Hub-and-Spoke

A Hybrid Model for Rural Professional Learning

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Small School Districts' Association

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Hub and Spoke Guidelines

A Hybrid Model for Rural Professional Learning

Lead Agency:	Small School Districts' Association (SSDA) 925 L Street, Suite 1185 Sacramento, CA 95814
Project Directors:	Kathy Hamilton Karen Mix
Author:	Jared Amalong
Producer:	Jessica Heidrich
Contributors:	Dr. Rebecca Bailey Edward Campos David Chun
Contacts:	Karen Mix - karen@ssda.org Jonathan Rhodea - jrhodea@scoe.net
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Abstract

Rural school districts face systemic barriers, including geographic isolation and resource constraints, that limit their access to high-quality professional learning (PL), particularly in computer science. To address this disparity, the CS4NorCal project developed, implemented, and refined the "Hub-and-Spoke" model, a synchronous, site-to-site hybrid delivery system for intensive PL. This article details the model's conceptual framework and operational components, which connect a central facilitation "Hub" to one or more regional "Spoke" sites where cohorts of educators gather. The model is defined by three pillars: an intentional technological infrastructure designed to foster telepresence, including a "Kiosk" system for cross-site collaboration; a distributed support structure of content Facilitators and local Room Hosts to manage cognitive load; and hybrid-specific andragogy.

Findings from a three-year implementation indicate the Hub-and-Spoke model is a viable, though resource-intensive, solution for increasing PL access. While it successfully fostered a sense of community across locations, the model's effectiveness was contingent on overcoming significant technological friction, particularly with audio management. Ultimately, the model presents a clear trade-off between the convenience of access and the quality of the participant experience. It serves as a blueprint for delivering equitable PL in rural contexts, underscoring that success requires substantial investment in human support and intentional design that extends beyond the technology itself.

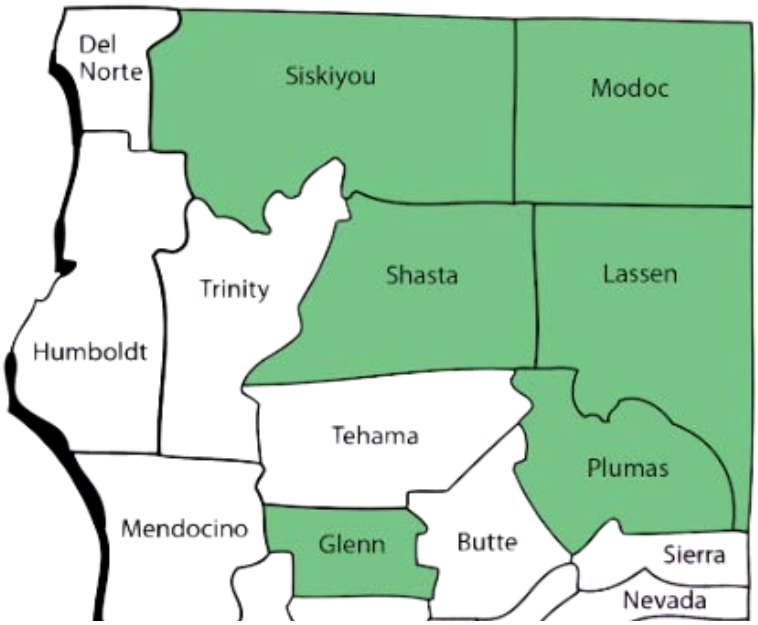
PART I - Background & Context

In 2018, California established statewide computer science (CS) standards but failed to provide a clear implementation plan for its numerous small, rural school districts. These districts face systemic barriers, including funding inequities, insufficient technological infrastructure, and limited access to professional learning (PL), that have impeded their ability to offer the same opportunities as their urban peers. During the 2019-2020 school year, only 24% of California's rural high schools offered a CS course, compared to 56% of schools in suburban and urban areas (Code.org et al., 2020).

One in every ten students in California lives in a rural area—over half a million students—and 67% of the state's school districts are classified as small (Jones, 2019).

The reasons for this gap are systemic. A national report found that superintendents in rural districts are significantly less likely than their urban counterparts to agree that their school board is committed to offering CS (Google & Gallup, 2020). These barriers include funding inequities, insufficient technological infrastructure, and limited access to PL.

"Why not here? Why should our kids be behind the 8-ball because of where they live?"
– Rob Adams, retired Superintendent, Redding Elementary School District



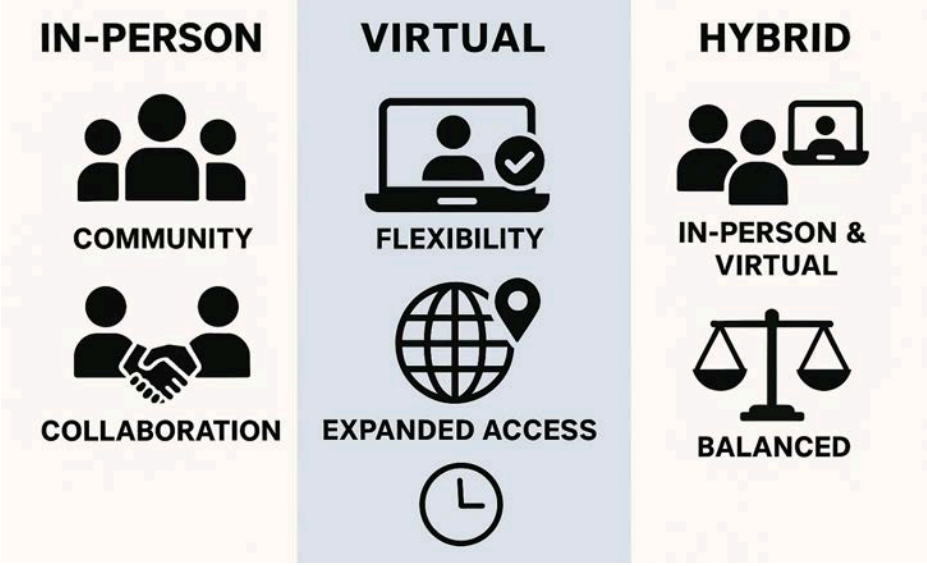
To address this disparity, the Small School Districts' Association (SSDA) secured a nearly $4 million federal grant to launch CS4NorCal. The project focused on six of California's most remote counties, where some districts serve fewer than 100 students, educators may drive hours for training, and unreliable internet can hinder online learning. CS4NorCal designed and delivered PL and student-facing resources tailored to overcome these specific challenges, building local capacity to create sustainable CS pathways.

One of CS4NorCal's most innovative strategies was a hub-and-spoke hybrid PL model that linked local, in-person workshop sites to a central virtual hub, connecting educators across Northern California's vast geography with relevant, high-quality training and a shared community.

Target Literature Review

Building on this understanding of persistent inequities, CS4NorCal PL was designed using effective strategies for supporting rural teachers. Research underscored the need for sustained, context-responsive PL that addresses isolation, resource constraints, and diverse student needs (Glover et al., 2016; Vernon-Feagans et al., 2013). The California Computer Science Strategic Implementation Plan notes that resourcing CS education is dependent on local contexts and best led by those who know them (California Department of Education [CDE], 2019). Reflecting this, the Small School Districts' Association (SSDA) designed CS4NorCal's PL on a Theory of Action that "a regional capacity-building approach…adaptive to local context can…provide students in high-need rural areas with a progressive continuum of exposure to CS instruction and experiences."

This regional, context-responsive approach was grounded in broader research that has identified the key features of high-quality PL, with prominent CS initiatives providing models for how to effectively support teachers and promote equity. According to research led by Darling-Hammond et al. (2017), effective PL includes sustained duration, moving beyond one-off workshops to be content-focused and collaborative. Research also consistently highlights unique advantages of face-to-face PL for K-12 teachers. High-quality in-person PL often encourages active collaboration, through which teachers can share ideas, observe each other, and engage in hands-on activities. In-person workshops also allow for immediate feedback and relationship-building. Teachers benefit from real-time interactions with facilitators and peers, including the informal "hallway conversations" that spark ideas and trust. Time spent in group discussions and working side-by-side with other educators can deepen engagement and accountability in ways that are harder to replicate online (Shareski, 2021). Overall, the literature suggests that face-to-face PL fosters a sense of community and shared purpose among teachers, which can enhance their learning and motivation to apply new strategies in the classroom (Darling-Hammond et al., 2017).



PART I - Background & Context

Rural educators face well-documented barriers to obtaining high-quality PL. One major challenge is geographic isolation and small school size, which contribute to "professional isolation" among rural teachers (Peltola, 2017). With fewer colleagues in the same subject or grade, rural teachers have limited opportunities to learn from peers or engage in collaborative training. Additionally, distance and travel constraints pose practical hurdles. In many rural areas of Northern California, attending an in-person workshop can require a drive of four to six hours, and districts often lack substitute teachers to cover classes while multiple staff attend multi-day workshops. As a result, rural teachers are frequently limited to one-time, "sit-and-get" PL sessions that are brief and disconnected from their ongoing needs (Martin et al., 2021). Sparse local resources, lack of time during the school day for PL, and high costs or logistics for travel are factors that undermine rural teachers' access to sustained, high-quality learning opportunities. Improving PL access for rural teachers may require creative solutions to overcome the limitations of distance and limited staff capacity.

Virtual PL has become increasingly prevalent, offering both opportunities and new challenges. Effective online PL is built on intentional design that adapts best practices of in-person training. Hanover Research (2019) identified four key advantages of well-implemented online PL: flexibility, community, accountability, and agency. Teachers can access workshops or courses at convenient times and self-pace their learning, which is especially valuable for busy educators. Virtual platforms also enable a wider reach to teachers in different schools or remote areas to network and share expertise beyond their local network (Hanover Research, 2019). To capitalize on these benefits, online PL should include interactive elements such as discussions, breakout activities, and feedback loops; these elements foster engagement and social presence despite the physical distance. Research during the COVID-19 pandemic demonstrated that virtual PL can be highly effective when it is thoughtfully adapted. Chandran et al. (2021) describe how a traditionally hands-on science teacher workshop was converted to an online format without sacrificing quality. By mailing materials to participants and using live video facilitation, the organizers maintained active learning; as a result, teacher outcomes in the 2020 virtual program were comparable to the in-person version, with nearly all teachers rating it "very good or excellent" (Chandran et al., 2021). This study noted that virtual PL is especially valuable when distance or finances would otherwise deter attendance, suggesting online models can improve equity of access (Chandran et al., 2021). In summary, best practices for virtual PL include leveraging its inherent flexibility while deliberately incorporating collaboration and support.

Conceptual & Practical Framework

Guided by this body of research, CS4NorCal developed a logic model (Appendix A) to translate these evidence-based principles into a concrete implementation plan. The logic model identified specific outcomes along with performance targets for delivering PL, implementing CS pathways, and providing work-based learning activities. Achieving these targets across the vast geography of Northern California, however, required a flexible delivery model that could provide high-quality, intensive training while overcoming the significant barriers of distance and isolation inherent in the rural context.

The demand for flexible PL models that blend face-to-face and online instruction has grown significantly, driven by the need to increase accessibility and personalization. For rural educators, technology-mediated PL is particularly crucial, as it can alleviate disparities in training opportunities and reduce the professional isolation often experienced in remote communities (Erickson et al., 2012). However, simply providing an online option is insufficient. Research on Hybrid-Flexible (HyFlex) and hybrid models indicates that without intentional design and specific pedagogical competencies, these environments risk creating unequal learning experiences, increasing the cognitive load on instructors, and negatively impacting engagement and equity for remote participants. Effective hybrid PL requires a cohesive strategy ensuring that all participants, regardless of location, feel part of the learning community and achieve equivalent learning outcomes (Beatty, 2019).

To address this challenge, CS4NorCal designed and iteratively refined the "Hub-and-Spoke" hybrid model. Initially piloted in 2022 as a single-day "minimum viable product," it evolved through iteration into a primary delivery mechanism for the project's intensive "Summer of CS" multi-day workshops. The model is defined by a central "Hub" location, where the lead facilitator and a cohort of participants are physically present. This Hub is connected synchronously via telepresence technology to one or more "Spoke" sites at other regional County Offices of Education, where other cohorts of participants are gathered. This model is exclusively site-to-site; it intentionally avoids having individuals join from home to foster local community engagement and limit virtual fatigue.

The conceptual design of this model focused on the pursuit of inclusivity and telepresence. It is distinct from simpler hybrid models (e.g., a "Peek In" model where virtual participants passively observe an in-person event) in that it explicitly aims to foster seamless interaction and community building across all locations. The goal is to foster inclusivity across and between sites, ensuring all voices are heard and all participants can engage meaningfully.

PART I - Background & Context

The practical framework of the Hub-and-Spoke model includes three interconnected pillars:

1. **Intentional Technological Infrastructure and Environment:** The model requires more than standard video conferencing. It necessitates standardized room configurations at both Hub and Spoke locations, utilizing dual screens (one for content, one for a continuous telepresence view of the other location) and high-quality audio/video equipment (e.g., 360-degree cameras, omnidirectional microphones) to capture the whole room context. A key innovation in this framework is the "Kiosk" system: dedicated devices (tablets or laptops) at participant tables in all locations that utilize video conferencing breakout rooms. This allows small groups at different physical sites to collaborate directly, transcending the physical limitations of their rooms and fostering a cross-regional community.
2. **Defined Roles and Distributed Support**: To manage the cognitive load of facilitating across multiple environments, the model relies on clearly defined roles. While a content expert (Facilitator) leads the instruction from the Hub, each Spoke location requires a dedicated "Room Host" who manages local technology, monitors engagement, assists with activity logistics, and serves as a crucial communication bridge between the Spoke participants and the lead Facilitator.
3. **Hybrid-Specific Andragogy and Protocols:** The framework demands that instructional strategies be adapted to ensure inclusive participation. This includes utilizing digital collaboration tools (e.g., shared slides, Jamboards), adapting hands-on activities for multiple modes (e.g., hybrid gallery walks using QR codes), and establishing clear communication protocols such as intentional pausing, prioritizing remote participants during discussions, and stating names before speaking to compensate for the absence of natural visual cues.

The Hub-and-Spoke Model

Product Design & Development

To realize this vision of an inclusive hybrid model, CS4NorCal invested in the deliberate design of a technological infrastructure capable of transforming dispersed workshop locations into a single, shared learning environment.

Model Overview

The architecture of the Hub-and-Spoke model centers on a primary facilitation site (the Hub) linked synchronously via video conferencing technology to one or more regional cohort sites (the Spokes). This decentralized yet connected design achieves a critical balance necessary for effective rural PL. It centralizes specialized content expertise at the Hub, enabling expert facilitators to reach a wide geographic area. Concurrently, it convenes educators at the Spoke sites, fostering peer engagement, network building, and collaborative problem-solving, which are essential for a dynamic workshop experience. This decentralized structure also provided adaptability during the COVID-19 pandemic and its continued impact. By facilitating smaller, regional cohorts rather than large centralized gatherings, the model allowed CS4NorCal to continue delivering essential in-person professional development while adhering to prevailing public health guidelines and evolving health and safety protocols. Furthermore, this approach significantly mitigates the prohibitive travel time and costs associated with attending intensive, multi-day workshops across the vast distances of California. By intentionally situating the Spoke sites at County Offices of Education (COEs), the model leverages existing regional infrastructure and affirms the COEs' role as accessible centers for PL and local capacity building.

CS facilitator instructing CS educators during a workshop in Redding, CA

CS facilitators, workshop participants at Sacramento COE

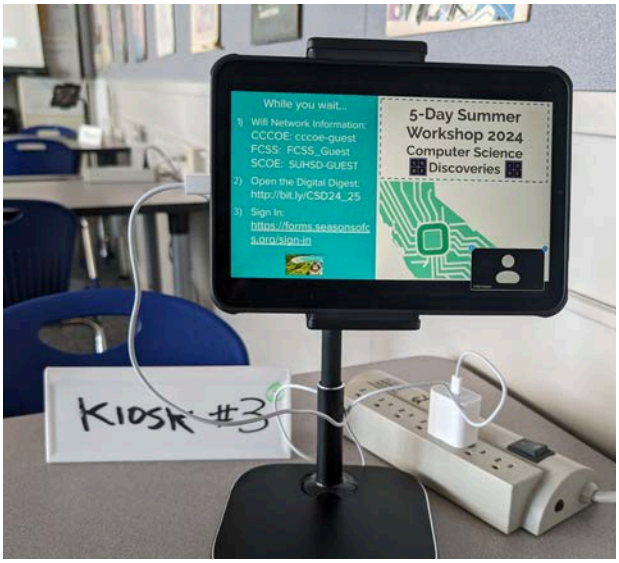
PART II - Technical Infrastructure & Considerations

Infrastructure Requirements

Implementing the Hub-and-Spoke model requires technologies capable of supporting sustained, high-quality synchronous network connections between sites. The primary prerequisite is robust network infrastructure; CS4NorCal established a required minimum bandwidth of 100 Mbps download and 50 Mbps upload at both the Hub and Spoke locations to ensure stability for multiple simultaneous video streams. To achieve the necessary sense of telepresence, a standardized dual-screen configuration is essential in every participating room. This setup dedicates one large display (projector or flat panel) for instructional content and a second, equally large display for a continuous, gallery view of the remote location. The physical size of these displays significantly impacts the sense of immersion and is critical for maintaining a visual connection between cohorts. Audio and video capture must be sufficient to transmit the context of the whole room, not just individual speakers. While this project utilized AI-powered 360-degree camera/microphone/speaker units (Owl Labs Meeting Owl 3s) to facilitate natural participant interaction, clear audio transmission also necessitates a dedicated, mutable microphone used exclusively by the facilitator to control the main audio feed.

Hybrid Workshop Room Setup

OWL Lab's Meeting Owl 3



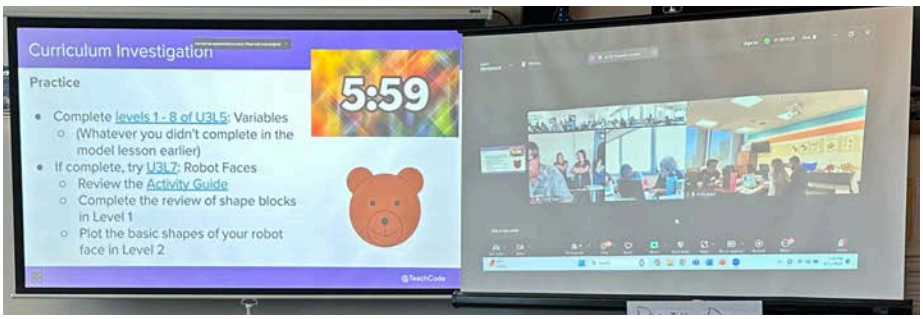
Kiosk system for hybrid breakout sessions

PART II - Technical Infrastructure & Considerations

Beyond the whole-room environment, the infrastructure must support individual engagement and seamless cross-site collaboration, utilizing an enterprise-level video conferencing platform (Zoom Meetings). All participants require individual devices (laptops or Chromebooks) to access digital resources and collaborative tools; these devices must remain disconnected from the video conference audio to prevent feedback loops. The cornerstone of cross-site interaction is the "Kiosk" system, which facilitates small-group collaboration through the platform's breakout room functionality. This requires dedicated Kiosk devices (iPad Minis), which have proven to be highly effective and stable. These Kiosks are logged into the main session, allowing small groups of two to three participants to be easily assigned to breakout rooms with peers at the remote site, thereby enabling direct, face-to-face collaboration independent of the main room feed.

Platform and Tools

The Hub-and-Spoke model relies on a curated suite of platforms and tools designed to maximize interactivity and manage the complexity of the multi-site environment. The core synchronous connection was managed using enterprise-level Zoom Meetings licenses, leveraging several critical features: robust breakout room capabilities for the Kiosk system, live captioning to ensure accessibility and Section 508 compliance, and advanced host controls. A dedicated "Room Host" laptop was essential for actively managing the session, which included using pinning and spotlighting to ensure the telepresence view remained prominent and strictly controlling audio inputs to prevent feedback loops. While facilitators utilized the platform's chat for backchannel communication, the primary mode of participant engagement centered on a "slides as workspace" philosophy. Utilizing shared platforms like Google Slides, instructional materials were designed not as presentation aids, but as interactive environments where participants at all locations engaged simultaneously on their own devices. This approach was anchored by a "Digital Digest" (Google Doc), which served as a centralized, accessible repository for agendas, resources, and links, and also facilitated participant contributions. Finally, the model intentionally bridged physical and digital activities using common, web-based collaboration tools (Google Jamboard); participants used device cameras to capture physical artifacts, such as chart paper or manipulatives, and uploaded the images to the shared digital environment, ensuring visibility and interaction across all sites.

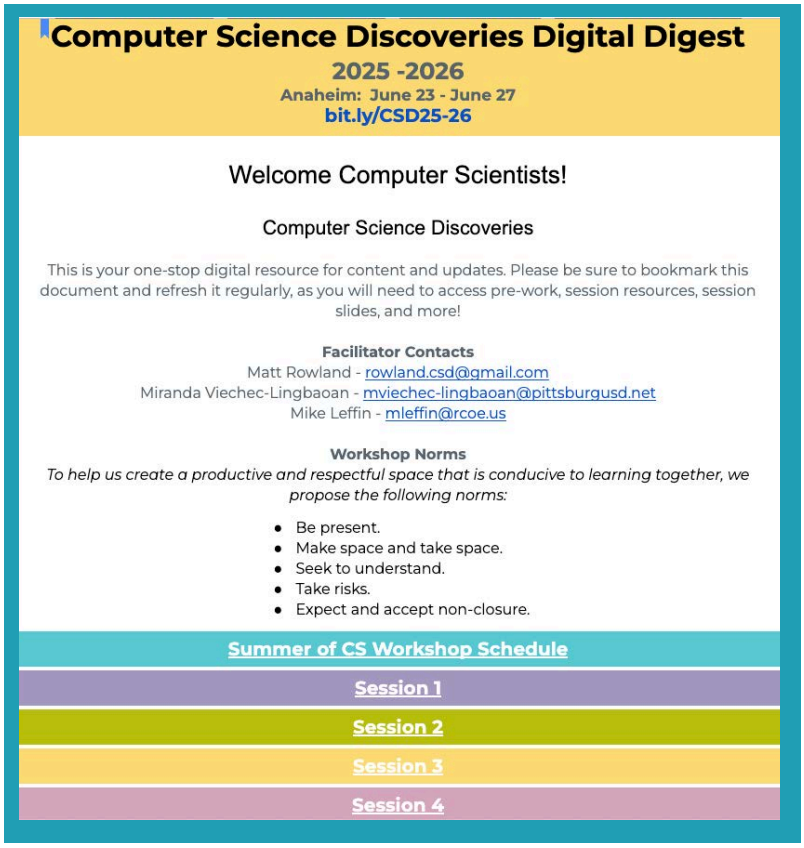


Hybrid platform dual screens

PART II - Technical Infrastructure & Considerations

Content Design & Delivery

The transition to the Hub-and-Spoke model required a fundamental shift in instructional design, moving away from traditional “sit-and-get” presentation methods toward a "digital-first" philosophy. All instructional materials, including shared slides and Digital Digests, were designed and reviewed in advance to ensure they functioned as the primary, interactive workspace for participants at both the Hub and Spoke locations. To maintain consistency and structure across various workshops, standardized templates were provided for Digital Digests (illustrated below) and Room Host slide decks. A critical consideration during the design phase was accounting for "technological overhead", which was the additional time required for technological transitions, audio management, and intentional communication protocols between facilitators and workshop hosts.



Computer Science Discoveries Digital Digest

2025 -2026

Anaheim: June 23 - June 27

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Facilitator Contacts

Matt Rowland - rowland.csd@gmail.com
Miranda Viechec-Lingbaoan - mviechec-lingbaoan@pittsburgusd.net
Mike Leffin - mleffin@rcoe.us

Workshop Norms

To help us create a productive and respectful space that is conducive to learning together, we propose the following norms:

- Be present.
- Make space and take space.
- Seek to understand.
- Take risks.
- Expect and accept non-closure.

Summer of CS Workshop Schedule

Session 1

Session 2

Session 3

Session 4

Agendas were structured with the necessary flexibility, acknowledging that the pace of delivery in a hybrid environment is inherently slower than a fully in-person workshop. Furthermore, activities were intentionally redesigned to ensure equitable engagement; when hands-on learning was essential, physical materials were shipped to Spoke sites in advance. All content adhered to 508 compliance standards, and facilitators were trained and encouraged to integrate Universal Design for Learning (UDL) principles and explicit visual cues, such as embedded timers, to support diverse learning needs across locations.

Logistics & Operations

The successful execution of the multi-site Hub-and-Spoke model relies on a robust operational framework characterized by well-defined responsibilities and standardized procedures. The CS4NorCal project utilized a hybrid management structure, dividing labor between a centralized operations team and the local COE partners. Centralized responsibilities included managing registration, procuring standardized technology, coordinating shipping, and finalizing facilitator contracts. The COEs hosting the Hub and Spoke sites were responsible for securing the physical space, coordinating catering, assigning a local Room Host, and managing the on-site setup. This partnership was formalized and maintained through recurring Task Force Meetings, which provided a venue to share information, solicit input from partners, and coordinate logistics in advance of the workshops.

Pre-Workshop Operational Timeline

Standardization and preparation were critical to minimizing technical disruptions. A rigorous site readiness protocol was implemented, beginning approximately one month before the workshop. This included standardized checklists for equipment setup, network testing, and room configuration at all sites. To confirm technological readiness, multiple "dry runs" and walkthroughs were conducted between the Hub, the Spoke(s), and the central operations team, with later sessions involving the facilitators to test the specific instructional setup. This proactive approach extended to resource management; physical materials were shipped to arrive several days prior to the workshop, with central staff tracking and confirming receipt. Facilitators were required to submit finalized digital materials approximately one month prior for review and distribution.

During the workshops, each COE site arranged for its respective IT departments to provide on-site support, particularly on the first day of the workshop. Real-time coordination between Facilitators and Room Hosts across locations was primarily managed using the Zoom Meetings chat, creating a dedicated backchannel for troubleshooting and logistical adjustments. Administratively, CS4NorCal developed an interconnected information system to manage the entire registration and attendance, which was reconciled with input from Facilitators and Room Hosts.

Implementation & Fidelity

The Hub-and-Spoke model was implemented iteratively over three years, evolving from a one-day pilot during the Summer of 2022 to a potential comprehensive delivery mechanism for intensive, week-long workshops during the Summers of 2023 and 2024. In total, 12 workshops utilized this delivery model. This scope included workshops funded directly through the CS4NorCal grant as well as statewide offerings funded by the California Department of Education's Educator Workforce Investment Grant for Computer Science (EWIG: CS). The EWIG: CS workshops adopted the CS4NorCal approach, and educators from the project's six-county region were invited to participate in those statewide workshops. All implementations exclusively utilized a configuration of one central Hub connected to multiple Spoke sites, demonstrating the model's capacity to manage complexity and serve geographically dispersed audiences simultaneously.

PART II - Technical Infrastructure & Considerations

Fidelity to the standardized infrastructure requirements and operational protocols was managed through a proactive, structured approach. The pre-workshop checklists, recurring "Task Force Meetings" with COE partners, and scheduled technical "dry runs" were the primary mechanisms for ensuring adherence to the model's design. This preparation resulted in few logistical challenges. Furthermore, despite the known challenges of network reliability in rural contexts, the established bandwidth requirements proved sufficient, and network outages were not experienced during the workshops, although facilitators and room hosts maintained contingency plans.

The most persistent challenges encountered during implementation were related to audio management, a common obstacle in synchronous hybrid environments. Early iterations experienced significant issues with audio feedback loops, particularly within the Kiosk breakout system, and inconsistent facilitator voice projection. To address these challenges, the model was iteratively refined. Dedicated facilitator microphones were introduced in the 2024 iteration to improve clarity and control over the main audio feed.

However, the inherent latency in broadcasting across multiple sites remained an occasional issue, particularly when co-facilitators were presenting from different physical locations, leading to instances of them inadvertently interrupting or "stepping on" one another. To resolve intractable feedback loops with Kiosks, some Spoke sites adapted by utilizing separate physical breakout rooms for small group work; this resolved the audio issues but introduced logistical "travel time" for participants moving between spaces.

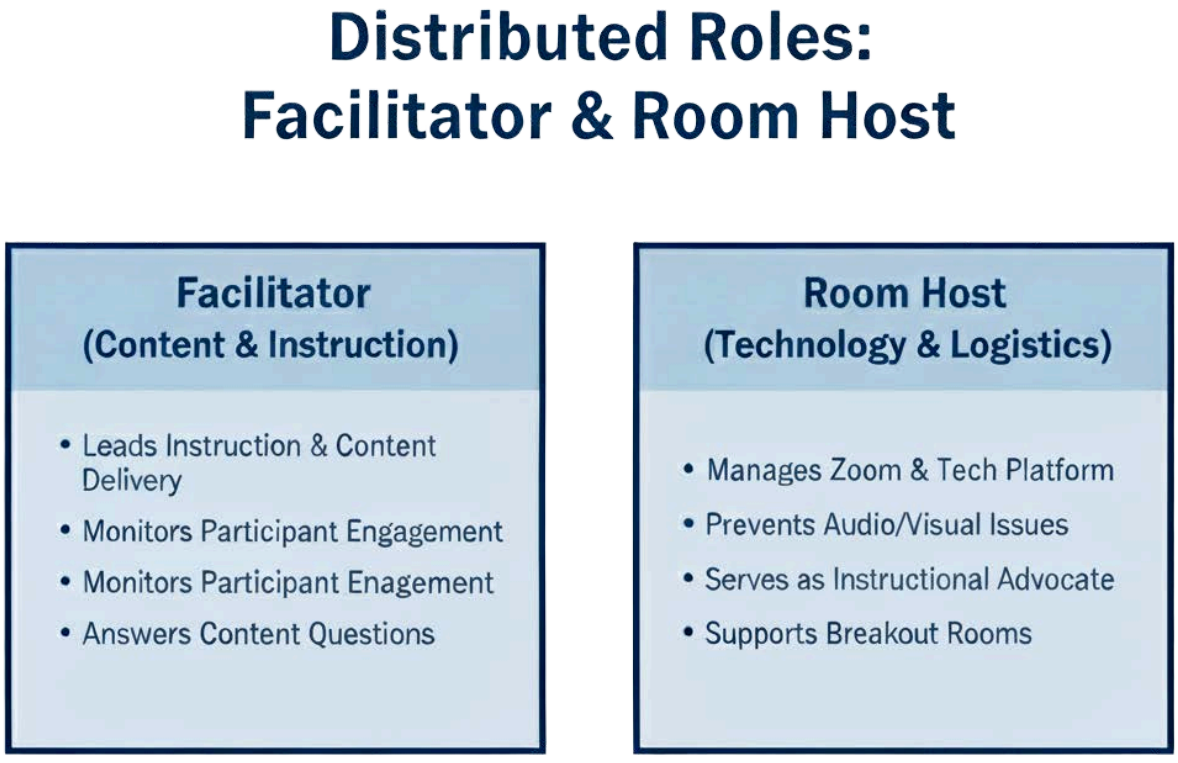
The expansion of the model from the regional CS4NorCal context to the statewide EWIG: CS workshops served as a critical test of its scalability. The established infrastructure requirements and operational protocols were maintained with the same rigor during this expansion. The model proved largely robust, successfully connecting diverse COE partners across the state. However, the scaling process did reveal variations in facility standards and technology readiness at different COEs. Instances where sites lacked the required dual-screen setup or utilized older, less reliable hardware for Kiosks underscored that deviations from the standardized infrastructure directly impacted the ability to achieve the intended inclusive telepresence.

Product Design & Development

The technological infrastructure previously described provides the foundation for the Hub-and-Spoke model; however, achieving a seamless, inclusive PL experience across multiple sites requires a specialized set of facilitator competencies and a clearly defined support structure.

Roles and Responsibilities

The complexity and high cognitive load inherent in a multi-site hybrid environment necessitate a distributed team approach rather than relying on a single facilitator. The CS4NorCal model established distinct roles (Facilitator and Room Host) that work in concert to manage content delivery, technology, and participant engagement across all locations. To ensure consistency, these roles were standardized across all workshops, supported by dedicated training, standardized scripts, and slide deck templates provided prior to the events. Facilitators are the content experts responsible for the instructional delivery and overall learning experience.



Recognizing the challenge of simultaneously managing in-person and remote audiences, workshops typically employed at least two co-facilitators. This allowed for a clear division of labor: while one facilitator actively presented the content, the other provided real-time support, monitored engagement across sites, and addressed questions from both Hub and Spoke participants.

PART III - Facilitator Development & Support

The Room Host is the crucial operational and logistical lead at each physical location, including the Hub. This role, often filled by experienced COE staff familiar with California's Quality Professional Learning Standards, is responsible for managing the local environment and the technology interface. Specifically, the Room Host manages the Zoom platform, handling tasks such as opening breakout rooms for Kiosks, managing audio inputs to prevent feedback, and using pinning/spotlighting to maintain the telepresence view. This intentionally offloads all technical management from the facilitators. Beyond technology, Room Hosts serve as instructional advocates for their local participants. They actively monitor local engagement and provide feedback to facilitators. They also synthesize participant questions, often utilizing a digital "parking lot" in the shared materials or compiling them directly for the facilitators. This ensures the site's voice is integrated into the broader workshop environment.

To keep connected, a "backchannel" was the real-time communication system used exclusively by Facilitators and Room Hosts. Managed primarily through the Zoom Meetings chat, this channel was essential for coordinating transitions, troubleshooting technical issues, and making logistical adjustments without interrupting the instructional flow for participants.

Train-the-Trainer Support

Facilitators of Hub-and-Spoke workshops were expected to possess the foundational characteristics required by the respective curriculum providers, including a strong equity focus, a growth mindset, deep content knowledge, and demonstrated experience in leading PL. Building upon this foundation, the CS4NorCal model required the development of a specialized set of competencies tailored to the unique demands of the hybrid environment, categorized into three domains: andragogical, technical, and operational.

The primary focus was the development of andragogical competencies centered on strategies to foster inclusivity and achieve telepresence. Facilitators were trained to adapt traditional instructional strategies to ensure equitable participation across all sites. This was supported by a "Facilitation Strategies Toolkit" (Appendix D), which provided concrete examples for adapting common facilitation strategies. These adaptations included utilizing QR codes for hybrid gallery walks, managing extended wait times, employing "Chat Waterfalls" for inclusive brainstorming, and structuring cross-site pair programming. In the technical domain, the emphasis was not on troubleshooting but on effective utilization. Facilitators were trained to integrate the dual-screen setup and the Kiosk system seamlessly into their instruction, overcoming initial reluctance to adopt these new tools. Operational competencies focused on effective collaboration with Room Hosts via the backchannel and the use of daily planning and debrief sessions to make real-time adjustments.

PART III - Facilitator Development & Support

The model explicitly separated andragogical and technical management; facilitators focused on instruction, relying entirely on the Room Host to manage the environment and address technical issues. The annual training for the Hub-and-Spoke model was mandatory for all Facilitators and Room Hosts and was designed as an experiential learning process. It included an annual training session supplemented by recurring, workshop-specific planning meetings.

Facilitator Compentancy Domains

A core component of the training design was the explicit modeling of expected techniques; the training sessions utilized the "slides as workspace" approach and the Digital Digest structure, immersing the facilitation teams in the environment they were expected to create. Practical application and scenario simulation occurred during the mandatory technical "dry runs." These sessions extended beyond basic connectivity checks, providing dedicated time for the teams to practice managing cross-site discussions, executing transitions using the Kiosks, and refining their coordination protocols.

The training program matured significantly over the three-year implementation period, mirroring the evolution of the model itself. Initial training in 2022 focused heavily on the logistics of the "minimum viable product," emphasizing basic technical setup and defining the new hybrid models. After confirming the functionality of the infrastructure, the training shifted its focus toward more sophisticated andragogical strategies for achieving telepresence, best practices for co-facilitating across sites, and standardized solutions for recurring challenges, such as audio management. Furthermore, recognizing the interdependence of the roles, the training structure evolved to train Facilitators and Room Hosts together. This integrated approach helped build rapport, clarify responsibilities, and ensure cohesive coordination across the facilitation team prior to the workshop.

Implementation and Fidelity

The effectiveness of the Hub-and-Spoke delivery model hinges on the consistent implementation of the defined roles and the specialized strategies covered during facilitator development. Fidelity to the model was maintained through structured meetings and intentional facilitation moves before, during, and after each session.

PART III - Facilitator Development & Support

Pre-Workout Preparation

Preparation for the hybrid workshops involved a standardized cadence of technical checks and collaborative planning. Before the workshop began, "Know-Before-You-Go" emails were sent to all participants to set expectations regarding the hybrid format, logistics, and access to the Digital Digest. While the pre-workshop "dry runs" were primarily focused on confirming technological readiness across sites, they also served as a critical opportunity for the facilitation team (Facilitators and Room Hosts) to establish communication norms and clarify their coordination strategy.

During the intensive multi-day workshops, the facilitation team adhered to a structured daily routine. Room Hosts and Facilitators arrived approximately one hour before participants each morning to boot up the hybrid technologies, connect the sites, and conduct thorough audio and video checks. This buffer time was crucial for troubleshooting any emergent technical issues without impacting instructional time. The teams also used this time for a daily planning meeting. The focus of these meetings was twofold: to confirm the technical setup and to review the day's agenda, making necessary adjustments based on the previous day's formative feedback and pacing.

In-Workshop Facilitation Strategies

A primary goal during the live sessions was to establish telepresence early and maintain an equitable learning environment across all sites. Introductory activities on the first day were intentionally designed to establish collaboration across sites. While specific activities varied by workshop, they often involved immediate engagement with the interactive slide decks, "speed networking" discussions that mixed participants across locations, or utilizing the Kiosks for initial small-group introductions.

PART III - Facilitator Development & Support

Facilitators must attend to participants' needs across multiple sites, which proved to be challenging. A key strategy was prioritizing the Spoke sites during discussions; facilitators were trained to take questions from the remote locations first. Additionally, facilitators explicitly directed checks for understanding to specific locations ("Let's hear from a participant at the Spoke site"). Room Hosts played a vital role in supporting participant equity of voice, monitoring local engagement, and actively ensuring participants at their site were included in whole-group discussions. The implementation of communication protocols, such as intentional pausing and stating names before speaking, was emphasized early in the workshops, though it often took time for these practices to become routine for both facilitators and participants.

Fidelity to the defined Facilitator and Room Host roles was high, characterized by cooperative relationships and dynamic actions. The backchannel was actively utilized throughout the sessions, primarily for technical coordination, managing the pacing of activities, and alerting the team to necessary transitions or adjustments.

Post-Workshop Follow-Up

The facilitation teams implemented a daily cycle of feedback and iterative improvement. Facilitators utilized various methods to collect formative feedback from participants each day, including digital or physical exit tickets, "Gots and Needs" reflections, or "Plus/Delta" charts. This daily feedback focused on both content understanding and the participant experience within the hybrid environment. While CS4NorCal administered formal post-workshop surveys at the end of the week, the daily feedback was essential for real-time responsiveness.

Each afternoon, following the conclusion of the session, the Facilitators and Room Hosts held a formal debrief meeting. While the specific structure was determined by the facilitators, the recommended agenda included a review of the daily participant feedback, an assessment of the day's pacing and engagement, and the identification of concrete adjustments for the following day's agenda and delivery. This structured reflection process allowed the teams to continuously refine their approach, addressing challenges and successes throughout the week.

Discussion

The CS4NorCal project's development and implementation of the Hub-and-Spoke model provides valuable insights into the complexities of delivering synchronous, site-to-site hybrid professional learning in rural contexts. The model aimed to overcome geographical barriers by centralizing expertise while fostering local community engagement. Findings from the three-year implementation, drawing on feedback from participants, facilitators, and hosts, suggest that the model is a promising, yet resource-intensive, approach to bridging the PL access gap. This discussion evaluates the model's success in achieving telepresence, the critical technological factors that influenced the participant experience, and the significant human effort required for implementation.

Achieving Telepresence and Community

A primary goal of the Hub-and-Spoke model was to move beyond simple broadcasting and create a cohesive PL experience across dispersed locations. Qualitative feedback indicates that this was largely achieved. Facilitators reported that when the technology functioned smoothly, "It really felt like one big group," and that a strong "community was built between the two locations." Participants echoed this sentiment, noting it was "awesome to connect with other educators" at different sites and appreciating the "ability to connect across agencies." This success relied heavily on intentional facilitation strategies, such as prioritizing Spoke participants in discussions and establishing clear communication protocols to ensure equity of voice.

The critical innovation enabling this connection was the Kiosk system. This infrastructure for small-group, face-to-face interaction proved essential for genuine collaboration and relationship building. As one facilitator observed, utilizing the Kiosks early in the workshop was crucial, noting that remote colleagues became "'real people' following a conversation in one of the kiosks." Participants affirmed this, stating, "I liked the small group work on the iPads - that was fun!" and highlighting the effectiveness of "having a way to have small group activities that spanned both locations." This underscores a key finding: true site-to-site telepresence requires dedicated infrastructure that supports direct, personalized interaction, not just whole-room broadcasting.

Technological Friction and the Importance of Audio

While the foundational infrastructure, such as network bandwidth and video displays, generally proved stable and effective, the implementation revealed that audio management remains the most significant technological challenge in hybrid environments. Participant and facilitator feedback consistently cited audio issues, including clarity, feedback loops, and background noise, as the primary source of friction. When audio failed, the entire experience suffered. One participant summarized their frustration: "The line had a lot of noise. I could not hear the other side well. I did not feel the engagement, and it impacted my ability to learn."

These challenges were compounded by the limitations and unpredictability of the hardware. Facilitators noted frustrations with "delays in muting and unmuting." The AI-powered, automated 360-degree camera focus was sometimes unreliable, leading one host to question the "Owl-gorithms", which affected both audio and visual functionality. Technical friction sometimes created barriers to natural interaction, with one participant sharing, "I felt disconnected from the facilitator since I was not able to raise my hand and ask a question in the moment." These findings highlight that without seamless, high-quality audio, the inclusivity and immersion of the learning experience are compromised.

Demand on Human Resources

The feedback also demonstrates that the Hub-and-Spoke model is resource-intensive, requiring a significant investment in time, labor, and human coordination. It is not a low-cost alternative to traditional professional learning. The logistical preparation was substantial, with hosts reporting that the initial room setup took "Hours!" due to the complexity of the technology, cabling, and room configuration.

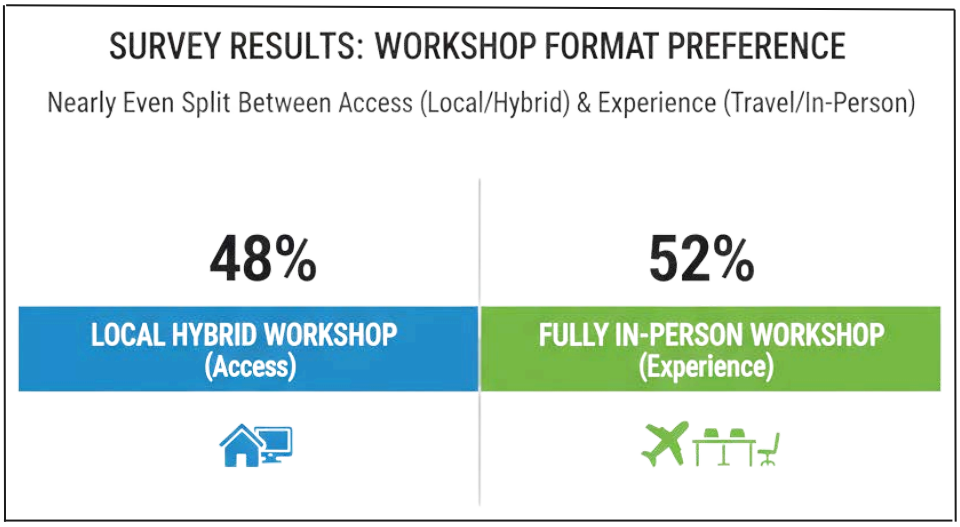
Moreover, the cognitive load on the facilitation team during live sessions is exceptionally high. The role of the Room Host evolved into a critical, intensive position, described by one host as "much more hands-on than expected" and requiring constant focus to manage the technology and advocate for local participants. Facilitators also noted the intensity of managing "split attention" across sites. This underscores the necessity of the distributed support structure, including dedicated Room Hosts and the use of co-facilitators. The practice of stationing facilitators at both the Hub and Spoke sites emerged as a positive adaptation, as having "a facilitator in both locations - available for questions and support" appeared to increase efficiency, though the centralized Hub model also proved effective. Organizations adopting this model must account for this substantial "human cost" in their planning and budgeting.

Trade -Off Between Access and Experience

> “Not as good as in-person , but better than straight virtual.”
> -Workshop participant

Ultimately, the Hub-and-Spoke model successfully addressed the critical need for access to professional learning in rural areas, delivering intensive workshops closer to educators' homes. Many participants appreciated this, with one stating, "I liked that I was able to attend without having to travel a long distance."

However, the findings reveal a clear tension between the convenience of access and the quality of the experience. When surveyed about their preferences (a local hybrid workshop without travel funding versus funded travel to a single, distant location), participants were notably split, with a slight majority preferring to travel. As one participant summarized the experience, it was "Not as good as in person, but better than straight virtual."



As travel norms stabilized following the COVID-19 pandemic, there appeared to be a renewed interest in traveling for a centralized experience. This suggests that while the Hub-and-Spoke model offers a viable and promising solution for equitable access, the inherent technological friction means it does not yet fully replicate the seamless, immersive experience of a traditional, single-site workshop.

Limitations

The findings regarding the Hub-and-Spoke model should be interpreted within the context of several limitations related to the evaluation methodology, the specific implementation environment, and the timeframe of the project.

First, the evaluation of the delivery model was primarily formative, designed to gather data for iterative improvement rather than to conduct a rigorous summative assessment of its impact. The data relies heavily on self-reported participant satisfaction and qualitative reflections from the facilitation teams. The evaluation design did not include objective metrics comparing participant learning outcomes or changes in classroom practice between Hub and Spoke locations, nor did it compare the Hub-and-Spoke model against a fully in-person or virtual control group. Furthermore, as surveys were administered at the end of the week-long workshops, there is a potential for survivorship bias; however, attendance data suggest that participant attrition during these workshops was nominal.

Second, the generalizability of the findings is influenced by the specific context in which the model was developed and deployed. The implementation was supported by substantial external grant funding, which facilitated the procurement of standardized technology and the allocation of significant staff time. While the human resource requirements (facilitators and hosts) are comparable to those needed for traditional in-person or virtual training, the high cost of the technological infrastructure may limit the model's replicability in less-resourced environments.

The model also benefited from strong partnerships with County Offices of Education (COEs), which provided necessary infrastructure and experienced personnel. While the model could potentially be replicated by districts, postsecondary institutions, or non-profit partners, success is contingent upon meeting the minimum technological requirements.

Additionally, the implementation occurred between 2022 and 2024, a period of significant transition following the COVID-19 pandemic. Attitudes toward hybrid engagement, the prevalence of "Zoom fatigue," and the increasing willingness and ability to travel for professional learning evolved during this timeframe, which may have influenced participant preferences and experiences.

Finally, the findings are specific to the technologies and configurations utilized. While standardization was the goal, there was variability in technological fidelity and facilitator preparedness across sites. The model accommodated some flexibility in local implementation, but this inconsistency makes it challenging to draw definitive conclusions about the effectiveness of the "ideal" standardized model. The rapid evolution of video conferencing technology may also limit the shelf-life of specific infrastructure recommendations, although the core functional requirements remain relevant. By design, this study focused exclusively on the site-to-site configuration; therefore, these findings cannot be used to draw comparisons against other hybrid configurations, such as HyFlex models that allow individuals to join remotely from home.

Future Research

The implementation and findings of the CS4NorCal Hub-and-Spoke model highlight several areas for potential future research to advance the understanding, optimization, and scalability of synchronous hybrid professional learning.

First, future research could explore the comparative efficacy of the delivery model. This could include quasi-experimental designs to compare the Hub-and-Spoke model against traditional in-person and virtual workshops. This research could focus on objective measures of impact, including participant learning outcomes and observable changes in teacher practice, to determine if the hybrid approach produces comparable results.

Second, future research could focus on the viability and scalability of the Hub-and-Spoke model. A formal cost-benefit analysis could determine the model's financial sustainability, particularly in the absence of external grant funding. This could include an exploration of lightweight versions of the model, testing whether reduced infrastructure requirements can still achieve acceptable levels of telepresence and engagement while lowering costs.

Finally, the high cognitive load experienced by the facilitation teams could warrant further investigation into optimizing the preparation of these teams. Research could explore the impact of more comprehensive, specialized training programs focused specifically on hybrid delivery andragogy and the operational strategies required to manage multi-site environments effectively. This approach could identify best practices for mitigating cognitive load and ensuring high-quality instructional delivery across sites.

Conclusion

The Hub-and-Spoke model emerged from a pressing need to bridge the professional learning gap for educators in California's vast and isolated rural regions. The CS4NorCal project demonstrated that a synchronous, site-to-site hybrid model can successfully increase access to high-quality training while fostering a genuine sense of an interconnected learning community. When implemented with fidelity, the model's intentional blend of technological infrastructure, distributed human support, and adapted andragogy proved to be a viable strategy for overcoming geographic barriers.

However, the model is not a simple replacement for in-person learning, but rather a complex solution with significant trade-offs. Its success is contingent upon substantial investment in both technology and human capacity, and its implementation revealed that persistent technological friction can hinder the participant experience. The Hub-and-Spoke model offers a promising and replicable approach for organizations committed to serving remote populations, illustrating that while technology can connect disparate locations, the pursuit of an equitable and seamless experience depends more critically on intentional, human-centered design and robust operational support.

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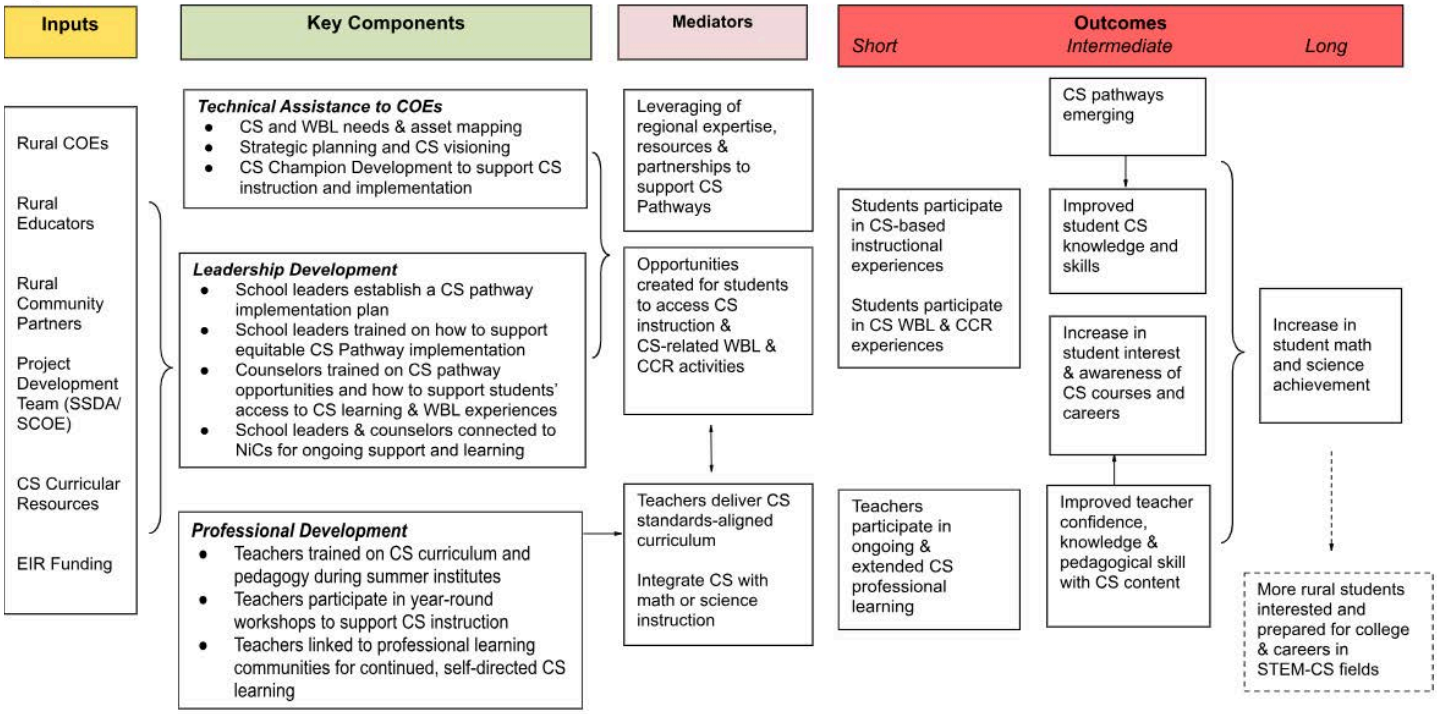
Appendix A - CS4NorCal Logic Model

Program: Rural STEM-CS Pathways Implementation Logic Model
Problem: Lack of access to STEM-CS-based instruction and opportunities in high-need rural areas inhibit potential college and career opportunities for students in high demand industry sectors.
Theory of action: A regional capacity-building approach to creating and supporting STEM-CS pathways that is adaptive to local context can promote an innovative field-based approach to providing students in high-need rural areas with a progressive continuum of exposure to STEM-CS instruction and experiences.



Appendix B - Sample Equipment & Room Setup Checklists

Appendix C - Facilitator Training Materials

CS4NorCal Workshop Facilitation Strategies Toolkit

As computer science professionals, facilitator expertise and contributions drive innovation and progress. Hybrid meetings can pose challenges for effective communication and engagement, but by leveraging best practices, hybrid professional learning can maximize productivity and foster collaboration among participants.

Here are a few implementation differences of professional learning best practices between in person, virtual and hybrid for groups, and virtual and hybrid for individuals.

In Person Strategy	Virtual/Hybrid Group	Virtual/Hybrid Individual
		
Building an inclusive culture	Hybrid meeting norms	Hybrid meeting norms

Gallery Walk	Hybrid Gallery Walk
	• Upload Pic to Jamboard via QR code
	  ○ Chart paper
	  ○ 8.5x11
		Virtual Gallery Walk
		Upload Pic to Jamboard via QR code
		• Chart paper
		• 8.5x11

Wait Time for Response	Hybrid Wait Time for Response • Note: wait time can be longer in hybrid • Chat Waterfall in Zoom • Use survey and quiz tools. Reveal responses after	Virtual Wait Time for Response • Chat Waterfall in Zoom • Use survey and quiz tools. Reveal responses after appropriate response time.

Appendix D - Digital Digest Template

Appendix E - Participant and Facilitator Team Feedback

Appendix F — Participant & Facilitator Team Feedback (Hybrid "Hub-and-Spoke")

Purpose & Scope

This appendix documents how participant and facilitator/room-host feedback was collected and summarized to inform improvements to the hybrid hub-and-spoke professional learning model. It includes: instruments, methods, descriptive statistics for closed-ended items, a de-identified thematic summary of open-ended feedback with representative quotes, and key reflections from facilitator/room-host retrospectives.

Data sources: 2023 Hybrid Experience Feedback (participant survey); facilitator/room-host reflections and checklists; hybrid protocols notes.