel like *interacting with people just makes it more dynamic and more memorable*. And that was exactly the case.”

The Zoom participants described mixed experiences related to interaction and how their opportunities to interact with others were more limited compared to in-person participants. One Zoom participant said:

"I think the *restriction is definitely you're not there in person*. So when they say bye on Zoom, they just go away. And you can't really like, you know, it's harder to like, come back and go, oh, wait, wait a second, I have a question. If you're over there, it's easier to just stay a little after, and kind of chat with people."

Finally, asynchronous participants experienced no interaction, which negatively impacted their overall experience. One asynchronous participant described his experience regarding interaction during the workshop:

"It was a lot of active conversation that I was not partaking of, but that I was listening to, you know, throughout the entire experience, so definitely, a little tough sometimes."

Engagement and Motivation

In-person participants frequently mentioned their cognitive engagement, with occasional references to their emotional engagement: "With being there in person, it is *a lot easier to connect*. Again, that *connection piece* is really big for me...if you're just talking at me for an hour on Zoom, I kind of zone out." Zoom participants expressed that they lost focus and struggled to engage at times, one Zoom participant compared their engagement experience to that of in-person participants and said:

"So one thing was, like, it was uncomfortable sometimes to have to be like, on the computer screen when they were all like in the classroom together and be like a big screen and then ask questions or talk about yourself. So like, where my association with the Western Noyce program came up? And they're like, how are you connected? And I'm like, this is kind of uncomfortable. Because it turns out the other Zoom participants were like, less associated than me. *It was different being a zoom participant, like some parts, it was really nice. But other parts, it was more difficult, because I felt like a disconnect from like the actual meeting itself.*"

Asynchronous participants reported a lack of engagement to a much greater extent. Below is the experience of one asynchronous participant:

"I think disadvantage in this isn't anything that can be done on anybody's and it should [be] just the nature of something being asynchronous and doing completely separate from like an in-person model, is it, it can be hard to, to just sort of like drill in and focus on pre-recorded stuff that you aren't an active participant of, you know, *it takes a level of dedication to sit and be like, I'm going to like, listen to all of this, I'm going to really focus on what's happening right now and not get distracted.*"

Similarly, motivation followed a similar pattern, with in-person participants describing a more positive experience, while other participants did not feel as motivated. In fact, in their survey responses, in-person participants cited distraction as a reason for not choosing another format.

Learning Process and Outcome

Both in-person and Zoom participants felt positive about the learning process. In-person participants frequently described their learning process as active, collaborative, and focused. One in-person participant said:

"I feel like *I learn a lot better when I'm in person. And it also helps me connect with those around me*. So I really enjoyed being in person. *I felt like I got more connected with what I was learning*, I could have a better response time with those around me. And I also like, if I had a question an hour later about something they talked about, I could be like, hey, like, really quickly? What's going on here? Very, I felt like it was more connected."

In comparison, Zoom participants mentioned active, collaborative, and focused learning less frequently but highlighted that "*breakout rooms were big on collaboration*," "*listening to people*" and "*opportunity for everyone to share what they thought or share what they had*" were important components of their learning process over Zoom.

Asynchronous participants stated that due to the lack of interaction, they experienced a more distracting, non-collaborative, and passive experience in their learning process.

In terms of learning outcomes, all in-person participants reported positive learning outcomes. One in-person participant explained the learning outcomes of this workshop:

"I had different connotations, but it was still great. And I think specifically what professor [BLINDED] presented on in regards to engaging students using a storyline and different, there are certain tools he [instructor of the workshop] provided us in readings *that did kind of shift my opinion on how to format and format my lessons and access kids a little bit better.*"

Zoom participants offered mixed responses; some had positive takeaways, while others felt they did not benefit, highlighting an overall negative experience. One Zoom participant had a positive experience and said,

"This is our second week of school, and so that's something that I'm already doing, that I kind of picked up from the workshop."

Asynchronous participants echoed their negative experiences to a greater extent compared to the Zoom participants, suggesting that they had predominantly negative experiences, leading to unfulfilled learning outcomes. One of them said,

“I feel weird having not learned that much from the workshop. That’s not what I went into it expecting but it is the truth.”

Flexibility

Unlike other disadvantages of the Zoom and asynchronous format, in both survey responses and interviews, flexibility was an advantage. Flexibility was primarily related to time and scheduling issues, the lack of travel requirements, and the self-paced nature of asynchronous learning. Zoom participants mentioned that they chose this format because traveling was not convenient for them. Although Zoom participants appreciated the breakout rooms and feedback from instructors, they expressed a preference for in-person participation if traveling had been more convenient or if their commitments and schedules allowed. Asynchronous participants, similarly, had work, family, and scheduling conflicts that made it difficult for them to commit to other formats. The flexibility in their learning pace allowed asynchronous participants to experience the workshop, as their schedules would not have otherwise permitted it. The only form of flexibility that was negatively experienced concerned access to materials and content, as well as the general organization of the workshop. This was related to issues with materials, recordings, and the structure of Zoom or asynchronous formats. A Zoom participant said because the school starting soon “traveling to Oregon would have been tough,” so, “I didn’t want to go over exhaust myself” but “I still wanted to have that live participation and still be able to ask and talk to the people in charge of the event.” Being able to take care of other responsibilities such as “tak[ing] over and be[ing] dad. So *being able to do it when she fell asleep was the best for me*” while learning from the workshop was an advantage in choosing an asynchronous format.

In contrast, in-person participants expressed satisfaction with the ease of access to materials, unlike Zoom and asynchronous participants. Several even noted that they found in-person participation more comfortable. The main negative aspect of flexibility for in-person participation was related to travel requirements, costs, and schedule and family-related concerns. An in-person participant described the disadvantages of “actually having to travel” and “front-loads the cost.”

Networking Opportunities

Networking opportunities were one of the most frequently and positively mentioned aspects of the workshop for in-person participants. On the other hand, both Zoom and asynchronous participants emphasized the lack of networking opportunities available. Survey responses further supported these findings. When asked about the number of new contacts they made, Zoom and asynchronous participants reported making no new contacts. Zoom participants believed that networking opportunities would have been easier if they had attended in person. They also suggested in the survey that facilitating the exchange of information and contacts among all participants, regardless of the format, could help foster new connections and enhance networking opportunities. One Zoom participant said,

“In terms of connections...I never got like anybody’s number” and similarly, an asynchronous participant only made contact with *“the instructors as I was bouncing stuff off of them.”*

Not surprisingly, in-person participants indicated they had made at least a few contacts during the workshop because

“it was a very small, intimate group, and we were in a classroom setting. I really appreciated that there were people from all over the country. That was one of the main reasons that I joined the project was to be able to collaborate with teachers from other areas of the nation.”

Discussion and Implications

In this study, we examined the affordances and limitations of different workshop modalities— in-person, synchronous (Zoom), and asynchronous—for STEM teachers, focusing on the different features of the learning process and the learning environment. Our study aims to distinguish different formats from a learner’s perspective. Our findings highlight distinct differences between these modalities, with in-person workshops standing out as the most beneficial in terms of interaction, engagement, and networking.

The in-person participants reported the highest level of cognitive and emotional engagement, driven by the opportunities for direct interaction with both instructors and peers. Active learning was encouraged through collaborative discussions and real-time feedback, allowing participants to reflect on the learning process during the sessions. The importance of social presence in learning was also evident, as in-person participants frequently mentioned feeling more connected to both the content and the other participants, supporting earlier studies that highlight the benefits of face-to-face formats for engagement and learning outcomes (Halverson & Graham, 2019; Suskie, 2009). Furthermore, networking opportunities emerged as a critical affordance of in-person participation, with participants able to establish professional connections that extended beyond the workshop itself. Some of these outcomes possibly emerged through the socializing activities outside the formal workshop hours such as site visits and group lunches and dinners that the other modalities (synchronous and asynchronous) didn't have.

The Zoom participants had mixed experiences. While the synchronous format allowed for some level of interaction, the level of engagement was lower than in in-person participation. Zoom participants cited challenges with maintaining focus and the limitations of interacting through a screen, which led to a sense of disconnection. The use of breakout rooms provided some opportunities for collaboration, but these were not as dynamic as the in-person interactions. However, participants appreciated the flexibility Zoom offered, particularly in reducing travel burdens and accommodating their schedules, aligning with findings on the flexibility of online learning.

The asynchronous participants expressed predominantly negative experiences. The lack of interaction and the absence of collaborative opportunities made it difficult for them to stay engaged and motivated. Although asynchronous learning offers flexibility, particularly for participants having both professional and personal commitments, they reported that the non-interactive nature of the format negatively impacted the learning process. This supports earlier studies (Serhan, 2020; Wang & Wang, 2021) that point to the challenges of asynchronous formats in fostering deep engagement and sustained motivation even though some studies found that asynchronous forms allow for deeper reflection and discussion because of the learners' response time (Morrison & Anglin, 2012; Soffer & Nachmias, 2018). Furthermore, asynchronous participants noted that their learning outcomes fell short of their expectations, particularly regarding networking opportunities, collaboration, interaction, and subsequently the application of workshop content.

While in-person workshops are most effective for engagement, collaboration, and networking, the flexibility of synchronous and asynchronous formats is crucial for teachers with constraints on time or location. However, the limitations of remote formats, more particularly asynchronous learning, suggest that these should be complemented with mechanisms to enhance interaction and networking. For example, incorporating more structured peer interactions including bonding activities (e.g., virtual excursions, online happy hours) or regular feedback sessions from instructors in asynchronous settings could help overcome some of the engagement challenges observed in this study.

Although in-person workshops are the most effective for the learning process, many prospective participants may be unable to attend due to personal (e.g., time, location, travel) or professional (e.g., work commitments) reasons. Therefore, understanding the limitations of distance learning is essential to implement the necessary mechanisms to enhance the learning process. Our study suggests that these improvements should focus on providing more feedback to participants through regular feedback sessions, encouraging hybrid networking activities open to participants across all formats, and offering more collaborative opportunities for remote learners, such as forming groups and encouraging group work, which can make remote learning more comparable to traditional in-person learning.

In conclusion, the findings suggest that while online modalities, particularly synchronous formats, provide valuable flexibility, in-person workshops remain superior for encouraging active learning and professional networking. As professional development programs continue to evolve, especially in high-need schools, a hybrid model that combines the advantages of different formats may provide the most comprehensive approach to supporting teachers' growth and development in STEM education. If in-person participation is not feasible at all, underlying theories of action and strategies to mitigate the shortcomings of remote delivery modes should be carefully addressed to make these modalities as effective as in-person ones in their weaker areas (e.g., engagement, active, learning, and social aspects).

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