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REPORT
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Math in a Child's World

Policy and Practical Challenges for Preschool Mathematics

Overview

In recent years, compelling research has found that mastery of early math concepts at a preschool level is a better predictor of later academic outcomes than literacy. Partly driven by these findings, increasing attention is being focused on improving math pedagogy at the preschool level. The issue has assumed added urgency as a result of California's adoption of the Common Core State Standards, as well as the roll out of transitional kindergarten, the first new "grade" in state schools in more than a century.

Several convenings, underwritten by the Heising-Simons Foundation, have been held during the past year in California focusing on early math at a national, state and local level. This working paper emerged from two convenings held at California State University, East Bay and the University of California Irvine, sponsored by the California STEM Learning Network (CSLNet), which focused on the policy and practical challenges for introducing a more comprehensive math curriculum at a local level, especially in preschools. This paper supplements two previous papers written by Deborah Stipek and Alan Schoenfeld based on convenings held at Stanford University and the University of California Berkeley in November 2011 and January 2012, respectively.

This paper identifies several key challenges based on discussions at the Cal State East Bay and UC Irvine meetings, as well as follow-up interviews with program administrators, educators involved with teacher training and other experts in preschool education in California.

This report was written with support from the California STEM Learning Network (CSLNet).

California STEM Learning Network
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"Kids can do challenging things in mathematics if they proceed from what they know right now, if they do it in a developmentally appropriate, active, hands-on manner, with a choice of materials, and lots of conversation between classmates and adults, building on their questions and helping kids explain why they think something is the way it is."

—Ada Hand, President, California Kindergarten Association

These challenges include:

- the paucity of math content in preschool teacher preparation and permit requirements;
- the lack of preschool professional development and in-service training;
- the barriers imposed by "math anxiety" among preschool teaching staff;
- linking the preschool experience with what awaits children in K-3 grades;
- the impact of the state's budget crisis on the capacity of state agencies, education institutions and preschool programs to respond to these challenges.

On a broader level, California also faces the challenge of how to reach the hundreds of thousands of children who are not enrolled in state-supported preschool programs, and who may not have adequate exposure to math concepts before they reach transitional kindergarten or kindergarten proper.

Introduction

During the past half-dozen years, the recognition of the critical importance of early math to later academic achievement has sparked intensive interest in the role of preschools in ensuring that children reach kindergarten with a sound understanding of basic math concepts.

At the preschool level these do not involve advanced concepts, but those that children encounter in their daily lives, such as understanding counting, sorting and classifying objects, recognizing simple patterns and shapes, as well as relationships like more/less, longer/shorter, heavier/lighter and taller/shorter.[1]

The interest in early math has been driven in part by the findings of Greg Duncan, an economist at the UC Irvine School of Education, and others that math concepts acquired at a preschool level are "the most powerful predictors of later learning," even more than reading and writing.[2] These findings were reinforced by a National Research Council report in 2009, which stated that:

> *Well before 1st grade, children can learn the ideas and skills that support later, more complex mathematics understanding. There is expert consensus that two areas of mathematics are particularly important for young children to learn: (1) numbers, which includes whole numbers, operations, and relations; and (2) geometry, spatial thinking, and measurements.*[3]

As EdSource has noted previously, gaps in early math proficiency that are evident in kindergarten are likely to persist. "Compelling evidence suggests that the achievement gaps that exist between students in second grade are foreshadowed at kindergarten entry," the report stated.[4]

"The broad acceptance of Common Core standards implies there will be increased breadth, depth, and coherence in the early grades…compelling states to offer richer math instruction than is required by most of the previous state standards. This, in turn, has important implications for early childhood education, whether it is delivered in home or center-based child care or preschool programs."

—Alan Schoenfeld and Deborah Stipek, 2011

Yet despite its importance to later achievement, math has generally received far less attention than literacy at the preschool level because of the intensive focus on the latter throughout the education pipeline over many decades. Surveys have shown that preschool programs spend far less time on math than reading. One study in North Carolina and Tennessee, for example, found that preschool programs included in the sample spent only 3 percent of their time on math content—or just 5.4 minutes out of a half-day program—compared with 11 percent on reading.[5]

It is not just a question of quantity, but also one of quality. As the 2009 National Research Council report noted:

> *Examination of current standards, curricula, and instruction in early childhood education revealed that many early childhood settings do not provide adequate learning experiences in mathematics. The relative lack of high-quality mathematics instruction, especially in comparison to literacy, reflects a lack of attention to mathematics throughout the childhood education system, including standards, curriculum, instruction, and the preparation and training of the teaching workforce.*

In many ways, California is ahead of many states. California has instituted a multi-layered set of frameworks, standards and assessment tools that all deal with math in some fashion at a preschool level (see box on page 6). They must be implemented only in state-supported preschools. Their existence underscores the high level of interest and engagement in this issue by a number of institutions and individuals over many years. Yet, as this report documents, the challenges of putting this panoply of state frameworks and tools into practice in preschool settings are considerable.

This issue has received renewed urgency in California. By 2014-15, the state will implement the Common Core State Standards in mathematics. These standards call for deeper and broader conceptual understandings of K-12 mathematics. In addition, California schools began requiring districts to offer transitional kindergarten classes for 4-year-olds in the fall of 2012. One intended goal of transitional kindergarten is to promote greater kindergarten readiness in subject areas such as reading and math. Taken together, these two major developments present opportunities to pay new attention to the teaching of mathematics in early childhood programs.

Two convenings were held in California in 2011 and 2012 to focus on this issue at a national and state level. Their purpose was to respond to the following question: "What must be done to ensure that early childhood

mathematics experiences are meaningfully linked to a K-3 system based on the Common Core State Standards?"

The first convening was held over a two-day period at UC Berkeley in November 2011. It was attended by 22 conferees from a variety of research institutions including UC Berkeley, Stanford University, the University of Wisconsin, Vanderbilt University and Columbia University's Teachers College. Representatives of the Heising-Simons Foundation also attended.

Written by Alan Schoenfeld, a professor of Education at UC Berkeley, and Deborah Stipek, the former dean of the Stanford University School of Education, a report based on that convening concluded that "although the mechanisms underlying such associations are not yet understood, the importance of early math—and thus the access to it for all students—is clear."

The report underscored that once students are behind in their mastery of math concepts, they rarely catch up. "Clearly any serious effort to close the achievement gap needs to include, if not focus on, children before school entry," the report recommended. But the report also emphasized that this is an issue that affects all students, not just those already behind when they enter kindergarten. Students in the United States generally lag far behind other industrialized countries in math. In fact, a recent study showed that the United States ranked 32nd (and California 36th) compared with other industrialized countries in math proficiency.[6]

The Berkeley gathering was followed by a similar event at Stanford in January 2012, but this time focusing on California. Nearly 30 California-based conferees attended, including the president of the California State Board of Education, community college leaders, deans of colleges of education, senior researchers, and representatives of early childhood associations. A report authored by Deborah Stipek and Alan Schoenfeld was also issued following that meeting.[7] The report called on California to reassert its leadership role in providing a high quality education:

> *California has, in the past, led the country in early childhood education quality and innovation. California could once again become a leader by developing policies and supports to ensure all young children's opportunities to develop that strong foundation.*

The Berkeley and Stanford gatherings pointed to the need for a deeper exploration of the following question: What are the policy and practical challenges to expanding the place of math concepts in the preschool curriculum? This report focuses on that question.

"Children persistently scoring at the bottom end of the math distribution were 13 percentage points less likely to graduate from high school and 20 percentage points less likely to attend college."

—Greg Duncan, "The importance of kindergarten-entry academic skills," in The Preschool Education Debates, 2011

CSLNet Regional Meetings

The California STEM Learning Network (CSLNet) is an organization whose mission is to increase interest, capabilities and engagement of all preK-14 students in science, technology, engineering and math (STEM), and to strengthen and expand access to STEM teaching and learning in schools, colleges and communities.

CSLNet hosted two regional meetings directed at leaders from early childhood education, school districts and county offices of education, higher education, and community partners directly involved with providing preschool services at a local level. Their purpose was to link research on early math to preschool practices, promote discussion among practitioners and plan next steps for implementation.

The Northern California meeting was held on March 14, 2012 at Cal State East Bay. The Southern California meeting was held on April 25, 2012 at UC Irvine. About 30 attendees participated in each session, consisting of educators involved with training of early childhood practitioners, program administrators, and representatives of school districts, county offices of education and First 5 commissions.

There was some overlap in the agenda of both meetings. They began with presentations on the state of research on the importance of early math. The presentations were followed by an examination of an effective math curriculum, including what kinds of teacher preparation and support are needed to promote well-articulated and effective instruction for young children from pre-K to 3rd grade. In addition, participants examined whether changes in state and federal policies should be enacted regarding curriculum standards, assessment and credentialing of early childhood teachers and instructors.

Highlights included a presentation by Greg Duncan on his research on early math, along with some more recent work showing the importance of math throughout the academic pipeline, not just at a preschool level. Duncan presented his findings that K-5 students with persistent math problems were less likely to graduate from high school, and even less likely to attend college.[8] Conversely, 14- to 16-year-olds who do well in mathematics were more likely to have greater success in the labor market and earn higher salaries.[9]

Alice Klein, a senior research associate at WestEd, presented her work on socioeconomic differences in early math knowledge, and what can be done to close the gap.[10] She noted the significant differences in Child

Math Assessment (CMA) scores among 3-year-olds between low- and higher-income children. The gap, however, did not narrow at all after they entered preschool. She compared these scores to those of low-income children in China who entered preschool with lower scores than higher-income children. In contrast to the United States, by the time a child had entered kindergarten, the gap had virtually closed.

Klein ascribed the difference in outcomes to China's provision of universal preschool to all children in urban areas, a national preschool math curriculum, and high parent and teacher expectations for children's math development.

By contrast, she argued, the gap in math performance between low- and higher-income children at a preschool level widens in the United States because low-income children receive less support for math development both at home and in preschool.[11]

Follow-up questionnaires sent to participants in the Hayward and Irvine meetings showed a high level of interest and engagement in the issue, with several indicating their desire to move forward on a preschool math agenda in their own school districts.

Frameworks, Standards and Assessments

California has instituted a multi-layered set of frameworks, standards and assessment tools that all deal with math at a preschool level. They underscore the high level of interest and engagement in this issue by many institutions and individuals over many years.

- In 2008, the California Department of Education published the **California Preschool Learning Foundations,** which outline the foundational skills and knowledge that children between 48 months and 60 months are expected to acquire before they enter kindergarten. The Foundations in preschool mathematics focus primarily on five areas: number sense, algebra and functions (classification and patterning), measurement, geometry, and mathematical reasoning.

- The **California Preschool Curriculum Framework** is intended to help promote curriculum development at a classroom level, including helping teachers select appropriate materials and plan and implement teacher-guided learning activities.

- The **Prekindergarten Learning and Development Guidelines** is described by the California Department of Education as "a user-friendly resource that can help administrators, teachers, and policy makers identify elements necessary for providing quality programming for children prior to their entry into kindergarten." The guidelines include a section titled "Mathematics Learning and Development."

- The **Desired Results** system was developed to document the progress made by children participating in state-supported child development programs from birth through age 12.

  The **Desired Results Developmental Profile,** or **DRDP,** allows preschool instructors to assess a child's progress at various developmental levels. In the latest version, the DRDP-R, "Math Development" is one of six "domains" on which all children participating in state-supported preschools must be assessed by teachers based on observations of students' work and behavior. A special DRDP aligned with the Preschool Foundations (DRDP-PS) was issued in 2010. The most recent addition is the DRDP-SR, intended to assess "school readiness" and progress in kindergarten and transitional kindergarten, will be ready for implementation by June 2013.

SOURCES

California Preschool Learning Foundations: www.cde.ca.gov/sp/cd/re/psfoundations.asp
California Preschool Curriculum Framework: www.cde.ca.gov/sp/cd/re/psframework.asp
Prekindergarten Learning and Development Guidelines: www.cde.ca.gov/sp/cd/re/prekguide.asp
Desired Results: www.cde.ca.gov/sp/cd/ci/desiredresults.asp

The California Context

In 2011, more than 1 million 3- to 4-year-olds lived in California, according to the American Community Survey (see Table 1). Among these preschool age children, nearly half were enrolled in a school setting of some kind. (The survey defines school for this age group as "nursery school, preschool or kindergarten.")

Table 1: **2011 EARLY CHILDHOOD EDUCATION AMONG 3- TO 4-YEAR-OLDS IN CALIFORNIA**

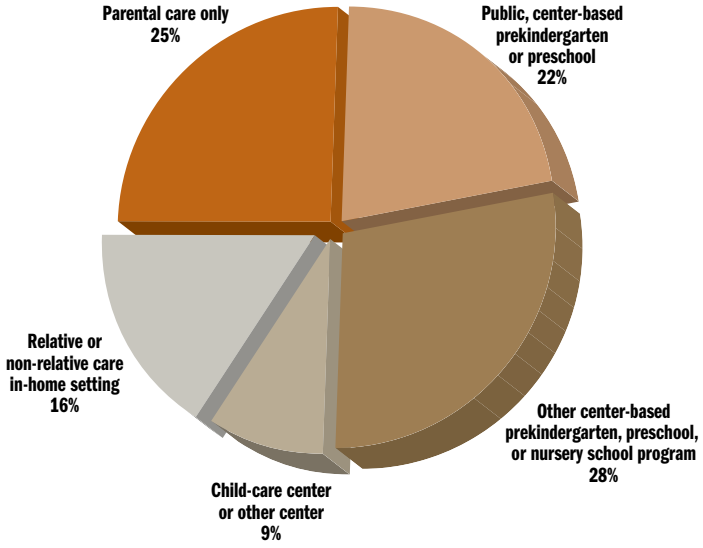
District	Number	Percent
Total Number of 3- to 4-Year-Olds	1,056,857	
Number Enrolled in a School Setting	514,874	49%

Source: American Community Survey, 2011 1-Year Estimates — EdSource 12/2012

A 2008 Rand Corporation survey of more than 2,000 parents underscored the wide range of preschool and early childhood settings for California children and the relatively small proportion in publicly funded preschool settings (see Figure 1).[12]

- 22 percent were in a public program of some kind: Head Start, California Title 5 program, a county office of education preschool or a preschool program run by a local school district.

Figure 1: **CENTER AND HOME-BASED ARRANGEMENTS FOR CALIFORNIA'S 3- AND 4-YEAR OLDS**



Adapted from Figure S.2 in *Prepared to Learn: The Nature and Quality of Early Care and Education for Preschool-Age Children in California*, The RAND Corporation, 2008. — EdSource 12/2012

"All kids get there if you give them the right foundation, in the right environment."

—Zee Cline, Associate Director, Teacher Education and Public School Programs, CSU Chancellor's Office

- 28 percent were in private school prekindergarten, preschool or nursery school.
- 9 percent were in a child-care center or other "center-based program" (for example, a recreation center-based program).

Of the remaining 41 percent:

- 16 percent were cared for in one or more home settings "in which the caregiver may be a relative or non-relative."
- 25 percent "had no regular care or early education arrangements with someone other than their parents."

The panoply of settings suggests that California's very detailed Preschool Learning Foundations are likely to reach only a small proportion of California's preschool-age children.

Even more disturbingly, the Rand report found that participation in high-quality, center-based programs is low for groups of children who could benefit the most. This suggests that children who are most likely to enter kindergarten without the math concepts necessary to succeed are also those who are the least likely to attend preschool settings where they will get a strong foundation in math concepts.

Major Challenges

Based on discussions at the two CSLNet regional events and in-depth follow-up interviews with a dozen participants as well as other preschool administrators, we have identified several key challenges facing implementation of early math at a preschool level. These interviews were supplemented by information drawn from interviews conducted by the Orange County Commission for Children and Families with early childhood coordinators in 21 school districts in Orange County on math and science curricula in their preschools.[13]

Those interviewed were not intended to be representative of early childhood educators in California. Rather, the goal was to illuminate the basic challenges that stand in the way of full integration of math into the preschool curriculum by talking to a range of experts in the field.

1. Lack of Math Content in Teaching Permit Requirements

The greatest challenge noted by interviewees is the paucity of math preschool staff receive in "general education" college-level courses and in teacher preparation classes required to receive a Child Development Permit.

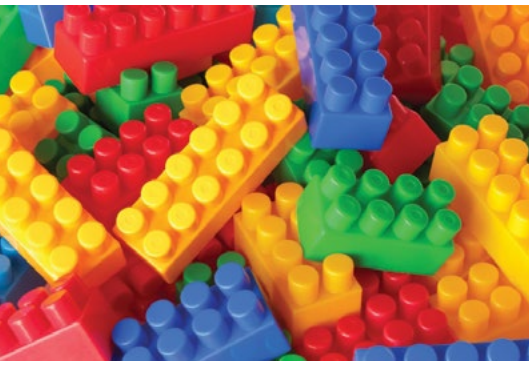


Table 2: CALIFORNIA'S REQUIREMENTS FOR A CHILD DEVELOPMENT TEACHING PERMIT

Teachers working in a California state-supported preschool (whether a state preschool or a state-contracted general child care and development program) must get a "Child Development Permit." This category of permit has four levels that vary by coursework requirements and days of experience required. Math is optional in the general education requirements to get an associate teacher or teacher permit, and math pedagogy is not specifically required in teacher preparation classes.

Requirements for assistant teacher permit*:

- six units of Early Childhood Education (ECE) or Child Development (CD), OR
- completion of an accredited Home Economics and Related Occupations (HERO) program or Regional Occupation Program (ROP).

Requirements for associate teacher permit:

- 12 ECE/CD units and 50 days of work experience, OR
- a Child Development Associate (CDA) Credential.**

Requirements for teacher permit:

- 40 units of education, including 24 units of ECE plus 16 "general education" units, which include one course each in English/language arts, math or science, social sciences, humanities and/or fine arts along with 175 days of work experience over four years, OR
- an associate degree in early childhood education plus 3 units of supervised ECE/CD field experience.

Requirements for master teacher permit:

- includes the requirements of the "teacher" permit above plus an additional 8 units in specialization/adult supervision and 350 days of work experience, OR
- a bachelor's degree in any field plus 12 ECE/CD units and 3 units of supervised ECE/CD field experience.

* This is an optional permit; assistants in childcare/development programs who are supervised by the categories of teachers listed here are not subject to specific requirements.

** This is a nationwide credential issued by the Council for Professional Recognition and can be earned by having 480 hours of work experience, 120 hours of formal training and other requirements.
See: www.cdacouncil.org/the-cda-credential/about-the-cda

Source: State of California Commission on Teacher Credentialing EdSource 12/2012

Teachers and associate teachers in a state-supported preschool or Head Start in California must receive such a permit, which has a range of requirements depending on the level of instruction. There are six teaching permit levels in California. (See Table 2 on page 9 for a description of requirements for each level.)

Preschool teachers in state-subsidized programs must earn 16 units of "general education" courses, typically from a community college, where they must take at least one course in each of the following subject areas: English/language arts, math or science, social sciences, humanities and/or fine arts. These are regular college-level courses that are not linked in any way to teaching the course content in an educational setting.

In addition, prospective preschool teachers working in state-subsidized programs must take eight courses totaling 24 units in early childhood education and child development. Typically, math does not figure prominently in these courses.

Unless students choose to take a math course as part of their math and science "general education" requirement, they can get their permits without having to take even one math course. In addition, the permit requirements do not require any specific course work involving the teaching of math itself.

Erin Freschi, program services administrator for First 5 Alameda County, said that usually the "Principles and Practice of Teaching Young Children" course or ones with a title like "Introduction to Curriculum" will include content on teaching math, but the amount varies depending on the instructor and is usually very limited, sometimes only comprising one day out of the entire course.

Peggy Nguyen, Early Childhood Education coordinator in the Newport-Mesa Unified School District, said that the absence of a math methods requirement in California's course requirements is "problematical."

"For what preschool teachers are expected to do, they are underqualified," she said.

Susan Wood, director of the California Institute of Technology's Children's Center in Pasadena, which has a math and science focus, was blunter, describing math preparation in the permit process as "terrible" and "non-existent."

Asked how much emphasis her college places on math instruction, Janice Townsend, an instructor on the Child Development faculty at Los Medanos College in Pittsburg, answered, "Probably not enough."[14]

She said that her college offers a class that does look at the teaching of science, math, art, literacy and language development. The course called "Curriculum Foundations for the Young Child," which includes just one activity in each of these curriculum areas, is one of the first courses a student takes. As a result, she said, "not as much sticks as it should."

Contributing to the problem is the impact of state budget cuts that have made it even more difficult for colleges to offer more than just the core courses students need to receive their permits. Alameda County's Freschi said math and science instructional classes are typically electives within early childhood education programs, so they tend to be the first to be cut from the schedule. By contrast, instructional classes on literacy and language development are rarely cut, she said.

It is worth noting that California licensing requirements for teachers working in any child-care setting other than state-subsidized ones only require a minimum of 12 early childhood education units. That means that in some private child-care settings, teachers may have had even less preparation than those receiving public support.[15]

Curriculum Alignment Project: Toward a common early childhood education curriculum

Beginning in 2006, the community college's Curriculum Alignment Project (CAP) has worked with faculty across the state to come up with a lower-division program of study in early childhood teacher preparation. It consists of eight courses that are intended to be a "foundational core" for all early childhood education professionals:

- Child Growth and Development
- Child, Family and Community
- Introduction to Curriculum
- Principles and Practice of Teaching Young Children
- Observation and Assessment
- Health, Safety and Nutrition
- Teaching in a Diverse Society
- Practicum

Some 103 community colleges (out of 112) now participate in CAP. So far, less than half (47) have courses that are officially "aligned" with each other. "Alignment" means that early childhood education programs offer "a minimum of 24 units, in eight courses with the same names, with at least a 3-unit load for each course that includes the components reflected in the sample outlines."

A review of the eight CAP course outlines indicates that math is mentioned in only two. In "Introduction to Curriculum," math is mentioned as one of five subject areas (language and literacy, social and emotional learning, sensory learning, art and creativity, and math and science). The Practicum/Field Experience course does offer the student the possibility of focusing on math—but as one of five subject areas students can choose from. In the Practicum courses, students are expected to:

> *utilize practical classroom experiences to make connections between theory and practice, develop professional behaviors, and build a comprehensive understanding of children and families. Child-centered, play-oriented approaches to teaching, learning, and assessment; and knowledge of curriculum content areas will be emphasized as student teachers design, implement, and evaluate experiences that promote positive development.*

Thus, the Practicum offers an opportunity for students to learn about teaching math in a hands-on way. But it is not known how many students choose to focus on math instead of another subject.

Source: Child Development Training Consortium, www.childdevelopment.org/cs/cdtc/printhdocs/services_cap.htm

Diana McGregor, an instructor in Early Childhood Development at Chabot College in Hayward, said that her college used to offer a 3-unit course on "Math and Science for the Young Child." But the course hasn't been offered for the past six years, mainly because of a lack of funding. The college does offer a course on "Literacy in Early Childhood," but none specifically in early math. With additional funding, she said, reinstatement of the math course is a possibility. But she noted that other higher priority courses have also been eliminated because of the state's budget crisis, so restoration of the course is not assured under any scenario.[16]

Formal training in math pedagogy, including becoming aware of a child's cognitive development, is especially important, several interviewees said, because so much of math pedagogy at the preschool level involves integrating math concepts into daily classroom routines, rather than relying on a set curriculum or other "off-the-shelf" materials. As Veronica Ufoegbune, director of the Woodstock Child Development Centers in Alameda, said, "People forget that math is a daily experience; it is part of everything you do."

Finally, in light of the need for improved instruction in math in the teacher preparation process, a sufficient supply of faculty with knowledge of math and math pedagogy will also be needed. Stanford's Deborah Stipek indicated that there are "very few" faculty in that category. "Expertise needs to be developed at that level before we can improve math pre-service preparation," she said.

2. Professional Development and In-Service Training

After the permitting process, interviewees named providing professional development and in-service training as their greatest challenge.

The 2000 National Survey of Science and Mathematics Education found that more than half of early kindergarten through 2nd grade teachers had not taken a college course in mathematics in more than 10 years.[17] The percentage is likely to be far higher among preschool teachers and staff, many of whom may never have taken or passed a college-level math course, and are years removed from math courses they took in high school.

Unlike reading, math is a subject that is easy to forget as anyone trying to recall his or her high school math knows. As a result, professional development and in-service training in math are crucial among teachers who work with young children.

But, as Ada Hand, president of the California Kindergarten Association, noted, preschool staff not only need to know about formal math concepts, but also about how to promote active, hands-on learning, providing objects to manipulate, along with games, blocks and puzzles, and enabling students to have a rich dialog with peers and adults.

Preschool teachers and other staff must take 105 hours of professional development within five years of receiving their permits in order to renew them. Thus, this requirement provides a formal way for teachers and other staff to make up for the lack of math course content they receive in the permitting process.

There are substantial professional development opportunities available, such as the classes provided by the California Preschool Instructional Network (CPIN). Local county offices of education also frequently offer evening workshops. Other possible opportunities include the California Subject Matter Project, which provides weeklong symposia and workshops mainly directed at K-12 teachers, but also open to preschool teachers and administrators.

But interviewees noted several major challenges to providing professional development and training in math. One overriding concern is the lack of funding. Preschool programs, already working on barebones budgets, have been hard hit by the state budget crisis, although as Deborah Stipek points out, this and other challenges described in this report existed long before the current crisis.

In addition, many of the available professional development opportunities continue to be heavily oriented toward literacy rather than math.

Another challenge is that teachers typically teach two three-hour preschool sessions, leaving them little time for professional development courses. In addition, preschool teachers are paid far less than K-12 credentialed teachers, so they are less likely to be able to pay for classes out of their own pockets.

Preschool programs generally don't offer the same number of days for professional development as K-12 teachers enjoy. Given their limited finances, preschools can't close their programs so teachers can participate in professional development opportunities, afford to pay for teachers to attend outside workshops and classes, or pay to provide on-site training.

In fact, the survey of districts in Orange County by the Children and Families Commission found that the most frequently cited barrier to

improving preschool math and science content was funding. One program administrator, for example, cited the lack of funding to pay for substitutes if teachers wanted to attend training workshops.

Newport-Mesa's Peggy Nguyen said providing professional development has been "our biggest struggle." All employees work full time and already barely have time to plan for classes, she said. Figuring out how to build in extra training is a challenge. Teachers are under contract to work until 4 p.m. each day. Children leave at 2:45 p.m., and she tries to use that time—from 2:45 p.m. to 4 p.m.—for professional development about two or three times a month.

Beatriz Levya-Cutler is director of Centro Vida, a private bilingual preschool program in Berkeley. Founded in 1976, the program receives Title V state funding for subsidized child care for low-income children. She said that her center closes for two professional development days each year, allowing teachers to work on their classrooms, prepare curriculum materials, work on their DRDPs (Desired Results Developmental Profiles) and so on. "For the very few days that we have professional development, we have already made decisions about what to do on those days," she said.

Nor do state regulations allow her center to close for additional days. "If you are closed, you are paying for it out of your pocket," she said.

It is also a question of priorities, she said. While math is important, her major focus is promoting literacy in English and Spanish by the time children leave the highly regarded program. "The thing I focus on is how our children become literate in English and Spanish, that they come out bilingual and confident, and fluent in both of their languages," she said.

Another issue is following up on in-service training or outside workshops so that what teachers have learned is actually used. The Anaheim City School District offers preschool classes for 1,200 children at 17 sites. This year, the district provided pre-service training in math, but has found that more intensive training is needed. "We train and train (staff), and then we go into the classroom and we just don't see it happening," said Elaine Coggins, Anaheim City's director of Early Childhood Education.

3. Curriculum Materials

One of the bright spots that emerged from our interviews is that there is no shortage of math-focused materials for preschool settings that

practitioners have found useful. The larger challenge is having teachers use them effectively as part of a comprehensive approach to integrating math into the entire school day.

Several preschool programs relied on the Houghton Mifflin Pre-K curriculum, which includes a strong math component. Other materials referred to were Lakeshore Learning Materials, TouchMath, Creative Curriculum, Children's Learning Institute, Circle Training and its multiple math activities, and Juanita Copley's The Young Child and Mathematics. Another impressive resource is Headstart's High Five Mathematize, as well as continually updated materials on the California Kindergarten Association's website.

Anaheim City's Elaine Coggins, for example, indicated that "we have a ton of material … you can always find something that catches children's eyes." As she and others noted, at best teachers will only be able to use a small portion of these curriculum materials because of the limited time available during the school day.

Her goal is to emphasize the notion that "math is everywhere," rather than relying on a set of curriculum materials. The bigger challenge, she said, is "really teaching teachers how to use the materials."

For example, Coggins said that preschool sites in her district have set up "math and science centers" with manipulatives such as blocks, shapes and other materials children can play with. But, she said, "you can put out all the material you want, but unless there is someone there to facilitate how they are used, it is not going to be especially helpful."

Caltech's Susan Wood, who also teaches an early childhood class at Pasadena City College, made the point that much of a preschool's curriculum materials could consist of everyday objects, rather than bombarding children with multi-colored, highly designed materials. "A lot of what I need for counting I get at the hardware store," she said. "Just matching a nut to a screw is interesting."

She also stressed that preschool math in particular demands that teachers go beyond relying on formal curriculum materials. For example, she said, "spontaneous math language" should be part of teachers' daily communication with children, as they constantly look for opportunities to ask questions such as: "How far away is that? What do you think would happen if? That is an odd shape, what do you call that?" That way, she said, you are "hitting all the domains."

"The same part of the brain that responds to fearful situations, such as seeing a spider or snake, also shows a heightened response in children with high math anxiety."

—Vinod Menon, Stanford Professor of Psychiatry and Behavioral Sciences

4. Math Anxiety

Underlying all these challenges are the conflicting emotions and fears that many teachers bring to the teaching of math. Typically, these are referred to under the catchall term "math anxiety." Others referred to it as "math aversion."[18]

These attitudes are not unique to the preschool environment. In fact, a recent Stanford study showed that there is a neurological basis for math anxiety, which becomes evident at an early age. The March 2012 study, which defined math anxiety as "a negative emotional reaction to situations involving mathematical problems," found that the brain scans of children with high levels of anxiety showed heightened activity in the amygdala, the brain's main fear center. (Significantly, the study also found that children with high math anxiety were less accurate and significantly slower at solving math problems than children with low math anxiety.)[19]

Cinda Munkenthaler, the project manager for Early Learning Programs for the Children and Families Commission of Orange County, said that math anxiety is "huge" even among teachers. A lot of teachers, she said, have struggled with math in college, and they bring their anxieties into the preschool classroom. "They do basic concepts and don't go any further," she said.

For many, passing a math course may well have been a major obstacle they needed to overcome to get an associate or bachelor's degree, adding to the anxieties surrounding math in general. A recent report by EdSource[20] showed a very high lack of completion rates (45 percent) in college-level math courses at California's community colleges. This is in addition to high failure rates in developmental math courses. Because math courses are required not only for an associate degree, but also to transfer to UC or CSU, failure in math has lifelong implications for students, more than in almost any other subject area.

All this contributes to greater anxiety levels related to math because of the high stakes involved. That was echoed by Gay Macdonald, executive director of UCLA Early Care and Education: "Teachers are math averse because they have failed a lot in math in their lives," she said.

However, interviewees noted that by showing teaching staff how math is part of daily life—their own and their students'—math anxieties can be overcome. This is especially the case at a preschool level where teachers aren't required to teach advanced math concepts.

Another approach is being implemented at Las Positas College in Livermore, where students can enroll in community college math classes specifically designed for students who already have or are studying for a Child Development Permit. Course assignments are related to working directly with children, and they work collaboratively with other students wishing to work, or already working, in preschool settings. Erin Freschi, who used to teach early childhood education courses at Las Positas, said, "The course demystifies math, helps them get over related anxieties about math in general and potentially will impact their ability to teach math in a classroom setting." Another side benefit, she said, is that it helps them complete the math requirement, which for many is a major hurdle in their path toward an associate degree.

5. Connecting the Preschool Experience with Kindergarten

Another challenge is ensuring that what children learn at a preschool level is aligned with what they are supposed to learn in kindergarten—as well as ensuring that once a child reaches kindergarten, he or she is able to build on prior math knowledge and experiences.

Some school-based preschools consciously facilitate meetings between their staff and kindergarten teachers, and also work to ensure incoming kindergarten teachers know what their students have learned in math and other subject areas during their preschool years.

In Newport-Mesa Unified School District, for example, each fall preschool teachers are given time to visit with kindergarten teachers on the school sites where their students will enroll the following year. That way they can get a good sense of what their students will be expected to know by the time they leave preschool. In the spring, the reverse happens, and kindergarten teachers visit preschools to get a better sense of what to expect from their incoming students in the fall.

Interestingly, teachers from private preschools in the Newport-Mesa area are also invited to visit kindergarten classes in the fall, but only a small number take advantage of the opportunity to do so.

In addition, at the end of the year, Newport-Mesa preschool teachers complete a "Kindergarten Transition Card" on each child that summarizes what he or she has learned, as well as other relevant information, including, for example, any health concerns. Because the preschool programs are in the district, the information can be easily forwarded to kindergarten teachers who will be teaching the child the following year.

This kind of alignment is probably only possible on a regular basis in school-based preschool programs, and is most likely a rarity even in these settings. It becomes considerably more difficult to do in the case of private providers. Centro Vida in Berkeley, for example, draws up what it calls a "Snapshot Form" about each student, which a parent can provide to kindergarten teachers. But it is up to the parent to do so, and there is no formal contact between Centro Vida and kindergarten teachers.

In addition to improving the transition of specific children from preschool (and now transitional kindergarten) to kindergarten, the California Kindergarten Association's Ada Hand says that regular meetings of preschool and kindergarten teachers to discuss common concerns in implementing a more challenging math instruction would help both groups.

An even more fundamental challenge is establishing a clear continuum of standards, curricula and assessments linking children's preschool experience with what awaits them in the K-3 grades. As Michael Kirst, the president of the State Board of Education, noted at the Stanford gathering mentioned earlier (see page 4), there is far more "articulation" between high school and college—aligning the exit requirements of one system to the entrance requirements of the other—than there exists between preschool and K-3. Both deserve attention.

Aligning Preschool Math with Common Core Standards

A massive national effort is currently underway to implement the Common Core State Standards in all grades from kindergarten through high school in 46 states, including California. That involves aligning curricula, teacher preparation and profession development to be consistent with the Common Core's new and, in many cases, more rigorous standards. But as Schoenfeld and Stipek have noted, "nothing comparable exists for preschool age children."[21]

As indicated above, California has already instituted a multi-layered set of frameworks, standards and assessment tools that all deal with math at a preschool level.

The issue of whether, or to what extent, the Common Core standards should be aligned with what children are expected to learn at a preschool level, and what that even means, is still a subject of considerable debate. Currently, there is no unified national effort to do so.[22] Central to the concerns raised is whether Common Core standards take into account the developmental needs of children at a preschool level. As an article

published by the Education Commission of the States noted, "The question remains: do rigorous K-12 standards represent a detriment to or opportunity for early childhood education, specifically aligning pre-K with K-12?"[23]

Initial analyses indicate that California's Preschool Foundations are substantially aligned with the Common Core. A recent analysis by the Child Development Division of the California Department of Education concluded that "even though the preschool foundations and the Common Core standards are organized somewhat differently, overall both cover the same areas in mathematics."[24]

Our small group of interviewees did not complain about having to use the Preschool Foundations and the DRDP system. Many indicate they were useful documents and tools.

However, some have adapted them to be able to increase their effectiveness. Caltech's Susan Wood, for example, said her center is using the DRDP in new ways "more consistent with their intent." Her center takes digital photos of a student's work and attaches them to the DRDP so parents can actually see the work students are doing, rather than reading about it. "A lot of tools are useful, but they are used poorly," she said.

However, it would make sense to review and revise the Foundations as needed to take into account both changes in pedagogy and the implementation of Common Core. For example, Zee Cline, associate director of Teacher Education and Public School Programs in the CSU Chancellor's Office, said that the foundations should emphasize to a greater extent the experiential nature of acquiring math concepts at a preschool level.

Others expressed concerns about the danger of overwhelming preschool staff with an additional layer of standards on top of the multiple state foundations, guidelines and assessment tools that already exist. Requiring preschools to adapt their use of existing state standards to the Common Core could be challenging, especially if it is not absolutely necessary.

More significantly, none of our interviewees or participants in the CSLNet regional meetings indicated that aligning what they are doing at a preschool level with the Common Core was a major concern or priority for them. Overcoming the challenges outlined in this paper were mentioned as a far greater priority.

CSU's Zee Cline cautioned against trying to link Common Core Standards too closely to math at a preschool level, in part because of the tremendous variations in developmental abilities at that age. "Standards imply you get it or you didn't get it," she said. "You can't say 'this is a good

4-year-old or a bad 4-year-old.' If children don't know their shapes, we shouldn't be judging them harshly. It is because they may need more exposure to shapes, or more language telling them what the shapes are."

At the same time, said Stanford's Deborah Stipek, standards have an important role to play. "There is a huge range of skill levels at all ages and grades," she said. "Standards are not about judging kids: they are designed to give educators some understanding of what to shoot for. It is hard to get anywhere when you don't know where you are going."

Despite the apparent close alignment of California's Preschool Foundations with the Common Core, this is clearly an area that deserves monitoring as the Common Core standards are implemented to ensure that young people entering kindergarten without adequate exposure to math concepts do not fall further behind than they are already—and are prepared to handle the greater conceptual demands of the Common Core standards as they translate into classroom practice, expectations and assessments.

Recommendations

This report points in several key policy directions:

1. There is a need for a revision of the child development permit requirements to include a math pedagogical requirement. Revisions should occur in tandem with the significant efforts currently underway to reform teacher preparation and credentialing in California.
2. Ways to add more math content into the training of teachers and associate teachers should be explored within the existing permitting process. This could include encouraging students in colleges offering the CAP 8 course sequence to make math a focus of their Practicum/Field Work course.

   An expansion of math pedagogy in the other required courses should also be explored in the absence of a formal revision of California's permit requirements.

   California's successful application for Race To the Top Early Learning Challenge funds emphasizes revision of the permitting process and its course content. Although math is not mentioned as a concern, the proposal presents an excellent starting point for discussion.[25]
3. Professional development and in-service training of preschool staff presents tremendous opportunities for fully integrating math into the preschool curriculum, but efforts must be made to eliminate the multiple barriers to doing so (time and cost being the primary ones).

4. In addition to more formal professional development and in-service training, at a site level preschool teachers should collaborate regularly—perhaps weekly—during children's nap time or other appropriate times, on successful math instruction strategies.
5. Successful efforts to help teachers overcome "math anxiety" or "math aversion"—by showing them how math is part of everyday activities and providing in-service observations of model math teaching in action—should be highlighted and disseminated.
6. Successful approaches to linking a child's preschool experience in math with his or her incoming kindergarten class should be identified and disseminated as possible models for replication. This should be part of a clear continuum of standards, curricula and assessments that link preschool to the K-3 experience.
7. All these efforts should be made in partnership with the Regional Leadership Consortia being established in some 16 communities in 15 counties as a result of California's $52 million Race to the Top Early Learning Challenge grant award.[26]

The paper by Deborah Stipek and Alan Schoenfeld summarizing the Stanford convening contains several recommendations that bear repeating here because of their importance:

8. Develop a pipeline of early math specialists who can serve as faculty in colleges that prepare preschool and early elementary school teachers.
9. Develop math teaching experts who can serve as mentors and coaches in early childhood education programs.
10. Develop a web-based, math-related resource center, with materials, information about curricula, and videos illustrating effective teaching and assessment.

Conclusion

The regional meetings sponsored by CSLNet underscore the considerable awareness within different preschool constituencies in California of the need to more fully integrate math concepts into preschool settings. Successful models exist, such as the programs at UCLA and Caltech referred to in this paper. There are also numerous high quality curricular approaches and programs that have been developed that could assist preschool administrators and teachers in implementing new approaches and directions.

At the same time, this report documents several key challenges facing preschool programs in implementing an optimal preschool math curriculum, including the paucity of math in the permit process, providing in-service and professional development, overcoming math anxiety, using curriculum materials in the most effective way, and figuring out ways to expand the role of math into an already-crowded preschool day. A positive development is California's receipt of nearly $53 million from the federal Race To the Top Early Learning Challenge fund that could assist in several of these areas, especially teacher preparation and permitting.[27]

Beyond these challenges, a major task facing the state is how to reach the large numbers of children who are not in any preschool program, in low-quality ones, or in family-based care without a formal educational component.

This is a daunting task. But if the goal for the state is to ensure that as many children as possible enroll in kindergarten without being far behind other students in their knowledge and exposure to basic math concepts, it is a task that California must take on. This, in turn, relates to the need to provide access to high quality preschools for all children. Currently, hundreds of thousands of 3- to 4-year-olds in California, and millions of children nationally, do not have that opportunity, with long-term consequences not only for their futures, but for California's and the nation's as well.

ENDNOTES

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13 The 21 interviews were conducted by the Children and Families Commission of Orange County, which provided us with a summary of their findings. We are grateful to Cinda Munkenthaler for permission to draw on these interviews.

14 For list of ECE courses offered at Los Medanos, see:
www.losmedanos.edu/departments/child/courses.htm

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ENDNOTES continued

15 See Section 101216.1 of California's Child Care Center General Licensing Requirements: www.dss.cahwnet.gov/ord/entres/getinfo/pdf/ccc4.pdf

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26 For more information on the Regional Leadership Consortia and California's Race to the Top Early Learning Challenge approach, see the PDF version: www.preschoolcalifornia.org/resources/resource-files/rtt-elc-informational.pdf

See also the U.S. Department of Education's website: www2.ed.gov/programs/racetothetop-earlylearningchallenge/awards.html