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California Statewide Early Math Initiative in Local Communities: Building Educator Math Capacity

Case Study Report

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The California Statewide Early Math Initiative is funded by the California Department of Education, Early Learning and Care Division and the California State Board of Education. The Fresno County Superintendent of Schools collaborates with the AIMS Center for Math and Science Education, the California State Board of Education, the California Early Math Project, and Les Mayfield III (feature film director) to implement the Initiative. WestEd serves as the independent evaluator of the Initiative.

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Executive Summary

This report summarizes the findings across two case studies conducted as part of WestEd's evaluation of the California Statewide Early Math Initiative (CAEMI). The case studies aimed to understand the planning and implementation of professional learning and coaching in local communities. They also examined changes in educators' math knowledge, confidence, and teaching practices.

The case studies utilized qualitative and quantitative methods, such as interviews, observations, and surveys, to address the following evaluation questions:

1. How do agency facilitators engage educators in professional learning and coaching in their local communities?
2. To what extent do the facilitators build educators' math content knowledge, confidence in supporting children's early math, and math teaching practices?

Of the thirty agencies participating in the CAEMI, WestEd purposefully selected two agencies to study local implementation. Two county offices of education agreed to participate in the case studies. In Case Study 1, three agency facilitators focused on spatial reasoning in professional learning and coaching offered to 14 early childhood education (ECE) teachers, nine elementary teachers, and 27 family child care (FCC) providers. In Case Study 2, four agency facilitators addressed coding and robotics, number sense, measurement, geometry, and mathematical reasoning in the professional learning and coaching they offered to 28 preschool teachers.

The two case studies shared the overall goal of building educator capacity in early math, but their implementation plans were very different in terms of content, structure, and participants. The following list reflects the key takeaways across the two case studies. Specific examples are included in each of the case study detailed descriptions and the conclusion.

- Planning and Implementation of Professional Learning and Coaching
  - The flexibility of the CAEMI grant allowed for variation in agency implementation plans, which was beneficial to tailoring supports for local communities.
  - The agencies integrated CAEMI content, hands-on activities, and resources into their local implementation.
  - The agencies provided diverse groups of educators, such as early childhood teachers, family child care providers, and elementary teachers, with access to early math professional learning.
  - The agency facilitators used a range of strategies to respond to educators' needs, concerns, and levels of experience.
- Impact on Educators
  - Educators reported significant increases in their math content knowledge, confidence in supporting children's early math, and frequency of math teaching practices from the beginning to the end of the initiative.
  - Educators increased their awareness that math was all around them.
  - All educators rated the professional learning and coaching as very valuable.

Introduction

To support the early math outcomes for California's children, the Fresno County Superintendent of Schools partners with the AIMS Center for Math and Science Education (AIMS), the California State Board of Education, the California Early Math Project, and Les Mayfield III (feature film director) to:

- Promote young children's math outcomes
- Raise educators' and families' awareness of the importance of early math
- Build positive math identities for adults who care for and teach young children
- Build confidence and capacity of educators and families to support children's early math

This report summarizes the findings across two case studies conducted as part of WestEd's evaluation of the California Statewide Early Math Initiative (CAEMI). The case studies aimed to understand the planning and implementation of professional learning and coaching in local communities. They also examined changes in educators' math content knowledge, confidence in supporting children's early math, and math teaching practices. Given the diversity of agencies participating in the CAEMI and the flexibility in the grant requirements, case studies offered an appropriate methodology to gather rich, in-depth information on local implementation.

To kick off the yearlong initiative, the facilitators from each participating agency attended a weeklong summer institute designed to develop their knowledge of early math and build their capacity to support professional learning and coaching. Throughout the initiative, the facilitators participated in monthly coaching sessions with their CAEMI coaches, in which they brainstormed ideas, reflected on their implementation, and acknowledged successes. The facilitators also attended four virtual community-of-practice sessions, which included opportunities for them to further develop expertise in early math and to share highlights from their implementation plans. At the end of the year, the facilitators participated in a virtual closeout CAEMI institute, in which all agencies presented posters summarizing their early math professional learning and coaching activities within the agencies' local communities.

Evaluation Questions and Methods

The case studies focused on the following evaluation questions:

1. How do agency facilitators engage educators in professional learning and coaching in their local communities?
2. To what extent do the facilitators build educators' math content knowledge, confidence in supporting children's early math, and math teaching practices?

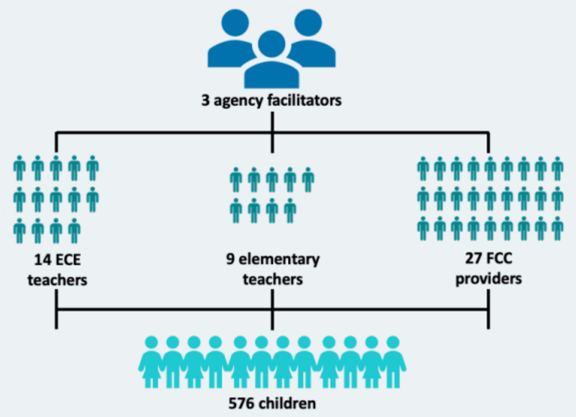
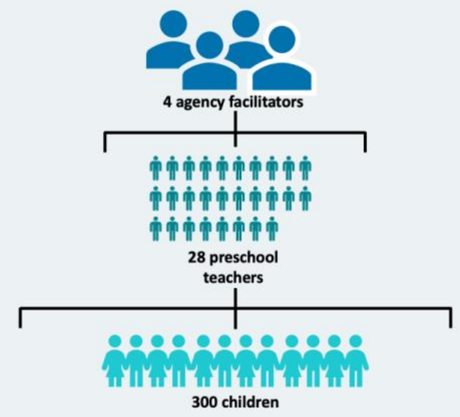
To answer these questions, the evaluation team gathered data through the following qualitative and quantitative methods:

- Observations of coaching sessions between agency facilitators and CAEMI coaches
- Semi-structured interviews with facilitators
- Document review of professional learning materials
- Observations of professional learning sessions for educators
- Educator interviews
- Surveys of educators' math content knowledge, confidence in supporting children's early math, and math teaching practices before and after the professional learning and coaching

Overview of Case Study Agencies

Of the thirty agencies participating in the CAEMI, two agencies were purposefully selected in order to study local implementation. The criteria for selecting agencies for the case study considered geography within the state, agency type, ages of children served by the agency, and diversity of roles of the agency facilitators. WestEd invited four agencies to participate: two county offices of education, one unified school district, and one nonprofit. The school district was unable to participate due to research restrictions in the district, and the nonprofit was unable to participate due to wildfires in its local community. The two county offices of education, from different parts of California, agreed to participate. Case Study 1 took place in a large urban county, and the team focused primarily on spatial reasoning. Case Study 2 took place in a small rural county, and their team introduced coding and other math areas. Exhibit 1 provides an overview of each agency's implementation plans.

Exhibit 1. Overview of Implementation Plans

Case Study 1: Spatial Reasoning for All	Case Study 2: Coding and Beyond
Participants: 	**Participants:** 
Ages of children served: Birth–8 years	**Ages of children served:** 3–5 years
Math content: Spatial reasoning, with connections to other math areas	**Math content:** Coding and robotics, number sense, measurement, geometry, mathematical reasoning
Duration: October 2019–June 2020	**Duration:** January 2020–May 2020
Professional learning sessions: ECE teachers and FCC providers attended one 3-hour in-person session. Elementary teachers attended two 3-hour in-person sessions.	**Professional learning sessions:** All teachers attended two 3-hour in-person sessions and two 1.5-hour virtual sessions.
Coaching approach: All educators participated in group coaching, and some engaged in individual emails, phone calls, and/or observations.	**Coaching approach:** All teachers participated in individual or group coaching. Some also engaged in observations or classroom visits.

Case Study 1: Spatial Reasoning for All

Educators Engaged

Three agency facilitators from the county office of education participated in the CAEMI: two early childhood program specialists (referred to in this report as "early childhood facilitators") and one elementary math coordinator (referred to in this report as the "elementary facilitator").

Educator and School Demographics

With support from their leadership, the facilitators identified a local elementary school with an early childhood program serving the full birth-through-eight continuum. The school serves 10% English language learners and 38% free/reduced-price lunch students,[1] and performs highly on standardized tests.[2]

From this school, the early childhood facilitators recruited 14 ECE teachers, engaging both lead teachers and instructional assistants. Two of the teachers worked in infant and toddler classrooms, while the rest taught preschool. One of the early childhood classrooms offers state-funded preschool serving income-eligible families, while the other classrooms offer fee-based care. The early childhood classrooms use the *Building Blocks* math curriculum.

The elementary facilitator recruited nine elementary teachers. The teachers represented all grade levels from transitional kindergarten through grade 3, including a special education teacher. On occasion, a district-level teacher on special assignment (TOSA) would also participate in the professional learning. The elementary classrooms use the *Math Expressions* curriculum.

In addition to recruiting the ECE and elementary teachers, the early childhood facilitators recruited 27 FCC providers from a local FCC network. Because the FCC network was planning to focus on literacy for the year, the facilitators promised to deliver two literacy trainings in addition to the math professional learning and coaching.

[1] Source: Ed-Data. Retrieved from http://www.ed-data.org

[2] Source: California School Dashboard. Retrieved from https://www.caschooldashboard.org/

The educators were mostly women. Of the educators who completed the survey (n= 38):

- Half (50%) of the ECE teachers identified as White; the others identified as Asian (25%), Latinx (8%), Native Hawaiian (8%), or more than one race (8%). All of the ECE teachers were fluent in English.
- All (100%) of the elementary teachers identified as White and were fluent in English.
- FCC providers were predominantly Latinx (83%), with others identifying as White (11%) or Black (6%). More than half (56%) were fluent in Spanish only; 33% were fluent in both English and Spanish, and 11% were fluent in English only.

Educator Professional Backgrounds

Educators across all three program types were highly experienced. Of the educators who completed the survey (n= 38), about 76% had more than eight years of experience. Prevalence of California child development permits or credentials varied by program type:

- 83% of the ECE teachers had a California Child Development Permit. Lead teachers had higher levels of permits than instructional assistants.
- 100% of the elementary teachers had a California Teaching Credential.
- 28% of the FCC providers had a California Child Development Permit, and 28% of the providers were working toward this permit.

Planning and Implementing Professional Learning and Coaching

Why Spatial Reasoning?

The agency facilitators decided to focus their professional learning and coaching on the math area of spatial reasoning. They wanted to choose a math area that would be suitable for educators working with children from birth through eight years, and they anticipated that spatial reasoning would have an impact on educators because it was not a primary focus of the curricula used in the ECE and elementary classrooms.

The facilitators identified several goals for the professional learning and coaching. By the end of the initiative, they hoped that educators would:

1. Understand the importance of spatial reasoning as it relates to children's success in school.
2. Be more aware of opportunities to support children's spatial reasoning.
3. Understand the California Foundations and Frameworks related to spatial reasoning, as well as how spatial reasoning connects to other math foundations and standards.
4. Support children's spatial reasoning through spatial language and interactions during everyday routines, play, and activities.

Professional Learning Approach

The agency facilitators recognized the importance of building relationships with educators, providing a theoretical background on spatial learning, and sharing a variety of resources that educators could use in their classrooms or programs to achieve the identified goals.

Building Relationships

Establishing trust was a critical first step, especially because the facilitators had never worked with the participating educators. The facilitators took time to get to know the educators during the professional learning and coaching sessions through icebreakers, informal conversations, and reflective discussions.

The facilitators used a variety of strategies to create professional learning and coaching that was responsive to the educators' strengths and needs. For example, the early childhood facilitators invited the ECE teachers to each write a specific goal that they wanted to accomplish in their classrooms. They also observed each classroom, and the facilitators provided a thank-you note to the teachers which included some strength-based feedback. In addition, the elementary facilitator invited participants to share feedback after the first professional learning session. In their feedback, teachers requested more activities that they could implement. In response to their feedback, during the next professional learning sessions, the facilitator integrated specific resources and activities they could use in their classrooms. Finally, the facilitators offered the FCC providers professional learning and coaching in English and Spanish, including access to resources, such as the California Foundations and Frameworks, in Spanish.

> *"[The facilitators] are truly wanting to connect on a personal level to understand everyone's background to meet [our] needs. They build on our strengths and . . . help in areas that we need help with. They are there every step of the way in making goals and breaking them into manageable pieces . . . they never make anyone feel inadequate. They ask, 'Can you help me understand how I can better support your needs? Tell me more how you want to do this.' They would make us think, 'We got this!' even though we might not feel we are math people. They have a lot of passion, and it's a domino effect. They are really listening and meet our needs, and so then we can meet the needs of students."*
>
> — FCC provider, interview response

The facilitators also valued the amount of time that the educators were investing in this initiative. To respect the educators' time, the facilitators provided food and started and ended the professional learning sessions on time. They also provided the educators with a stipend, resources (e.g., articles, books), and educational materials for their classrooms or programs.

Engaging Adult Learners in Hands-On Math Activities

The professional learning sessions incorporated many hands-on opportunities for adult learners to engage in math experiences. Many of these activities were introduced as part of the CAEMI summer institute or community-of-practice meetings. For example, the ECE teachers and the FCC providers experienced the collaborative building of an icosahedron, and they also took part in the hole-punch visualization activity in which they had to fold a piece of paper, punch a hole, and predict where the hole would be located. In the elementary sessions, the teachers engaged in *Which One Doesn't Belong?*, an open-ended activity in which they identified and provided a rationale for why three out of four shapes belonged together, while the fourth shape did not. They also participated in clothesline math, an activity that invites learners to integrate spatial reasoning with other math concepts as they order cards on a life-size number line. The teachers had opportunities to explore complex math concepts themselves (e.g., how to order and space out fractions, percentages, and whole numbers on a single number line), as well as to explore age-appropriate math concepts for the students they work with (e.g., how to order and space out number or dot cards). These hands-on adult learning experiences allowed teachers to explore and grapple with different math concepts and consider how to use them with their students.

Balancing Theory and Practice

In order for educators to understand the importance of spatial reasoning in children's development, the facilitators introduced educators to important research in this area. For example, each professional learning session for elementary teachers included a slide with five compelling reasons for engaging students in spatial reasoning. The reasons included research findings such as "spatial thinking is an important predictor of achievement of STEM careers" and "spatial reasoning and mathematical thinking are intimately linked." All of the facilitators also shared articles with research findings on spatial reasoning with the educators through the Padlet platform. The educators expressed how much they appreciated learning about the "why" of engaging children in spatial reasoning because it helped them become more intentional in their interactions with children and facilitated buy-in from others in their communities, such as from the school principal or from other instructional assistants who were not participating in the initiative.

In addition to providing a theoretical background for spatial reasoning, the facilitators shared several activities that educators could use with children. For example, early childhood facilitators recommended specific books, manipulatives, vocabulary, and embodied cognition activities that could be used to support spatial concepts. The elementary facilitator introduced spatial reasoning activities, such as *Which One Doesn't Belong?*, shape puzzles, skyscraper puzzles, and clothesline math.

Beyond specific activities, the facilitators used the Padlet platform to share several resources to inform teaching practices, such as PowerPoint presentations, photos, and articles. For example, the elementary facilitator introduced the elementary teachers to the "Questions to Support Engagement in the Standards for Mathematical Practice" from the *California Mathematics Framework*. Educators appreciated receiving these resources and rated receiving resources as one of the more valuable components of the initiative.

Finally, the educators were able to choose new spatial reasoning materials for their classrooms or programs, and the facilitators purchased the materials for them. For example, ECE teachers and FCC providers chose wood puzzles, shape sorters, sorting rings, magnetic blocks, rhythm sticks, and CDs with songs for music and movement.

Overall, the facilitators strove to balance providing educators with relevant theory and research on spatial reasoning and providing them with specific activities and materials that they could integrate into their environments and curricula.

Coaching Approach

The agency facilitators conducted coaching in small groups, primarily due to time and scheduling constraints. The group coaching was offered in person, but some of the coaching for FCC providers was offered individually, over the phone or over email. In addition, the early childhood facilitators conducted observations in the early childhood classrooms, and the elementary facilitator offered demo lessons or observations to the elementary teachers.

Structure and Challenges of Group Coaching

At the outset, the early childhood facilitators grouped the ECE teachers by their roles of lead teacher or instructional assistant. They decided on these groups based on teacher availability (i.e., instructional assistants were available in the morning for coaching, and lead teachers were available for coaching after school). Later on, as part of their own lessons learned, the early childhood facilitators shared that they would consider grouping lead teachers and instructional assistants from the same classroom together, rather than by role. The elementary facilitator allowed the elementary teachers to first self-select into an action research group or an article study group for their professional learning, and then transitioned them to whole-group coaching.

The facilitators reflected on how to provide individualized feedback to participants within the structure of group coaching. At times, they found offering individual feedback to the participants challenging because they did not observe the participants systematically to gain firsthand knowledge of classroom implementation. In their reflections, the facilitators discussed how they would build opportunities for observations into any similar initiative in the future. This lesson learned aligns with educators' feedback that they would have liked more in-class observations with opportunities for individualized feedback throughout the initiative.

Adapting Implementation Due to COVID-19

When schools closed at the onset of the COVID-19 pandemic, the early childhood facilitators had been planning to conduct a few more coaching conversations, and the elementary facilitator had been planning to conduct one additional professional learning session and two additional coaching sessions. The facilitators were able to adapt their plans by making use of Zoom meetings with each group of educators. Educators were able to share examples of their progress and successes through the virtual platform.

Educator Perceptions of the Professional Learning and Coaching

Educators were asked to rate the value of various components of the professional learning and coaching, such as group coaching sessions, observations, math resources, hands-on experience, and discussions about the importance of spatial reasoning.

On average, educators rated the various components of the professional learning and coaching as *very* to *extremely valuable*. The highest-rated components were the three-hour professional learning sessions, in-person coaching, and resources available on the Padlet platform. Educators who received observations or demo lessons rated them as *extremely valuable*.

Educators reported that they learned a lot from the facilitators, and many expressed that they felt much more confident in integrating spatial reasoning into the classroom by the end of the initiative. Educators also reported that they appreciated learning about the "why," having ready-to-implement activities and resources, and learning how to build spatial vocabulary into the classroom in an intentional way.

They also suggested a few areas of improvement. Some educators expressed wanting more opportunities for observations and feedback, more resources for infants and toddlers, and content that went deeper into specific math topics.

> *"I am more aware that what I'm doing and saying to the infants really does make a difference in their development. They picked up on everything so much faster than I could have thought."*
>
> — ECE teacher, survey response

Educator Outcomes and Implementation

Educators rated their knowledge of children's math development, their confidence in supporting spatial reasoning, and the frequency of their spatial reasoning teaching practices, both before and after taking part in the initiative. In interviews, educators shared more about their experiences with the professional learning and coaching, as well as what they implemented in their classroom or FCC setting.

Knowledge of Children's Math Development

Educators across the three program types (ECE, elementary, and FCC) rated their knowledge of children's development in several math areas, on a scale of 1 (*not at all knowledgeable)* to 5 (*extremely knowledgeable*). Before the initiative, educators felt least knowledgeable in the area of spatial reasoning. ECE and FCC educators rated themselves as most knowledgeable in classification and patterning, and elementary teachers rated themselves most knowledgeable in both number and operations in base ten and operations and algebraic thinking. When averaging across all math areas, FCC providers rated their knowledge lower before the initiative than the ECE and elementary educators

By the end of the initiative, all educators rated their knowledge higher in all math areas. Because the data were not normally distributed, non-parametric exact sign tests were used to test if the growth was statistically significant. Exact sign tests indicated that educators reported significant growth in all math areas, but generally, the greatest increase was in the area of spatial reasoning, the math area targeted by this agency. This increase is particularly noteworthy given that educators felt least knowledgeable in this math area at the beginning of the initiative. Exhibit 2 shows the change in knowledge of spatial reasoning across participants in the three program types.

Exhibit 2. Change in Knowledge of Spatial Reasoning

Participants	Pre-Survey Median	Post-Survey Median	P-value
ECE Teachers	3	4	<.001
Elementary Teachers	3	4.5	<.01
FCC Providers	2	4	<.001

The data suggests that the professional learning and coaching supported all groups of educators across program types to grow in their knowledge of children's math development. Growth in knowledge across all math areas suggests that the professional learning and coaching raised educators' awareness of math in general, as the facilitators made connections between spatial reasoning and other areas of math.

Confidence in Supporting Children's Spatial Learning

In addition to the growth in educators' knowledge of children's math development, educators reported significant growth in their confidence over the course of the initiative. Educators rated their confidence in supporting children's spatial learning on a scale of 1 (*not at all confident*) to 5 (*extremely confident)* at the beginning and end of the initative. At the start of the initiative, most of the educators felt only *slightly confident* in supporting children's spatial learning. By the end of the initiative, they reported feeling *very confident*. Exact sign tests indicated significant growth in their confidence from the beginning to the end of the initiative. The medians were identical for each program type (Before: Mdn = 2.00, After: Mdn = 4.00).

When asked to explain why they felt more confident in supporting children's spatial learning, educators explained that they had become more aware of the different ways in which spatial learning could be incorporated into children's daily lives and how important this was for children's development.

> *"Spatial reasoning is all around us. I wasn't aware how much we use it every day in many of our activities. It was interesting to know what questions to ask to get the students more engaged in their own learning and reasoning."*
>
> — Elementary teacher, survey response

This increased confidence, along with increased knowledge of math development and better understanding of the teaching practices to help children develop spatial skills, allowed educators to be more intentional and confident in implementing spatial reasoning activities with children. For example, many educators reported becoming more fluent in using spatial vocabulary throughout the day, during play, everyday routines, and spatial reasoning activities.

Frequency of Spatial Reasoning Teaching Practices

Educators also reported changes in the frequency with which they engaged in spatial reasoning teaching practices after taking part in the initiative. Educators rated the frequency of their use of specific teaching practices on a scale of 1 (*never*) to 4 (*often*) at the beginning and end of the initiative. Before the initiative, educators reported that they *rarely* or *sometimes* engaged in practices that promoted spatial reasoning. However, by the end of the initiative, educators reported that they *sometimes* or *often* engaged in these practices.

For example, ECE teachers went from engaging children in visualizing how their bodies or objects move and fit in space *sometimes* to *often* over the course of the initiative (Mdn: before = 3.00, after = 4.00).

Similarly, over the course of the initiative, FCC providers went from reading children's books that focus on spatial relationships *sometimes* to *often* (Mdn: before = 3.00, after = 4.00). Exact sign tests indicated that the changes in the frequency of practices were significant.

Elementary teachers also increased the frequency with which they engaged in a variety of teaching practices. Most teachers reported using the following teaching practices *rarely* before the initiative (Mdn = 2.00) and *often* after the initiative (Mdn = 4.00): integrating spatial reasoning into lesson plans, using spatial reasoning to make connections across math standards, and asking students to explain their thinking for spatial reasoning problems. Again, exact sign tests indicated that these changes in the frequency of practices for elementary teachers were significant.

Examples of Educator Implementation

ECE Teachers and FCC Providers

Educators reported that, before the initiative, spatial reasoning was not a significant area of focus in their curriculum, *Building Blocks*, or their daily activities. By the end of the initiative, educators reported that they were more aware of and intentional about how to incorporate spatial concepts or vocabulary into existing activities in their daily routines.

Examples of ways in which educators reported becoming more intentional in introducing spatial reasoning in their activities include:

- Using spatial vocabulary when children are engaging in routines, such as setting the table, washing hands, or lining up.
- Creating movements that match the words of a song during music and movement activities.
- Using positional vocabulary as children navigate their bodies through obstacle courses, both indoors and outdoors.
- Introducing children to books that have spatial vocabulary.
- Asking children to make predictions or solve problems related to fitting different-sized objects in different-sized spaces during block-building activities.

Elementary Teachers

Before the initiative, the elementary teachers primarily used lesson plans from their curriculum, *Math Expressions*, which does not have a strong focus on spatial reasoning. By the end of the initiative, the elementary teachers reported implementing a range of spatial reasoning activities into their lesson plans, transitions, or daily routines. The elementary facilitator provided the elementary teachers with some specific activities that they could implement in the classroom with their students. The teachers reported using these activities multiple times per week, both in the context of small-group play and as whole-group activities.

The elementary teachers reported using the following activities:

- Shape puzzles (100%)
- *Which One Doesn't Belong?* (100%)
- Clothesline math (100%)
- "Questions to Develop Mathematical Thinking" from the *California Mathematics Framework* (88%)
- Polyhedrons (88%)
- Block play (75%)
- Skyscraper puzzles (38%)

Educators expressed that they particularly liked activities such as *Which One Doesn't Belong?* or shape puzzles, because these activities are short and can be used as icebreakers, transitions, or brain breaks. For example, educators often used *Which One Doesn't Belong?* as a transition between other activities. Introducing teachers to these short activities was particularly important considering that many elementary educators expressed concerns that spatial reasoning, which was not a part of their curriculum, would take time away from other math concepts that they had to teach.

These activities could also be used flexibly and in different contexts. For example, *Which One Doesn't Belong?* was introduced as a whole-group activity, but was later used during choice time or in small groups after children were more familiar with the activity. Also, educators enjoyed the flexibility of the clothesline math activity because it could be used to support a variety of math areas, such as counting, fractions, or liquid measurement.

Lastly, all of these activities were ready to implement, which teachers found very valuable. The elementary facilitator provided teachers with opportunities to explore these activities during the professional learning sessions, and gave all of them the materials that were necessary to immediately integrate the activities into their classroom. This helped teachers feel more confident about introducing spatial reasoning into the classroom easily and frequently.

Observations of Child Engagement and Learning

Educators reported that children enjoyed engaging in the spatial reasoning activities and showed progress in their spatial reasoning skills across the year. For example, teachers reported children's growth in:

- Understanding and using more spatial vocabulary.
- Building structures that are more complex and using symmetry.
- Learning how to use appropriate language to justify their thinking.
- Gaining body awareness, especially when engaging in dancing during music and movement activities.

In interviews, the elementary teachers also discussed how the spatial reasoning materials and activities provided meaningful entry points for diverse learners. For example, they talked about how children who had no formal schooling experience, or who were not skilled at paper-and-pencil tasks, engaged and excelled in using the spatial learning manipulatives and activities. The elementary facilitator was particularly concerned about some teachers' deficit thinking related to students' abilities, and during the professional learning sessions, conveyed the idea that spatial reasoning is malleable, to support teachers to see the strengths of diverse learners.

> *"We used to think spatial reasoning was one of those things that you are either born with it or not. But it's not that way. We can change our knowledge of spatial reasoning."*
>
> — Elementary teacher, interview response

Case Study 2: Coding and Beyond

Educators Engaged

Four agency facilitators participated in the CAEMI, including the program manager of preschool programs, a preschool site supervisor, an early childhood specialist, and a STEM coordinator.

Teacher and School Demographics

The facilitators included all nine state-funded preschools in the county to participate. Twenty-eight preschool teachers engaged in early math training and coaching sessions.

- 46% of the teachers identified as White, 32% as Latinx, 14% as Asian, 4% as Native Hawaiian or Other Pacific Islander, and 4% as more than one race or ethnicity.
- 93% of the teachers were fluent in English, and the teachers spoke a total of 14 other languages fluently.
- A majority (68%) had eight or more years of experience.
- A majority (82%) held at least one California Child Development permit.
- In the last five years, 39% of the teachers had not attended any training in math, and 68% had not received any coaching in math.

The nine preschools served income-eligible families, with some sites using Head Start funding to provide wraparound, full-day care. The average number of children in each classroom was 24. The classrooms had some flexibility in their curricula. Some teachers used *Creative Curriculum* and others were more Reggio-inspired or focused on STEM learning. All classrooms ensured that their curriculum plans aligned with the California Frameworks and Foundations, and used the Desired Results Developmental Profile (DRDP) to assess children's learning.

Planning for Professional Learning and Coaching

Using Data to Inform Implementation

The agency used a range of data sources to select the math focus for its professional learning and coaching. In the fall, the facilitators conducted observations to understand how math was supported in preschool classrooms across the county. They observed that teachers were routinely engaging children in cardinal and rote counting, patterning, and some measurement. These observations were consistent with how teachers described the math learning in their classrooms prior to the initiative. The facilitators observed how math was already incorporated into some routines and activities, and recognized opportunities to deepen teachers' math knowledge and promote higher-order thinking skills in children.

In addition, facilitators reviewed data from the DRDP and chose math areas that they felt were in need of further support and attention - geometry and mathematical reasoning. The facilitators drew on this knowledge to plan future professional learning sessions and to build teachers' confidence in these math areas. Specifically, the facilitators focused their planning on developing higher-order thinking skills that would develop teachers' knowledge and confidence in mathematical reasoning.

Finally, the evaluators administered a pre-survey to all participating educators, to collect baseline data on teachers' knowledge, confidence, and teaching practices prior to the initiative. The evaluators also collected baseline information related to coding and robots, to understand teachers' knowledge and experience with coding in preschool. The evaluators shared the following findings from the pre-survey data with the facilitators and informed planning of professional learning and coaching:

- Teachers reported being knowledgeable in most math areas (mathematical reasoning, algebra and function, geometry, number sense, measurement) except for coding and robots. Teachers reported being most knowledgeable in number sense and measurement. In contrast, teachers reported having the least knowledge in coding and robotics.
- Teachers began the initiative feeling confident in their abilities to support children in early math.
- When asked how they engaged children in early math, teachers reported using activities related to number sense most often, and reported using activities that included aspects of mathematical reasoning least often.
- Some teachers mentioned their excitement about learning and seeing how children engage in coding. Others were more concerned about incorporating coding into the classroom.

Teachers' concerns with coding were related to introducing technology to young children. As a result of this finding, the facilitators aimed to alleviate some of these concerns through observations of coding and informal classroom visits.

"Preschoolers already use technology so much at home. I like to focus my short time with them each day on social skills, communication skills, etc."

— Teacher, pre-survey response

Why Coding in Preschool?

The facilitators found coding and robots of particular interest at the CAEMI Summer Institute 2019 and decided to incorporate coding into their implementation plan. Given some teachers' concerns about the use of coding in their classrooms, the facilitators were intentional in addressing how coding is used and how it could enhance their practice. In the first professional learning session, the facilitators shared why they chose coding for the initiative and how it offered children learning experiences in all domains, including language, literacy, and social-emotional development. The facilitators also saw coding as an opportunity for teachers to integrate communication and problem solving, in addition to math concepts and skills, into their daily routines. Incorporating coding into their implementation plans also allowed teachers to highlight spatial vocabulary (e.g., "left, right, up, down") while children were manipulating robots or other objects.

In addition, the facilitators sought to show the full progression of coding and robots and how teachers may already be integrating some of the foundational coding skills into their daily routines. For example, sequencing or patterning activities provide the foundation for coding. Using directional or positional language during everyday routines reflects an important aspect of coding. Based on these skills and concepts, children can learn and benefit from using robots to apply coding skills that are more advanced.

Piloting Activities Before Implementation

The agency purposefully piloted coding and robot activities with children prior to sharing them with teachers. The facilitators wanted to ensure that the materials were developmentally appropriate and feasible for preschool classrooms, in order to support teacher buy-in. One of the facilitators was also a classroom teacher. He used the coding materials and robots with children in his classroom and identified what worked well, such as introducing materials in a way that reflects children's developmental progressions. He also recognized what could be improved—for example, that cards should be laminated for young children. Utilizing the activities early on also allowed him to think through various activities and strategies that teachers could use in their classrooms.

Implementing Professional Learning and Coaching

Guiding Principles

The facilitators brainstormed themes that they wanted to infuse throughout their professional learning and coaching. These themes were:

- **Math in all areas of the classroom:** Facilitators aimed to infuse math learning in various activities and routines, not only in one math center.
- **Valuing children's math knowledge:** Facilitators and teachers valued children's math knowledge through professional noticing and through the questions that teachers posed to children during interactions. For example, facilitators would ask, "What does the child

already know?" They would also encourage teachers to ask children what they noticed before beginning an activity.

- **Providing teachers with skills, prompts, and strategies to promote math learning:** During professional learning sessions, facilitators modeled strategies such as facilitative questioning for teachers to understand children's thinking.

Professional Learning Goals

Informed by the various data sources, the facilitators selected different goals for each professional learning session that were related to the math area that they would cover. Sample goals in each math area included:

- **Number sense:** Expand knowledge and ability to offer counting opportunities, such as subitizing, part-part-whole, and estimation and comparison of quantities.
- **Geometry:** Explore geometry concepts beyond identifying simple shapes and positions (e.g., discussing attributes of shapes).
- **Coding and robots:** Understand how coding and robots support children's learning and development in all domains.

The goals reflect the facilitators' approach in developing higher-order thinking skills throughout the initiative and across all math areas. In addition, the goals show the facilitators' intentions to develop teachers' capacity through expanding their knowledge and exploring teaching practices and tools. In observing professional learning sessions and completing document reviews of the materials, it was apparent that the facilitators developed the goals with both teachers' and children's learning in mind.

Professional Learning Components

The facilitators planned four professional learning sessions. Two sessions were conducted in-person and two sessions were delivered online due to COVID-19-related school closures. All professional learning sessions, whether in-person or online, included the following four components:

- **Mini-lectures to provide content on math areas:** Facilitators provided brief lectures to introduce concepts, such as subitizing or using spatial vocabulary to describe objects in space.
- **Hands-on activities:** Hands-on activities during the sessions included exploring coding materials and robots, an online "I Spy" shape game, and an online scavenger hunt.
- **Discussions of how materials can be used:** Facilitators engaged teachers in conversations about how to use materials with children and families, such as how to use children's books for math learning and how to engage families in their children's math learning.
- **Homework or opportunities for practice:** Homework allowed teachers to try the activities in their classrooms and discuss how the activities went with their colleagues in professional learning or coaching sessions. The agency also supported team time for teachers' planning and reflection during professional learning sessions.

These four components were similar in structure to the sessions offered at the CAEMI Summer Institute in 2019. To build the teachers' capacity to notice and reflect on children's understanding of math concepts, the sessions also introduced professional noticing. Facilitators encouraged teachers to recognize not only whether children have reached the correct answer or an incorrect answer, but how children think through concepts. The facilitators used questions to prompt teachers to engage in discussion around their understandings of children's math learning and how to help children move forward with their learning.

The following vignette from the first professional learning session highlights how the facilitators implemented the key components.

Introducing Coding and Robots to Teachers

After one facilitator did a deep dive into number sense, another facilitator transitioned to a new area for most of the participants in the room, coding in preschool classrooms. He introduced the participants to coding by sharing how important this area of learning is in building communication and higher-order thinking skills. Then he offered participants the opportunity to explore a range of coding materials. Participants began by playing with coding penguins, which are small penguins with directional arrows on them that can be used to solve mazes. After the participants played with the penguins, the facilitator asked them how they thought this activity supported the desired results for children in different domains. They discussed how the activity could support children in understanding arrows as directional symbols, learning spatial vocabulary, using fine motor skills to manipulate the penguins, and working collaboratively to solve mazes. The facilitator then shared photos and examples of how he used the penguins with children in his classroom (e.g., he attached magnets to them to use them on a whiteboard as a whole-group activity during circle time).

Next, the participants explored "Robot Races," which features a large mat on the ground and arrows to create different paths. Participants could move their bodies according to the arrows, and their colleagues used language to help navigate them through the path. Finally, the participants had an opportunity to explore two different robots: the Sphero and the Matatalab. The Sphero is operated by using a phone as a remote control to move the robot in desired directions, and the Matatalab has tiles that program the robot to move. Participants first played with and explored robots, and then discussed the relevant desired outcomes for children; the facilitator then shared additional examples of how the materials could be used with children. A few participants expressed concern about the developmental appropriateness of the robots, particularly for the younger children in their classrooms. The facilitator acknowledged that some of the activities may be more appropriate for older children, but he shared a range of examples with entry points for younger children as well. At the end, participants were invited to try using one of these materials with children in their classroom and report back in the next coaching session on how the children engaged in coding.

This vignette demonstrates how the facilitator opened with a mini-lecture on the importance of coding, and then offered participants several opportunities to engage in hands-on experiences to explore the range of materials. The participants discussed how the materials could be used with preschool children to support their development in the areas of the DRDP. Finally, the facilitator invited them to practice using the materials before the next coaching session.

Coaching Approach

The facilitators approached coaching as an extension of their professional learning sessions. Approximately 20 teachers received coaching. The facilitators split coaching support by school site, and each coach had a slightly different approach, according to their coaching styles. For example, one coach split teachers into two smaller groups and provided opportunities for teachers to discuss challenges and successes, while another coach provided support through observations and informal questions and conversations.

Ways in which coaches provided support included:

- **Group coaching:** Some facilitators split their teachers into smaller groups within their sites. Topics of discussion were informed by the teachers' needs, questions, and interests.
- **Informal classroom visits:** The facilitators visited classrooms to observe how teachers and children were engaged in math learning. Facilitators provided encouragement and offered support where needed.
- **Observation of coding implementation:** Site supervisors observed the facilitator teaching to see an example of how children engaged with coding materials. Teachers asked questions and observed the facilitator's teacher-child interactions and math learning.
- **Individual support by phone:** When facilitators were not in classrooms, they were available by phone for informal texts and to answer questions. Teachers were eager to share the activities they were using in the classroom with the facilitators.

Although there were differences in approach, all coaches supported teachers in integrating math throughout their classrooms, supported the use of early math materials and activities, and answered questions from teachers.

Adapting After COVID-19 School Closures

After schools closed due to COVID-19, the facilitators shifted their implementation and offered professional learning sessions and coaching online. The last of three professional learning sessions was initially planned as a three-hour in-person session. When it was adapted to a virtual format, it was divided into two 1.5-hour Zoom sessions. In these sessions, teachers were able to use different online platforms, such as Seesaw, to engage in math learning. Participants discussed math learning experiences in both online preschool and at-home learning with families. Additional online coaching was provided to some teachers to support the transition to math learning at home.

In addition to providing online professional learning sessions and coaching, the facilitators arranged for all families in the county to receive a family math kit, which included loose parts and open-ended materials for children to play with and explore. Although teachers mentioned that they wanted children to freely explore the kits without much instruction, teachers provided parents with some tools to enhance children's experiences with the materials. For example, some of the teachers developed a series of videos to provide families with ideas on how to use the materials. In response, families sent the teachers photos and videos of their children engaging with the materials, demonstrating their children's engagement with and enjoyment of the materials.

Teachers' Perceptions of Professional Learning and Coaching

At the end of their participation, teachers were asked to rate the value of various components of the professional learning and coaching, such as math resources, coaching support, and classroom observations. Teachers rated all items on a scale of 1 (*not at all valuable*) to 5 (*extremely valuable*). All of the professional learning and coaching components were rated very highly, with average ratings for all components ranging from very valuable to extremely valuable. On average, math resources and trying out the activities with children or the "homework" were rated the highest, followed by in-person training and receiving coaching support.

In an open-ended question, they also expressed a few areas for improvements in the professional learning and coaching, such as:

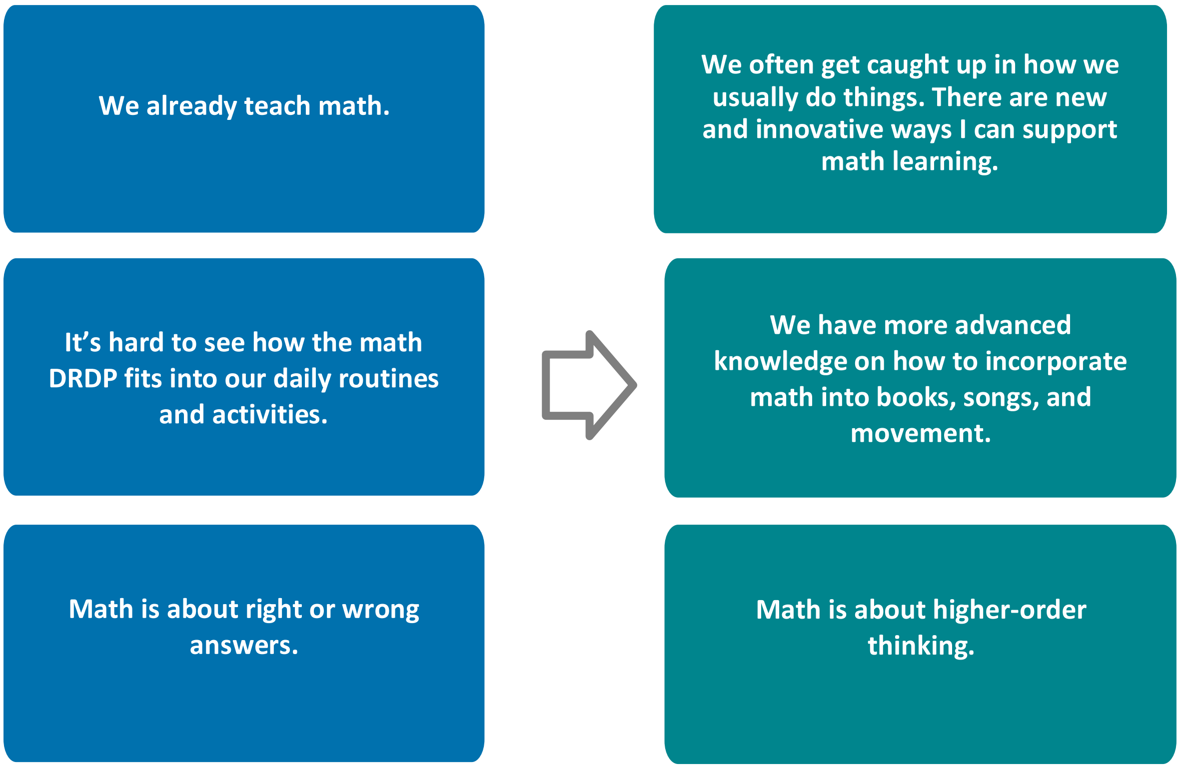
- Including more activities for younger children.
- Providing more time to explore materials during the professional learning sessions.
- Involving parents in at-home math learning.

Educator Outcomes and Implementation

A Shift in Teachers' Math Mindsets

In interviews, the facilitators talked about their efforts to support teachers' math mindsets. They said they wanted teachers to see how math language and concepts can be incorporated into all areas of the classroom, not only in one math area. Early in the process, teachers had their own teaching practices in place; some were hesitant to implement new coding activities, while others thought they already knew how to teach math. After professional learning and coaching, teachers began to see the benefit of the new strategies and activities. The facilitators also observed a change in teachers' interest in math. Specifically, they noticed that teachers were requesting more math materials for their classrooms. In online preschool, the facilitators observed that teachers increased their focus on math activities for at-home learning. In surveys and interviews, teachers discussed how the initiative provided ways to support math learning throughout their daily routines. They also discussed how the professional learning and coaching changed how they thought about early math learning overall. Based on teacher interviews and surveys, Exhibit 3 summarizes examples of shifts in teachers' math mindsets.

Exhibit 3. Shifts in Teachers' Math Mindsets: Knowledge of Children's Math Development



As previously described, teachers were asked about their knowledge of children's math development. In the pre-survey, teachers rated all knowledge items on a scale of 0 (*not at all knowledgeable*) to 10 (*very knowledgeable*). Prior to the initiative, teachers reported being knowledgeable in several math areas, with teachers rating their knowledge highest in measurement and number sense. In comparison, at the beginning of the initiative, teachers rated their knowledge of coding as fairly low. Overall, teachers did not have much experience in coding, and did not use technology in their classrooms very often.

After the initiative, teachers generally rated their knowledge higher in all math areas. Because the data were not normally distributed, non-parametric exact sign tests were used to test if the growth was statistically significant. Results showed that there was significant growth in all math areas. The largest increase was in the area of coding and robots. Exhibit 4 shows changes in knowledge of all math areas.

Exhibit 4. Change in Knowledge of All Math Areas

Math Area	Pre-Survey Median	Post-Survey Median	P-value
Number Sense	8.00	10.00	<.001
Algebra and Functions	8.00	9.00	<.001
Measurement	9.00	10.00	<.001
Geometry	7.00	10.00	<.01
Mathematical Reasoning	9.00	10.00	<.01
Coding and Robots	5.00	8.00	<.001

Awareness and Understanding of Coding

Prior to the initiative, many teachers reported that they did not use coding or robots in their classrooms and that they had very little experience with technology in the classroom in general. As seen in Exihibit 5, a majority of teachers had an awareness of coding or were learning the basics of using coding in preschool. After the initiative, 52% of the teachers reported understanding how to implement coding with children, and 18% felt comfortable and confident using coding and robots in an ongoing way. These data indicate a shift from teachers only having an awareness and knowing the basics of coding prior to the initiative to developing an understanding of and feeling comfortable using coding with children. Overall, data suggest that, while the initiative supported growth in all math areas, it was particularly effective in developing teachers' foundational knowledge of and capacity for using coding in preschool classrooms. Teachers became more comfortable using coding and reported that children began to use spatial language more regularly.

Although growth in self-reported coding knowledge and skills can be considered a success of the initiative, developing coding knowledge and skills also posed some challenges. In surveys and interviews, teachers expressed their concerns about coding and robots in preschool classrooms. One concern that teachers discussed was whether robots were developmentally appropriate, and whether technology should be used in the classroom at all. Teachers were concerned about their youngest learners and whether these children would be able to use and learn from the materials. However, after some teachers observed coding in another teacher's classroom and had coaching, they were more comfortable using coding in their classrooms. One teacher explained, "I was not very confident about coding, and sometimes struggle with some activities related to coding. Now, I understand what logic games strengthen children's math skills." Although the teachers approached coding with some hesitation at first, they are continuing to develop knowledge around coding and its use with children in the classroom.

Exhibit 5. Awareness and Implementation of Coding and Robots

	Before	After
Awareness and no implementation	55%	0%
Learning the basics and no implementation	45%	30%
Understanding and occasional implementation	0%	52%
Comfortable and ongoing implementation	0%	18%

Confidence in Supporting Children in Early Math

Prior to the initiative, teachers rated themselves as having high levels of confidence in various teaching practices, such as incorporating math into everyday routines, observing children's progress in math, and integrating math into various parts of the classroom. At the end of the initiative, teachers continued to feel confident in supporting children in early math. In the post-survey, teachers rated their confidence on a scale of 1 (*not at all confident*) to 5 (*extremely confident*). About 22% of teachers reported feeling somewhat confident, 70% reported feeling very confident, and 8% reported feeling extremely confident. In open-ended responses on the post-survey, teachers described how the new activities, ideas, and tools helped them feel more confident in supporting children's early math.

> *"I was seconding guessing my knowledge or how well I taught inside the classroom. However, when we did these trainings, I learned new style of teaching mathematics and the terminology, as well as the science, behind math in preschool. I feel that helped solidify my confidence in the classroom."*
>
> — Teacher, post-survey response

Teaching Practices and Classroom Implementation

In the pre-survey, teachers reported using a variety of practices to support math learning. When asked to provide two or three examples of how they engaged children in early math learning, teachers reported engaging children in activities related to the following areas: number sense (89%), algebra and functions (50%), geometry (29%), measurement (25%), and mathematical reasoning (4%). Teachers reported incorporating math into activities (e.g., learning centers), as well as into routines, such as counting while lining up. In addition, teachers reported that they provided manipulatives, games, puzzles, and songs to support math learning.

After the initiative, teachers reported that they continued to use a variety of activities and teaching practices to support children in all math areas. Many of these activities and practices were highlighted in the professional learning sessions, to support higher-order thinking in particular math areas. Activities reported by teachers include the following categories:

- **Number sense activities:** Prior to the initiative, teachers reported using counting as a common practice. After the initiative, a majority of teachers continued to incorporate number sense activities into their classrooms. Teachers reported engaging children in practices such as estimation and subitizing, which were introduced within the professional learning sessions. When asked in the post-survey if they had used number sense activities, about 96% of teachers reported using some form of number sense activity.
- **Shape activities:** Prior to the initiative, teachers discussed pointing out shapes, either in their environments or through using shape puzzles and blocks. After the initiative, all teachers (100%) reported using some form of activity involving shapes. During one professional learning session, facilitators discussed the types of attributes that can be the same or different in shapes. As a result, teachers mentioned using these shape conversations with children in their classrooms.
- **Coding activities:** Prior to the initiative, teachers reported that they had not previously used coding in preschool. After professional learning and coaching, about 85% reported using coding activities and/or robots at least once in their classrooms. Teachers reported using a penguin coding game to develop children’s precoding skills, and using the Sphero and Matatalab robots for coding skills.
- **Spatial reasoning activities:** Prior to the initiative, teachers did not discuss using spatial vocabulary. The use of spatial vocabulary (e.g., “up, down, left, right”) was emphasized both in the CAEMI institute and in the professional learning sessions within the agency. After participating in professional learning sessions and coaching, about two-thirds (67%) of the teachers reported using spatial reasoning activities in their classrooms, and teachers reported incorporating spatial vocabulary more intentionally into daily routines and activities.

Facilitators and teachers reported that teachers implemented a range of specific activities shared through the intiative in the classroom, in online preschool, and with families at home. The box below highlights a few of these activities.

Sample Activities Implemented During the Initiative

Number sense beyond counting

Teachers used an estimation jar to have children guess how many items were in the jar. Teachers and children discussed the children's different answers and why they guessed specific numbers.

"I Spy" shapes in online preschool

During online preschool, teachers asked children to look for different shapes at home. The children then shared their findings and discussed them with their peers and the teacher.

Art through coding

Children used a phone to manipulate the Sphero robot to move in different directions and create art with paint. The children took turns using the robot, exploring how a robot moves in space, and seeing how colors mix together.

Family math kits for all families

The county provided family math kits for each family after shelter-in-place orders were issued due to COVID-19. One teacher created a resource for families on how to use the kits to support math learning at home.

"Parents and children are enjoying the family math kits. The parents send us pictures and videos of children working with ramps or counting. They say that their children are playing and learning at the same time."

— Teacher, interview response

Observations of Child Engagement and Learning

Teachers reported that children enjoyed the early math activities and learning experiences. They also shared examples of children's math engagement and learning in nearly all areas, such as the following:

Number Sense: Subitizing

In an interview, a teacher explained she had created cards with stickers to subitize. Children were eager to guess how many stickers they saw. After using the cards a few times, the teacher began to introduce addition and subtraction with the subitizing cards. During free time, children chose to subitize with their peers asking, "How many did you see?"

Shapes in Virtual Learning

During online preschool, a teacher shared a YouTube video on shapes with their class. A facilitator had previously shared the video in an online professional learning session. In the online learning space, children were able to get up and move their bodies while learning with their peers on Zoom. In an interview, the teacher shared that children were very engaged throughout the activity.

Children's Engagement in Coding

During a classroom observation, an evaluation team member observed that children gravitated toward coding materials and robots that were placed in centers. For the Sphero robot art center, children generally used the materials independently, with occasional support from an adult. Several of the children spent 15 to 30 minutes at this center working together, demonstrating their engagement with the materials and with their peers. While at the center, children practiced social skills, such as turn-taking and sharing, and used spatial vocabulary, such as "I made mine go down and then up." In interviews, the teachers often mentioned children's excitement about coding and coding activities.

Social-Emotional Learning Through Coding

Multiple teachers mentioned how children practiced social-emotional skills during math activities, specifically during coding. In one interview, the teacher explained how the children practiced sharing and problem solving during a small-group activity with a penguin coding game. During this activity, children were running out of arrow tile pieces to use. The teacher began to ask how the children could solve this problem. Ultimately, the children brainstormed that they could share the arrow tile pieces, or that they could turn one of their arrow pieces so that the penguin could go in the direction they wanted it to go in. In this example, the children were able to engage in active problem solving, while also exploring directionality and the orientation of objects.

Spatial Vocabulary Used Everywhere

Teachers noticed that children were using more spatial vocabulary, both during math activities and in their everyday routines. During an interview, one teacher talked about instances where children would use or notice arrows in their environment. Children would draw arrows on paper, or use chalk, to guide people on where to go. Additionally, parents told teachers that children pointed out arrows on their way to school. These examples show how children's understanding of direction extended beyond the classroom activities and could be applied to real-life examples in their environments.

Conclusion

The case studies aimed to understand the planning and implementation of professional learning and coaching in local communities, as well as to examine any changes in educators' math knowledge, confidence, and teaching practices. This section provides an overview of the key takeaways of the case studies, as well as some limitations and future directions.

Key Takeaways

The two case studies shared the overall goal of building educator capacity in early math. Although their implementation plans looked very different from each other in terms of content and structure, all educators who participated in local professional learning and coaching overwhelmingly reported increases in their knowledge, confidence, and teaching practices.

Planning and Implementation of Professional Learning and Coaching

The flexibility of the CAEMI grant allowed for variation in agency implementation plans, which was beneficial to tailoring supports for local communities.

The case studies illustrated how agencies varied in math areas, structure, and duration of professional learning and coaching. Case Study 1 went in-depth on spatial reasoning, while Case Study 2 introduced the new area of coding as well as addressed number sense, measurement, geometry, and mathematical reasoning. Between October 2019 and June 2020, Case Study 1 offered one or two in-person professional learning sessions to three different sets of participants, and followed up with group coaching. Between January and May 2020, Case Study 2 offered two in-person professional learning sessions and two virtual professional learning sessions to one set of participants, and followed up with individual or group coaching.

The agencies integrated CAEMI content, activities, and resources into their local implementation.

Across both case studies, the agencies used content from the CAEMI in their professional learning PowerPoint presentations, such as slides on supporting research. Both agencies integrated hands-on activities into professional learning to engage adult learners in the learning. For example, Case Study 1 used the icosahedron activity, Piaget's perspective-taking tasks, and shape puzzles. Case Study 2 invited participants to explore a range of coding materials, some of which were introduced at the CAEMI Summer Institute (e.g., Matatalab, robot races). The facilitators also integrated various resources from the CAEMI, such as articles on spatial reasoning or professional noticing, into the professional learning and coaching.

The agencies provided diverse groups of educators with access to early math professional learning.

Both case studies wanted to ensure that specific groups of educators had access to early math professional learning. Case Study 1 engaged teachers serving children from birth to grade 3 in a single school. Within the school, the engaged educators included instructional assistants, a special education teacher, and a district-level TOSA. In addition, the facilitators offered professional learning and coaching to FCC providers, in both English and Spanish. The agency in Case Study 2 offered professional learning and coaching to all of its preschool teachers in state-funded preschools. In different ways, both case studies strove to provide a diverse range of participants with access to professional learning. Notably, both case study agencies exceeded the grant requirement of serving 20 educators in order to meet their local needs.

The agency facilitators used a range of strategies to respond to educators' needs, concerns, and levels of experience.

The facilitators used different strategies in order to be responsive to the needs, concerns, and levels of experience of the diverse educators. For example, Case Study 1 sought to understand the needs of FCC providers. In addition to offering professional learning, coaching, and resources in Spanish, the facilitators asked the providers questions to understand their needs, and broke content down into digestible pieces to meet them at their levels. In Case Study 2, the facilitators listened to educators' concerns and questions related to integrating technology and coding into the preschool classroom, and adapted their implementation plan to invite educators to observe one of the facilitators' implementation of coding in his preschool classroom.

Impact on Educators

Educators reported significant increases in their math content knowledge, confidence in supporting children's early math, and frequency of math teaching practices from the beginning to the end of the initiative.

Despite the variation across the case study implementation plans, educators in both case studies reported increases in their math knowledge, confidence, and teaching practices. The educators also shared many specific examples in interviews, corroborating the survey data. In Case Study 1, educators reported increases in their knowledge of all areas of math, with the largest growth in the area of spatial reasoning. In addition, they reported that they felt more confident and more frequently used teaching practices that support children's spatial reasoning. In Case Study 2, even with high pre-survey levels of knowledge and practices, educators reported increases in their math knowledge across all areas, with the largest growth in the area of coding and robotics. At the end of their participation, they reported that they felt confident and prepared to continue implementing teaching practices to support children's early math.

Educators increased their awareness that math was all around them.

Across both case studies, educators described how their experiences in the CAEMI opened their eyes to math all around them. In Case Study 1, teachers and FCC providers discussed how they began to see opportunities to support children's spatial reasoning all throughout daily routines and activities. For example, an elementary teacher talked about how children in earlier grades use spatial reasoning to fit their belongings in their desk or to write letters and words that fit on lined pages. The educators also talked about using spatial language with children during routines (e.g., mealtime), indoor play with manipulatives, outdoor gross motor play, and small- or whole-group activities.

In Case Study 2, educators moved beyond offering math at a single math center or activity, to using it throughout the classroom. They also reported that, at the outset of the CAEMI, they offered rote or basic math activities, such as counting and identifying shapes, but by the end of their participation, they were supporting different types of math concepts, such as comparing and contrasting attributes of shapes, subitizing, and estimating. Both case studies demonstrate how educators' participation in the CAEMI illuminated new ways of identifying and supporting math in children's everyday environments.

All educators rated the professional learning and coaching as very valuable.

In both case studies, educators were asked to rate the value of each of the components of the professional learning and coaching, which were customized to each agency. Across both agencies, educators reported that all components were very or extremely valuable. In Case Study 1, educators rated the three-hour professional learning sessions, in-person coaching, and math resources on the Padlet platform as most valuable. Most participants who received observations or demo lessons rated them as extremely valuable. In Case Study 2, educators rated the three-hour professional learning sessions, math resources, and homework (i.e., opportunities to practice what they learned) as the most valuable components.

Limitations and Future Directions

The case studies have a few limitations that should be considered when examining and interpreting findings. First, the case studies only included one agency type, county offices of education; other invited agencies, such as a school district and a nonprofit organization, were not able to participate. The case studies also only included two of the thirty agencies participating in the CAEMI. Although these two agencies share some characteristics with other CAEMI agencies, they are not representative of all of the participating agencies across the state.

Additionally, the changes in educator knowledge, confidence, and teaching practices were all self-reported through surveys and interviews. Educators may have inflated their ratings of their knowledge, confidence, and skills, due to social desirability, and may have been less likely to share any challenges or negative experiences. However, educators gave rich, specific examples of implementation in their early learning settings, which served to reinforce the high self-reported ratings. Future evaluations may consider direct assessments and observations of changes in teachers' knowledge and skills, as well as of any changes in children's early math outcomes.