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How CAL-MSCS Communities of Practice Build Educator Capacity

Connecting CAL-MSCS Professional Learning Opportunities to Research on Effective Communities of Practice

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The California Mathematics, Science, and Computer Science Partnership (CAL-MSCS) is a collaborative program designed to foster a sustainable and powerful professional learning infrastructure statewide. CAL-MSCS's vision is to ensure that all California's educators experience professional learning that allows them to provide high-quality mathematics, science, and computer science learning for student success. The program has adopted a Community of Practice (CoP) approach as one way to anchor its aims and bring together grades 4–12 educators from across California. This approach features three CoPs, one each for mathematics, science, and computer science.

This report describes the CAL-MSCS CoPs and illustrates how their design aligns with research-identified features of effective CoPs in service to the project goals.

The report first describes what a CoP is and what features of a CoP have been identified within CAL-MSCS. The report then illustrates how each of the three CAL-MSCS CoPs align with the research on CoPs, with examples of how the learning opportunities build educator capacity. A brief discussion of why these CoPs matter for California closes the report.

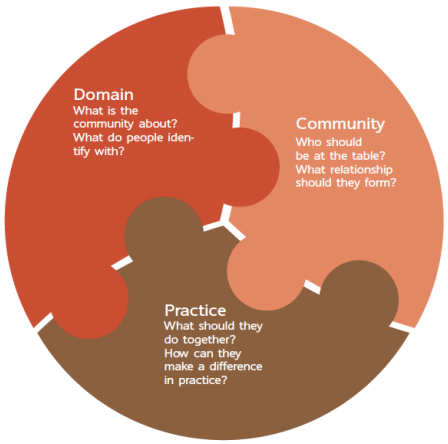
What Makes an Effective Community of Practice?

CoPs are groups of people who share a concern or a passion for something they do and learn how to do it better through regular interactions (Wenger-Trayner et al., 2023). CoPs can vary dramatically along three key structural dimensions—domain, community, and practice (see Figure 1)—with collaborative learning as their primary intent.

Three Structural Dimensions

- ***Domain*** is the focus of the CoP that members identify with and care about—the shared issues of practice that members address together.
- ***Community*** is the composition of the group and social fabric that supports learning through relationships over time. The ability of the CoP to make progress depends on the leadership and expertise of the group, trust, support, commitment, member initiative, and continuity of membership over time.
- ***Practice*** is the specific knowledge, tools, and approaches that members develop together. Their roles as practitioners shape their shared demands, challenges, and contexts. Their learning and ability to devise solutions are facilitated by members sharing relevant practical experience and combining their collective wisdom.

Figure 1. Structural Elements of a Community of Practice



Source. Wenger-Traynor et al., 2023.
Transcription. **Domain**: What is the community about? What do people identify with? **Community**: Who should be at the table? What relationship should they form? **Practice**: What should they do together? How can they make a difference in practice?

Seven Features of Effective Communities of Practice

Empirical research identifies the following seven interrelated features that distinguish effective CoPs from ordinary meetings or networks and that predict CoP effectiveness and member satisfaction (see Appendix A for a summary of research on these features):

- job relevance and impact on practice
- member connectedness and shared identity
- knowledge sharing and collaborative knowledge creation
- strong, multidimensional leadership
- member commitment and active engagement
- differentiated participation structures
- iterative refinement and responsiveness

Researchers found that **job relevance**—the degree to which CoP activities helped members improve their actual work—was the most powerful driver of perceived effectiveness.

How These Features Are Illustrated in This Report

In the remainder of the report, we organize examples from the three CAL-MSCS CoPs around the three structural dimensions of CoPs and illustrate how the effectiveness features are expressed across the math, science, and computer science communities. These examples are meant to offer a window into how the CoPs are building capacity among California educators. Similarities and differences across disciplines reflect each community's distinct context and stage of development, not necessarily the presence or absence of any particular feature.

Focusing the Learning Agenda on What Matters Most

As mentioned earlier, the *domain* is the foundation of any CoP, defining what the community cares about and why members identify with it. A well-defined domain gives the community its focus, its reason for gathering, and the shared concerns that make learning feel purposeful rather than perfunctory. Across the three CAL-MSCS CoPs, domain is not a passive background dimension but rather an active design choice steering teams to make deliberate decisions about what content to center, how to frame shared challenges, and how to evolve the learning agenda as the field and the program develop.

Grounding the Domain in Systemic Change

All three CoPs share a common orientation toward systemic change, but each has articulated its domain in ways that reflect the distinctive landscape of its discipline.

- The Math CoP centers its domain on leading systemic change, focusing on instructional improvement, family and community engagement, and implementation of the 2023 California Mathematics Framework (CMF) at scale.
- The Science CoP similarly frames its domain around advancing systemwide transformation in science education and strengthening capacity for high-quality professional learning, with an explicit emphasis on the roles of families, communities, and science champions.
- The Computer Science CoP organizes its domain around three core "building blocks": integrated computer science through deeper learning, standards alignment, and career pathways and industry partners.[1]

Despite these disciplinary differences, a consistent thread runs across all three CoPs: Each has defined its domain in terms of what county office teams are actually being asked to accomplish rather than around abstract content. This is more than a stylistic choice—defining the domain by the shared responsibilities of its members helps ensure that job relevance becomes structural rather than incidental.

[1] Family and community engagement was originally a fourth building block of the Computer Science CoP, but that area is now a priority receiving projectwide, multidisciplinary attention.

Evolving the Domain in Response to the Field

A hallmark of effective CoPs is that their domain is not fixed. Communities refine their focus over time as members develop shared understanding and as the field changes around them. The Math CoP offers a clear illustration. In its first year, key learning sessions were organized around the CMF's three dimensions of systemic change—a framework useful for establishing shared language among members who came with varying levels of familiarity. In the second year, the Math CoP's Steering Team shifted the organizing frame to the four CAL-MSCS project goals,[2] aligning the learning agenda more directly with what county office teams are explicitly accountable for. This was a deliberate act of domain refinement.

The Computer Science CoP faces a distinct domain challenge. The California K–12 computer science standards, first released in 2018, are currently under comprehensive revision, with publication expected in late summer 2026. Because computer science is not yet part of the state's School Dashboard, these standards have received less institutional attention than those in other disciplines, leaving many educators, especially those at the elementary level, less familiar with how to incorporate the standards into practice. The Computer Science Steering Team, which includes district leads and advisers to the standards revision process, has positioned the CoP as a space for educators to develop working knowledge of the standards being finalized, effectively shaping the community's domain in real time alongside a field in flux. At the December 2024 convening hosted at Sanger Unified School District, participants explored questions such as "How would you explain computing systems to someone from 1955?" to bring the Networks and the Internet core concept to life. They also discussed graphics and AI-generated images to explore Data and Analysis and Impacts of Computing, grounding standards work in the kinds of instructional problems that educators actually face.

The Science CoP's domain has similarly evolved to reflect emerging priorities. Current themes include cross-community connections, science-centered content integration, leadership and sustainability, and ways to further understanding of the Next Generation Science Standards. All these themes have been shaped iteratively by participant feedback and the Steering Team's sense of where the field is heading. This responsiveness to context is consistent with what Wenger et al. (2002) describe as communities "renewing relevance" as they mature.

[2] The four project goals, focused on grades 4–12 and the three content disciplines, are (a) expanding existing statewide infrastructure and capacity to provide educator professional learning opportunities and coaching; (b) generating and disseminating professional learning opportunities for educators that are designed to enable local [standards] implementation; (c) supporting local efforts to improve family and community engagement and positively engaging families and communities in implementing the standards; and (d) coordinating with grantees of other mathematics, science, and computer science educator professional development initiatives.

Building the Social Fabric That Makes Learning Possible

Community is the social dimension of a CoP—the relationships, trust, shared identity, and structures of participation that allow members to learn with and from one another over time. Effective communities require deliberate cultivation. Across the three CAL-MSCS CoPs, the social fabric is built through intentional attention to who participates, how relationships are nurtured, how leadership is distributed, and how members come to see themselves as part of something larger than their own organization.

Membership Structures: Who Belongs and How

Each CoP has made deliberate choices about membership that reflect its domain and goals. The Math CoP structures participation by allocating spaces based on county office of education (COE) size, enabling local teams to bring relevant partners engaged in their work. This approach balances broad geographic representation—a significant concern given California's 58 COEs—with the coherence that comes from a community whose members share similar institutional responsibilities.

The Science CoP follows a similar approach, allocating space for every COE and its local implementation teams while also integrating convenings into existing statewide events like the California Association of Science Educators annual conference to broaden participation and reduce logistical barriers.

The Computer Science CoP has made a strategically different membership choice. Rather than centering county office staff, it focuses on local education agency (LEA) staff—principals, teachers, and instructional coaches—who are directly embedded in the contexts in which computer science education must take root. Members joining in person are encouraged to bring at least two LEA teammates, enabling teams to jointly experience classroom visits and collaboratively develop a local computer science improvement plan. This team-based, place-based design reflects the Computer Science Steering Team's judgment that the most important learning happens when practitioners experience instruction together and plan together for their own contexts. The Steering Team codesigns each convening with partner districts and local implementation teams, emphasizing shared experiences across diverse roles.

This difference in membership focus—county office teams for math and science, LEA practitioners for computer science—illustrates a broader principle in the CoP literature: that membership structures should be defined by the domain and by who is best positioned to make

progress on the shared practice. There is no single right answer, but the choice has consequences for the community's learning culture and the kinds of trust that can develop among members.

Fostering Connection and Shared Identity

Member connectedness—the sense of belonging, emotional connection, and shared identity that members feel with their community—is among the strongest predictors of both CoP effectiveness and member satisfaction (Hemmasi & Csanda, 2009; Li et al., 2009). All three CoPs invest deliberately in building these connections, though they do so through different means.

The Math CoP allocates dedicated time to community building at every convening, centering these sessions on doing math together—a design choice that serves multiple purposes. Steering Team cochair Lauren Aranguren articulated three justifications: building community through shared, culturally relevant mathematical experience; helping participants rewrite their personal narratives about mathematics; and modeling mathematics leadership for future professional learning. For example, at the spring 2026 convening, the "Joyful Math" activity opened with a quote from the 2023 CMF about ensuring that students experience the "wonder, joy, and beauty of math." Members organized into trios to explore a data visualization that was revealed incrementally, discussing what story it told and how it might inform their leadership, before reflecting as a whole group. This approach directly supports development of a shared repertoire—grounding relationship building in mathematical practice, rather than in generic icebreakers, so that community building and domain learning reinforce each other rather than compete for time.

The Science CoP takes a similarly identity-centered approach but organizes it around a distinctive metaphor. Steering Team members have embraced the identity of "marigolds," drawing on the gardening practice of planting marigolds near other plants to protect them from pests and disease (Gonzalez, 2013). The metaphor conveys a core leadership message: surround yourself with people who are nurturing, protective, and encouraging. Community-building sessions at Science CoP events reinforce and encourage, sending the message that everyone belongs to the community and everyone—from administrators to classroom teachers—has a part to play as a science leader and advocate. Dedicated time for whole-group science experiences, followed by structured reflection, offers multiple entry points for participants to connect around the shared experience of "doing science," helping them draw on their identities as science learners to strengthen their roles as science leaders both locally and statewide.

The Computer Science CoP builds community through the immersive, shared experience of visiting schools and classrooms together. The place-based design—with convenings hosted at partner districts and structured around live classroom observation—creates a common

reference point that generates both relational connection and a concrete shared understanding of practice. Whereas the Math CoP builds identity through mathematical experience and the Science CoP through science experiences and a nurturing ethos, the Computer Science CoP builds it through the shared act of witnessing instruction and planning together for improvement. Across all three communities, the underlying principle is the same: Connection grows most durably when it is rooted in the shared domain, not separated from it.

Multidimensional Leadership

Leadership quality is a direct predictor of both job impact and perceived effectiveness in CoPs (Hemmasi & Csanda, 2009). The CoP literature describes effective leadership as "diverse and distributed"—not a leader–follower hierarchy but rather an ecology of roles in which members at different levels contribute to nurturing the community (Wenger-Trayner et al., 2023). By organizing sizable and diverse Steering Teams and Leadership Councils for all three disciplines, all three CoPs are able to distribute leadership for their design and effective implementation.

For example, the Science Steering Team includes more than 20 representatives from COEs; higher education; local education systems; and science organizations, including the K12 Alliance, California Science Projects, the Exploratorium, and the Lawrence Hall of Science. The approach to leadership is horizontal, inviting multiple voices into decision-making and focusing on student-centered science teaching and learning. The Steering Team's orientation toward distributed leadership extends beyond its own internal functioning. The marigold metaphor and the community-building activities that it shapes are explicitly designed to develop science leadership capacity across all role groups statewide, treating the CoP itself as a vehicle for leadership formation.

The Math and Computer Science Steering Teams similarly serve as distributed leadership structures, each bringing together statewide organizations, COE representatives, and project leadership. These leaders take an active role in designing and facilitating key learning sessions during the CoP events. The Computer Science Steering Team, by codesigning convenings with partner districts, provides an opportunity for local leaders to highlight their noteworthy computer science activities.

Science Leadership in Action: From Priorities to Practice

Defining and establishing Cal-MSCS priority areas exemplifies how science leadership drives CoP professional learning. Priority areas are developed through a multifaceted process in which Steering Team members review participant data and feedback, assess statewide needs, draw on individual and shared experiences, and then collaborate to define and refine priorities through dedicated reflection across multiple meetings, voting on them annually. Once set, all Steering Team members are invited to join planning teams organized around stratified roles: a Lead Point Person serving as liaison, Primary Leads who design and facilitate priority area work, and Thought Partners who contribute expertise and support. These efforts ultimately culminate in Science CoP sessions and professional learning.

Differentiated Participation and Access

Effective CoPs support multiple trajectories of participation, recognizing that members at different stages of engagement, expertise, or logistical circumstance need different modes of access (Lave & Wenger, 1991; Wenger, 1998; Wenger-Trayner et al., 2023). Each CoP has grappled with how to make participation viable across California's enormous geographic and institutional diversity.

The CS CoP has made broad access a defining feature of its design, offering dual participation pathways at each meeting: a full-day in-person experience and a half-day virtual option. These pathways reflect a deliberate commitment to ensuring that geographic distance or logistical constraints do not determine who can participate. In-person members attend convenings hosted at partner districts across the state and engage in live classroom visits. Virtual members can view classroom visit video segments and access live programming, including panels and keynote speakers. Access is extended through follow-up coaching sessions and an end-of-year Models of Practice event, creating a progression of participation opportunities across the year.

These Computer Science CoP structures are thoughtfully designed, though not without challenges. The three-member team requirement for in-person participation has posed challenges for small rural counties, and virtual participation has at times been hampered by technological difficulties. The Computer Science CoP's rotating locations across the state—itself a strategy for distributing access—can also make travel burdensome for some attendees. These challenges reflect a real difficulty in designing for equity of participation in a state as large and varied as California. Structures that widen access for some members may inadvertently create new barriers for others.

The Math CoP addresses differentiated participation through its learning modality structure. In the second year, the Steering Team introduced three options for how members engage with key learning content: panel discussions (hearing from practitioners in the field), facilitated learning sessions (exploring tools and strategies in depth), and table-talk discussions (holding collaborative peer conversations). This structure allows members at different stages of implementation to engage at the depth that best fits their current needs—a design principle that Wenger (1998) associates with communities that successfully support diverse members across a spectrum of expertise and experience.

The Science CoP also structures multiple types and levels of participation by offering members whole-group activities, breakout sessions focused on priority topic areas, and special events at meetings. For example, the May 2025 Science CoP included a family science event to foster members' science engagement with family and community—key populations that can influence students' science learning and extend the CoP's membership.

Practice: Developing Knowledge That Can Be Used

Practice is the third structural dimension of any community of practice: the specific knowledge, tools, approaches, and shared repertoire that members develop together in response to the demands of their work. Unlike domain (which defines what members care about) and community (which describes who learns together and how), practice is about what members actually do with their shared learning—how their learning gets built, documented, applied, and carried back into local contexts. Across the three CAL-MSCS CoPs, practice is developed through knowledge sharing, collaborative creation of new resources and frameworks, and structures that connect learning during convenings to action in members' home contexts.

Knowledge Sharing and Collaborative Knowledge Creation

Effective CoPs create structures for members to both share existing knowledge and develop new knowledge together (Brown & Duguid, 1991; Li et al., 2009; Wenger et al., 2002). In the Math and Science CoPs, dedicated breakout sessions and professional learning experiences are embedded throughout each convening, with time for peer and team reflection, sharing of local discipline-based success stories, and exploration of targeted tools and instructional aids. Finalized and draft resources are made available through electronic public folders or bit.ly links, resulting in a living repository that extends learning beyond individual events.

For its CoP members, the Science Steering Team has created a number of resources that are aligned with priority science areas and work. For example, the team has created a matrix of science practices that serves as a framework for improving educator knowledge and strategies grounded in the core belief that all students can excel in science and that quality professional learning shifts educator mindsets accordingly. Steering Team members use the resource when planning breakout sessions and facilitating learning experiences, both modeling science practices and helping community members develop shared understanding of how to apply pedagogical principles in their own instruction and classrooms. In doing so, the Steering Team has created a tool that functions as a "repertoire for the practice" (Wenger-Trayner et al., 2023)—a systematically developed resource that captures the community's evolving understanding and makes it usable and sharable across contexts.

The Computer Science CoP creates a similar dynamic through its use of hands-on, inquiry-based activities and digital resources. Both the inquiry activities and the digital resource reflect the Computer Science Steering Team's emphasis on collaborative sense-making. When participants

explored the Computer Science standards at the December 2024 convening at Sanger Unified, they were presented with the concepts through accessible, generative questions and invited to work through the ideas together, generating shared understanding in the process. The March 2025 convening in Redding featured a collaborative opportunity to explore a Computer Science Teachers Association report and think through ways that districts could implement its recommendations for course progressions, computer science integration, and other supports.

Connecting Learning to Local Practice

A core challenge for any statewide CoP is ensuring that what members learn together translates into changed practice in their local contexts—what the CoP literature describes as "learning loops" that connect community-level learning to site-level action (Wenger-Trayner et al., 2023). All three CoPs have built explicit structures for this connection, though they have done so in different ways.

The Computer Science CoP's practice structure is organized explicitly as an ongoing cycle. Each convening integrates classroom observation, practitioner insights and panel discussions, focused professional learning on the convening theme, and collaborative team action planning around a concrete change idea that members carry back to their own contexts. The Open Design Labs that follow each convening provide coaching as teams refine and apply their work. The Models of Practice Summit completes a loop that involves shared learning, local application, and shared reflection on results. This cyclic design directly supports the idea of building learning loops that connect local practice back to the community (Wenger-Trayner et al., 2023).

The Math CoP creates a connection to local practice through structured tools and planning time embedded in each convening. Learning sessions are paired with opportunities for planning collaboratively and using the reflection tools (see Tools for Connecting Local and Communal Learning). In the second year, the introduction of three differentiated learning modalities (described above) gave each member more agency in choosing how to engage with content, making it more likely that learning would connect to their specific implementation context. The announcement of a grant opportunity to support COE teams in future local work represents a further evolution. The community is now actively resourcing members' ability to apply what they have learned, signaling a shift from knowledge reception to knowledge generation and local application.

Tools for Connecting Local and Communal Learning

The Math Steering Team has developed an electronic "storyboard" template to help COE teams collect their learning, consider next steps, and document how they would apply new ideas to their local work. The storyboard serves a dual function. It creates a shared repertoire artifact that makes teams' thinking visible across the community, and it establishes a structure for two-way communication about mathematics work happening across the state. The template was simplified between the third and fourth convenings in response to participant and Steering Team feedback, reflecting the Math CoP's ongoing responsiveness to members' needs and its maturing capacity to adapt shared tools to better serve practice. The Math Steering Team can access information the teams provided in the storyboards in order to drive ongoing programming and support. The Science CoP introduced a similar "Learning Journey" tool at its May 2026 convening.

The Science CoP builds the connection to local practice through planning time and resource sharing embedded throughout each convening—via county or team approaches, individual and peer reflection, and the sharing of local science success stories. Recently, the CoP developed a "learning journey" template to support participant reflection and connection to practice.

This emphasis on local work within each convening reflects a design principle consistent across all three communities: that the CoP is not a separate learning event but rather an amplifier of what members are already doing and a resource for what they are trying to do next.

Coaching to Extend Learning in the Computer Science Community of Practice

During the afternoon of each Computer Science CoP event, LEA teams reflect on the computer science teaching and learning they observed in the morning and then work together on action planning. Teams receive an overview of PDSA (plan-do-study-act) Cycles and a template to help them identify an idea they want to implement related to computer science teaching and learning. Once they have collaborated on this idea in person, they are asked to attend a follow-up Open Design Lab session.

These virtual meetings are offered within a month of the CoP, and LEA teams are paired with experts from the Computer Science Steering Team who provide individualized coaching (including resources, ideas, and thought partnership) to refine their change idea and think through the do, study, and act phases of the PDSA Cycle. The team uses an in-depth template for these meetings to capture districts' and coaches' thinking so it can serve as an ongoing resource for the LEA implementation team. This process supports each team's work and gives the Steering Team insight into computer science needs, priorities, and implementation challenges in districts across the state.

Iterative Refinement of Practice Structures

The practice structures of all three CoPs have evolved over time in response to member feedback and the changing demands of the work. The shift in the Math CoP events offers a clear longitudinal illustration, with key learning sessions shifting focus from CMF's three dimensions of systemic change to the four CAL-MSCS project goals. Each shift has been deliberate, driven by the Steering Team's attention to what forms of learning members need most at each stage of implementation.

The Science CoP's practice structure has similarly evolved, with time allocated to breakout sessions and professional learning increasing at each successive convening—a signal that the Steering Team is listening to what members find most valuable and adjusting accordingly. The Computer Science CoP's iterative responsiveness is most visible in how each convening is shaped by the specific strengths and opportunities of the host district. In all three communities, iterative refinement is not a response to things going wrong but rather a fundamental feature of how effective CoPs learn and improve.

Member Commitment and Active Engagement

Participation at Scale

Who shows up—and who returns—for CoP events is a critical measure of their success. Additionally, in a state the size of California, the number of participants and their geographical distribution matter a great deal for how well the CoP-embedded learning scales broadly. From records maintained by the Steering Team for each discipline, a few example statistics give a sense of the scale and ongoing commitment of the members of these three communities (which also have an overlapping membership).

- Approximately 500 unique California educators have attended at least one Math CoP event, and 71 have attended all four.
- Similarly, 491 unique educators attended at least one Computer Science CoP event, and 65 educators attended three or more; another 364 educators have attended only the Models of Practice Summit.
- The Science CoP events have included 457 unique educators, with 73 attending all three.

As far as geographical inclusion across the state, only three county offices have been unable to join a Math CoP convening, and 38 out of 58 COEs have been represented at all four Math CoP events. Science CoPs demonstrate similar geographic spread, with between 42 and 46 counties represented across the three events. In the past year, 40 of the 58 county offices participated in at least one Computer Science CoP event, despite the challenges associated with LEA staff traveling to events across the state (e.g., substitute coverage, funding).

What Members Report Learning

Participant surveys help measure these community members' engagement. After each CoP event, attendees were asked how much they agreed with six statements about their experience, rating each one from "strongly disagree" to "strongly agree" (see Appendix B). The results were consistently positive.[3] Across all three CoPs, at least 95 percent of participants said they learned something new and planned to use what they learned in their work. In math and science, more than 95 percent also said they planned to stay in touch with people they met at the event to continue working or learning together. Computer science participants showed similarly high agreement that they came away with a better understanding of what is happening in their field beyond their own schools or organizations. The one area in which enthusiasm was slightly lower, though still strong, was engaging families and communities and communicating academic standards to caregivers. Even so, 84–91 percent of participants across all three subjects agreed they had grown in these areas.

[3] Results are based on data from four Math CoP events (474 respondents), three Science CoP events (311 respondents), and six Computer Science CoP events (228 respondents).

Why Do These Communities of Practice Matter for California?

Addressing Regional Differences Through Horizontal Networks

CoPs matter for California education because they address a problem that no single district or county office can solve alone: how to improve domain-specific teaching and learning statewide. Professional learning needs in mathematics, science, and computer science are both urgent and uneven across the state, with rural and remote county offices facing the greatest gaps in content expertise and staffing. Each COE was offered CAL-MSCS grant funding for local math, science, and computer science efforts; in the resulting project action plans, half the COEs raised equity concerns. These concerns included recurring worries about marginalized students' access to courses, credentialed teachers, and rigorous instruction. Rather than pushing resources from the top down, CoPs create horizontal networks in which educators at every level can share assets, candidly name challenges, and learn from one another's practice. The literature on CoPs reinforces why this structure works: Trust builds when practitioners can bring their real problems into a shared space. That trust becomes the foundation for genuine innovation and sustained improvement over time.

Building Statewide Infrastructure for Learning

The state's decision to move from private foundation funding to an $50 million public investment in CAL-MSCS signals a recognition that this model is not a supplemental program but rather a core infrastructure need. When such a broad group of educators, at varying levels and across all 58 COEs, engage in project activities like asset mapping, setting local improvement goals, and participating in shared professional learning, the statewide system begins to learn as a whole rather than as 58 separate parts. In this way, these communities of educators are building institutional memory and collective capacity—so that knowledge does not disappear when individuals leave their positions within one county or region. For California, a state with extraordinary diversity in geography, demographics, and resources, this kind of sustained, relationship-centered professional learning infrastructure is not simply valuable. It is the architecture through which equitable outcomes for students become possible.

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Appendix A. Research on the Features of Effective Communities of Practice

Table A1. Effective CoP Features and Key Sources

Effective CoP feature	What the research says	Key sources
Job relevance and Impact on practice	Activities must connect directly to members' actual work. CoPs fail when topics lack relevance to daily concerns. Job impact is the strongest predictor of perceived effectiveness.	Dube et al., 2006; Gongla & Rizzuto, 2001; Hemmasi & Csanda, 2009; Wenger-Trayner et al., 2023
Member connectedness and shared identity	Members' sense of belonging, emotional connection, and shared identity with peers predicts both effectiveness and satisfaction. CoPs should foster relationship building.	Hemmasi & Csanda, 2009; Li et al., 2009; Wenger, 1998; Wenger-Trayner et al., 2023
Knowledge sharing and collaborative knowledge creation	Effective CoPs create structures for members to both share existing knowledge and develop new knowledge together. This includes sharing stories, tools, and strategies.	Brown & Duguid, 1991; Li et al., 2009; Wenger et al., 2002; Wenger-Trayner et al., 2023
Strong, multidimensional leadership	Leaders must define goals, motivate members, provide resources, and facilitate interaction. Leadership quality directly predicts both job impact and perceived effectiveness.	Hemmasi & Csanda, 2009; Wenger et al., 2002; Li et al., 2009; Wenger-Trayner et al., 2023
Member commitment and active engagement	Committed members who actively participate in community activities improve the direct impact of the CoP on their job performance.	Hemmasi & Csanda, 2009; Wenger, 1998; Wenger-Trayner et al., 2023

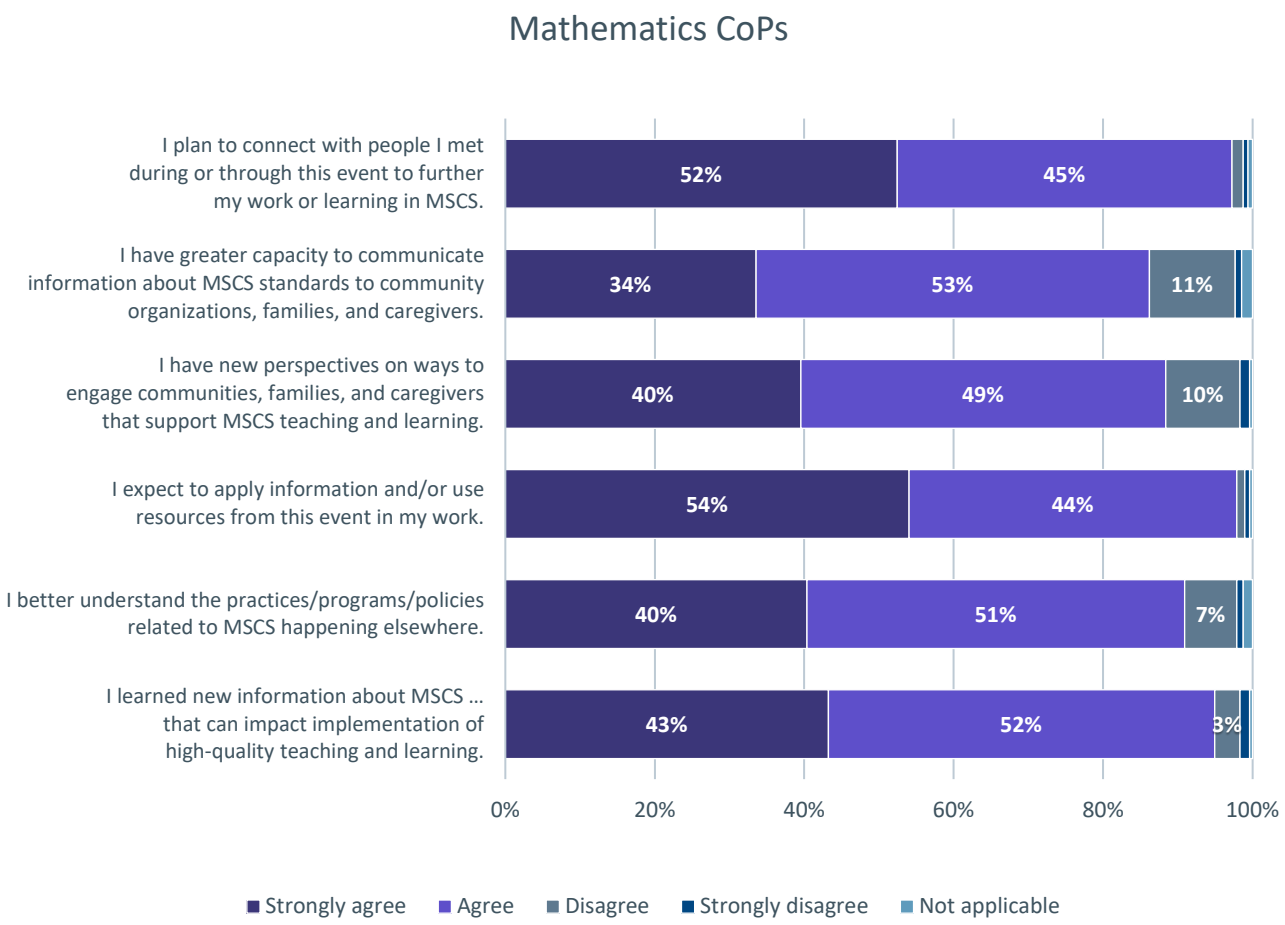
Effective CoP feature	What the research says	Key sources
Differentiated participation structures	Effective CoPs support multiple trajectories of participation, from peripheral to core. Novices and experts benefit from different modes of engagement.	Lave & Wenger, 1991; Wenger, 1998; Wenger-Trayner et al., 2023
Iterative refinement and responsiveness	CoPs evolve through life stages. Successful communities adapt their structures based on member feedback and changing needs.	Gongla & Rizzuto, 2001; Wenger et al., 2002; Wenger-Trayner et al., 2023

Appendix B. Survey Items and Results for Each Community of Practice

Based on the information and support received through your participation in this event, please rate the extent to which you agree or disagree with the following statements. [Scale: Strongly disagree, disagree, agree, strongly agree, not applicable to this event/session]

1. I learned new information about math, science, and/or computer science or related ideas that can impact implementation of high-quality teaching and learning.
2. I have a better understanding of the practices/programs/policies related to math, science, and/or computer science that are happening elsewhere (outside of my organization or school).
3. I expect to apply information and/or use resources from this event in my work.
4. I have new perspectives on ways to engage communities, families, and caregivers that support math, science, and/or computer science teaching and learning.
5. I have greater capacity to communicate information about the math, science, and/or computer science standards for students to community organizations, families, and caregivers.
6. I plan to connect with people I met during or through this event to further my work or learning in math, science, and/ or computer science.

Figure B1. Survey Results for Mathematics CoP Participants

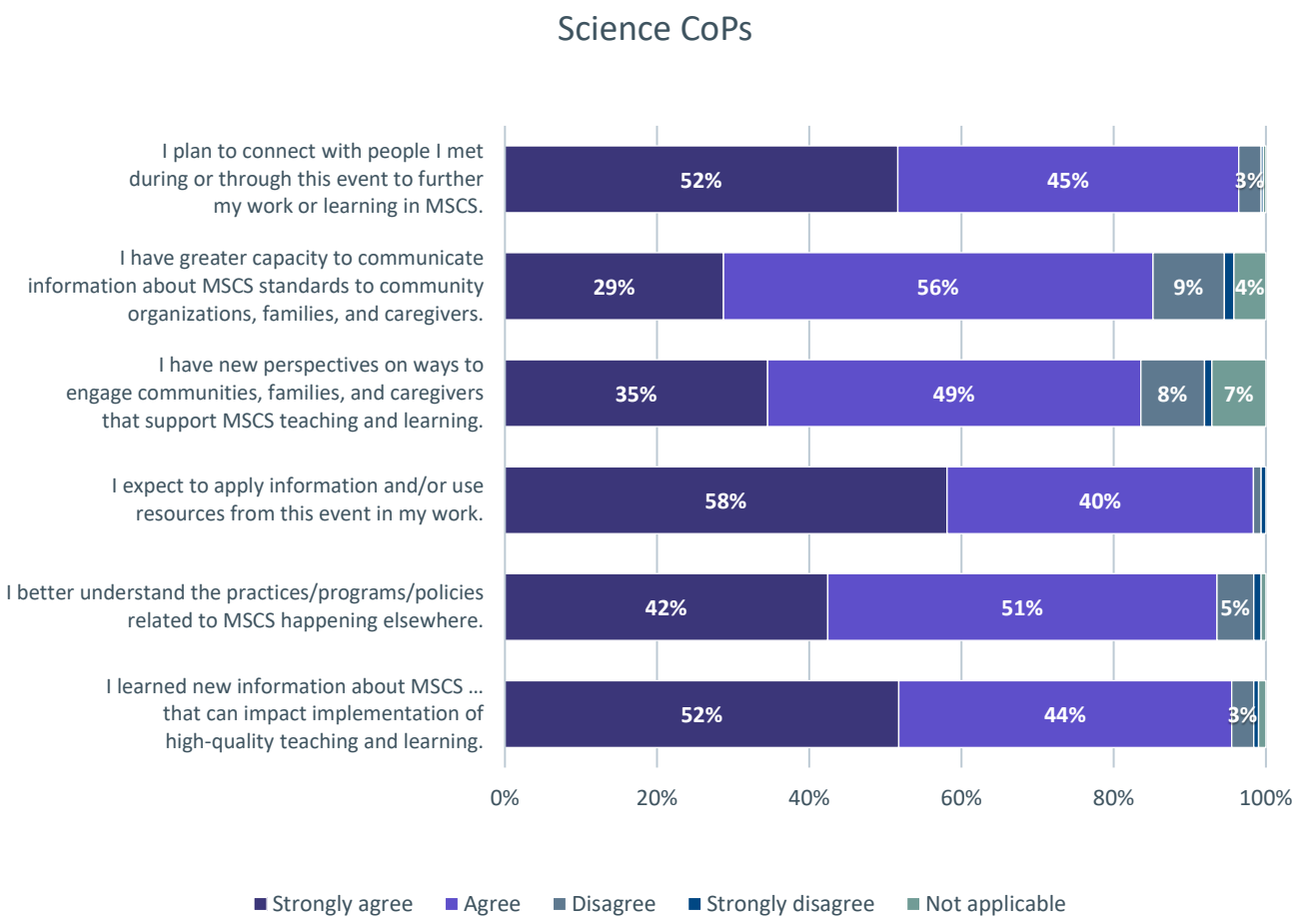


Note. Questions were shortened and data labels for percentages 2% or less were removed for clarity of presentation.

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I plan to connect with people I met during or through this event to further my work or learning in MSCS.	52%	45%	1%	1%	1%
I have greater capacity to communicate information about MSCS standards to community organizations, families, and caregivers.	34%	53%	11%	1%	1%

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I have new perspectives on ways to engage communities, families, and caregivers that support MSCS teaching and learning.	40%	49%	10%	1%	0%
I expect to apply information and/or use resources from this event in my work.	54%	44%	1%	1%	0%
I better understand the practices/programs/policies related to MSCS happening elsewhere.	40%	51%	7%	1%	1%
I learned new information about MSCS ... that can impact implementation of high-quality teaching and learning.	43%	52%	3%	1%	0%

Figure B2. Survey Results for Science CoP Participants

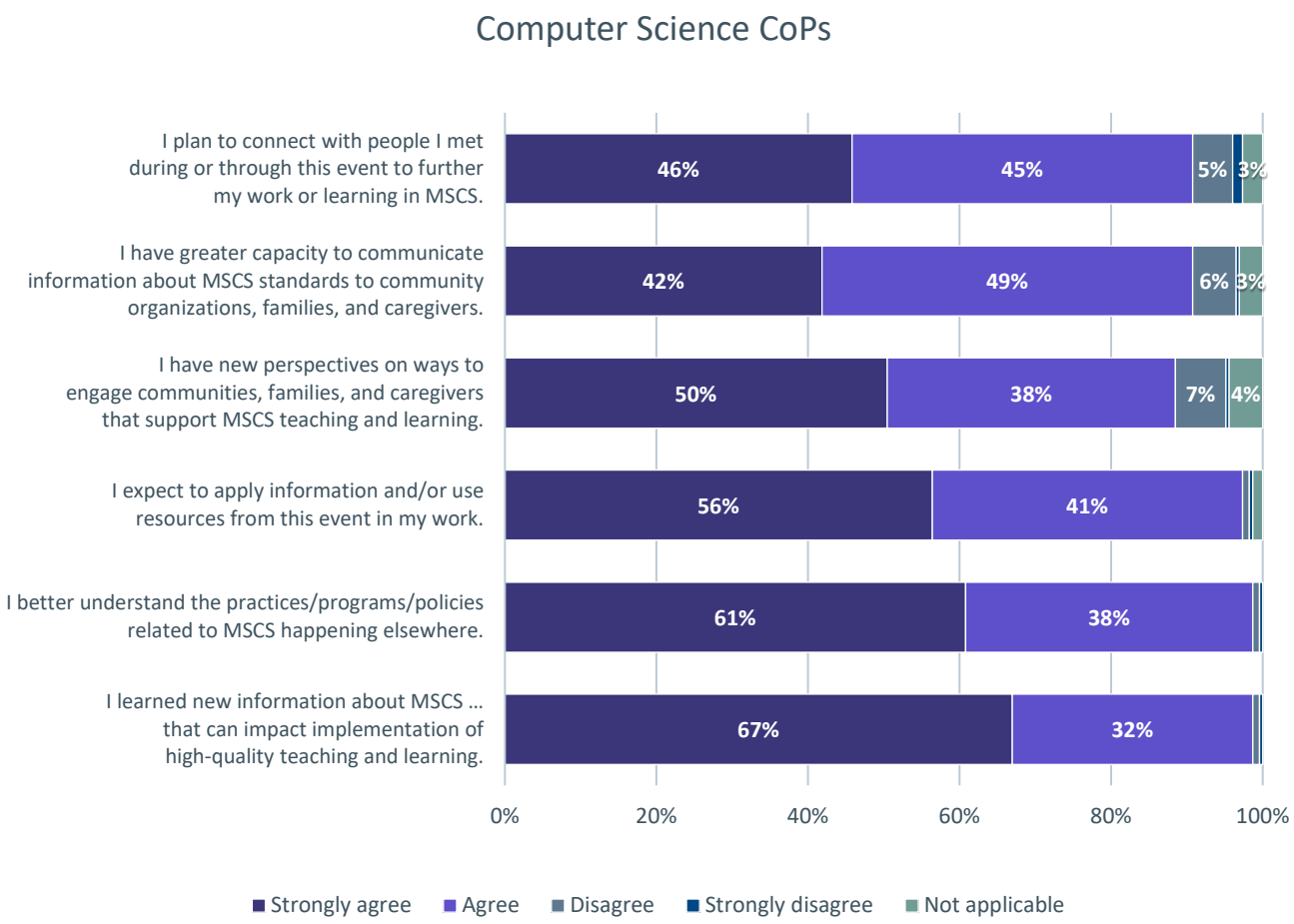


Note. Questions were shortened and data labels for percentages 2% or less were removed for clarity of presentation.

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I plan to connect with people I met during or through this event to further my work or learning in MSCS.	52%	45%	3%	0%	0%
I have greater capacity to communicate information about MSCS standards to community organizations, families, and caregivers.	29%	56%	9%	1%	4%

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I have new perspectives on ways to engage communities, families, and caregivers that support MSCS teaching and learning.	35%	49%	8%	1%	7%
I expect to apply information and/or use resources from this event in my work.	58%	40%	1%	1%	0%
I better understand the practices/programs/policies related to MSCS happening elsewhere.	42%	51%	5%	1%	1%
I learned new information about MSCS ... that can impact implementation of high-quality teaching and learning.	52%	44%	3%	1%	1%

Figure B3. Survey Results for Computer Science CoP Participants



Note. Questions were shortened and data labels for percentages 2% or less were removed for clarity of presentation.

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I plan to connect with people I met during or through this event to further my work or learning in MSCS.	46%	45%	5%	1%	3%
I have greater capacity to communicate information about MSCS standards to community organizations, families, and caregivers.	42%	49%	6%	0%	3%

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree	Not Applicable
I have new perspectives on ways to engage communities, families, and caregivers that support MSCS teaching and learning.	50%	38%	7%	0%	4%
I expect to apply information and/or use resources from this event in my work.	56%	41%	1%	0%	1%
I better understand the practices/programs/policies related to MSCS happening elsewhere.	61%	38%	1%	0%	0%
I learned new information about MSCS ... that can impact implementation of high-quality teaching and learning.	67%	32%	1%	0%	0%


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