BRIEF

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A Critical Calculation

Supporting the Inclusion of Math in Early Childhood Degree Programs

By Abby Copeman Petig, Ph.D., Lea J.E. Austin, Ed.D., Marcy Whitebook, Ph.D., and Allyson Dean, Ed.D.

Summary: This brief summarizes findings related to early mathematical content included in early childhood education degree programs across eight states. Conducted between 2012 and 2017, the studies explored how institutions of higher education and their programs were situated to educate and support early care and education (ECE) professionals in this content area. Findings from the studies and implications for the degree programs and the wider ECE field are included.

Key Findings

- Only one-half of degree programs required the inclusion of key math topics as part of their curricular requirements.
- Only 64 percent of early childhood education faculty members believe that including early math education for pre-service teachers is very important.
- Faculty members across degree types felt most capable of addressing broad, informal topics within math education and less capable of teaching more concrete or tangible skills.
- Faculty members indicated a need for professional development on teaching practitioners to implement instructional strategies and to use assessment to inform and individualize their instruction.

Policy Recommendations

- Require early childhood education degree programs to align required content with the core early math teacher competencies.
- Require contextualized math courses and rich field experiences as standards for early childhood education degree programs in order to ensure student competency in early math.
- Promote awareness of the importance of early math development — both within the ECE field and in the larger community.
- Support professional development for faculty in early mathematical instruction to ensure faculty efficacy in this area.

Introduction

Young children — even infants and toddlers — possess mathematical understanding and the building blocks of early math skills. Within the first year of life, infants begin developing implicit theories to explain the actions of people and objects in the world around them (Gopnik & Wellman, 2012; Waismeyer, Meltzoff, & Gopnik, 2015; Yott & Poulin-Dubois, 2016). Children as young as six months can differentiate between groups that contain different numbers of objects, and children between two and three years old typically begin to count objects using number words (Geary, 2006).

To encourage the progression of children's innate early math skills and ensure positive experiences with math in the early elementary years and beyond, attention must be paid to these burgeoning skills during the early childhood period and within early childhood education (ECE) settings (Fuson, 2004). Although some ECE providers, researchers, and advocates voice concern about an overemphasis of academic instruction in ECE settings, others encourage the inclusion of developmentally appropriate practices around math with young children in these settings. When implemented in careful and meaningful ways, these practices and curricula produce positive outcomes for children's mathematical understanding and skills development (Clements, Sarama, Wolfe, & Spitler, 2013).

> "Children as young as six months can differentiate between groups that contain different numbers of objects (Geary, 2006).

Research also indicates that there are common cognitive skills involved in math and language and that strong mathematical abilities play a role in supporting children's language development (Duncan et al., 2007; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005; Purpura, Hume, Sims, & Lonigan, 2011). Taken together, research indicates that mathematical thinking supports more than just numeracy and acts as a foundation for general cognition and learning (Clements & Sarama, 2009; Sarama, Lange, Clements, & Wolfe, 2012).

Although all children benefit from the inclusion of developmentally appropriate early math instruction, it may be particularly valuable for children from disadvantaged backgrounds. These children tend to experience gaps in their exposure to math and math skills-building experiences when compared to their higher-income peers (Garcia, 2015). As early experiences provide the foundation for later learning, gaps that exist at early ages will persist into elementary school if not addressed (Fuson, 2004; Rouse, Brooks-Gunn, & McLanahan, 2005).

As with all aspects of ECE, positive outcomes for children and families are linked to high-quality environments and interactions with teachers (Curby et al., 2009; Hamre & Pianta, 2007; Mashburn et al., 2008). When examining the issue of early math skills development,

it is crucial that ECE teachers can provide developmentally appropriate and effective methods of math instruction to the children in their care. To effectively support children's early math skills, teachers of young children need to understand how mathematical understanding develops and learn pedagogical strategies to nurture this development in their students. However, as noted above, the inclusion of math in ECE is often a controversial issue, with a perceived tension between a focus on "play" and an avoidance of "instruction," as well as resistance to the inclusion of intentional math learning integrated into ECE curricula and daily routines. The result is that nationally, the majority of ECE programs and settings have not placed a strong emphasis on early math skills development (Connor, Morrison, & Slowinski, 2006; Early et al., 2010; La Paro et al., 2009). Reflecting the consensus that early mathematical learning plays a vital role in both children's development and in setting the stage for later success in school, more emphasis and resources are needed to prepare early educators to teach mathematical concepts, reasoning, and problem solving (IOM & NRC, 2015).

This situation is complicated by gender dynamics at play within the ECE and mathematics fields. The field of ECE is a historically female-dominated field, with the majority of ECE teachers and higher education faculty in early childhood education being women. However, mathematics, like science, technology, and engineering, has historically been male dominated, and women have often not been encouraged in (or have actually been dissuaded from) their pursuit of such studies. This phenomenon has resulted in generations of women in general, and ECE professionals specifically, who often do not feel comfortable or confident in their mathematical knowledge or abilities (Copley, 2004; Ginsburg, Lee, & Boyd, 2008).

In addition to ECE teachers not feeling competent in their ability to support children's math skills development, higher education faculty in the ECE field may also experience anxiety or discomfort in teaching pre- and in-service ECE teachers in this area. This reality presents a challenge to institutions of higher education responsible for training and preparing the early childhood education workforce. To better understand how these institutions and their programs are situated to educate and support ECE professionals, the Center for the Study of Child Care Employment (CSCCE) created the *Early Childhood Higher Education Inventory*. This brief summarizes findings from *Inventory* studies conducted in eight states between 2012 and 2017.

About the Early Childhood Higher Education Inventory

The *Early Childhood Higher Education Inventory* (hereafter, "the *Inventory*") is a research tool that describes the landscape of a state's early childhood degree program offerings at the associate, bachelor's, master's, and doctoral levels (Kipnis, Ryan, Austin, Whitebook, & Sakai, 2012). It was created to look closely at a number of variations among programs at different degree levels (e.g., curricular focus, age-group focus, field-based experiences). The *Inventory* consists of three modules: the mapping module, the program module, and the faculty module.

Through an extensive document review, the mapping module identifies a state's early childhood higher education programs by collecting information on each college or university, the departments that house the programs, the degrees and certificates offered, and the characteristics of students attending the programs.

Using an online survey tool completed by each degree program's dean or coordinator, the program module collects information on program content and age-group focus; alignment with state standards; accreditation; methods of student assessment; types, sequencing, duration, and supervision of field-based learning experiences; student supports; and challenges currently faced by the institution.

Finally, using an online survey tool offered to all faculty members teaching in a given degree program, the faculty module collects information on faculty employment status, teaching experience and expertise, professional development experiences and interests, and past experience in the early childhood field.

In addition to broad questions around curriculum requirements and student experiences posed in the program and faculty modules, a series of questions developed for the *Inventory* focuses specifically on the issues of early mathematics, with particular attention to program content and faculty attitudes. Bearing in mind the challenges facing the ECE field in the realm of early math education, this brief presents highlights of the *Inventory* findings related to early mathematics across eight states: Arkansas, California, Florida, Indiana, Nebraska, New York, Oregon, and Washington.[1]

1. As the *Inventory* studies took place over several years, adjustments were made to the survey tools. As a result, the following findings are primarily based on data from these eight states and, occasionally, a smaller subset of the states, depending on the timing of each state's *Inventory* (CSCCE, 2016).

Key Findings

When examining the information collected from these eight states through the program and faculty modules, four questions guided the analyses for this brief:

(1) What are the program requirements for teacher training programs at each degree level (associate, bachelor's, graduate) and for each age group (birth to two years, three to four years, kindergarten to third grade)?

(2) What are faculty members' beliefs about the inclusion of math education in teacher training programs?

(3) How competent do faculty members feel teaching courses on early math topics, and how much experience do they have teaching these courses?

(4) What early math professional development opportunities have faculty members participated in, and which topics are they interested in learning more about?

Program Requirements

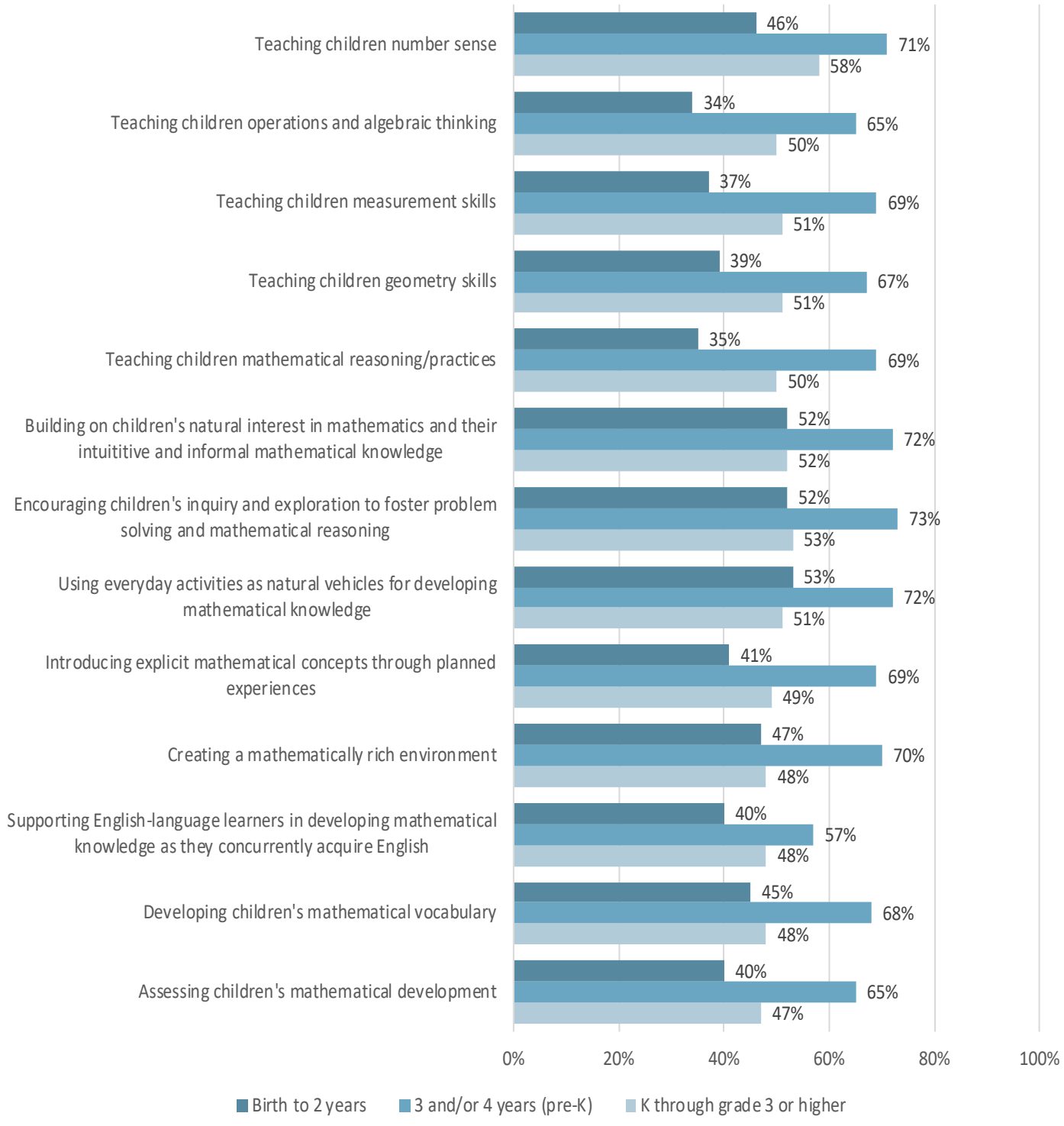
Table 1	Early Math Topics Included in Inventory Survey
	Teaching children number sense
	Teaching children operations and algebraic thinking
	Teaching children measurement skills
	Teaching children geometry skills
	Teaching children mathematical reasoning/practices
	Building on children's natural interest in mathematics and their intuitive and informal mathematical knowledgeZ
	Using everyday activities as natural vehicles for developing mathematical knowledge[2]
	Developing children's mathematical vocabulary
	Encouraging children's inquiry and exploration to foster problem solving and mathematical reasoning
	Introducing explicit mathematical concepts through planned experiences
	Creating a mathematically rich environment
	Assessing children's mathematical development
	Supporting English-language learners in developing mathematical knowledge as they concurrently acquire English[3]

The *Inventory* includes questions about the content of early childhood degree programs. Within the program module, the deans or coordinators were asked to note which early math topics were required curricula to earn the degree (see **Table 1** for the 12 possible topics). Across the eight states, each topic listed on the survey was most likely to be required for programs preparing teachers to work with pre-kindergarten or preschool children (ages three to four), regardless of the degree level, compared to programs preparing teachers to work with younger or older children.

In general, 70 percent or more of programs in each state required one or more of the 12 early math topics in their courses for teachers of three- and four-year-olds. Programs focused on teachers working with either younger children (birth to two years) or older children (kindergarten to third grade) were more varied in the courses they required for each degree level (see **Figure 1)**. In general, topics were required for elementary-age children in only about one-half of programs and for infants and toddlers in even fewer programs (only about 40 percent of programs).

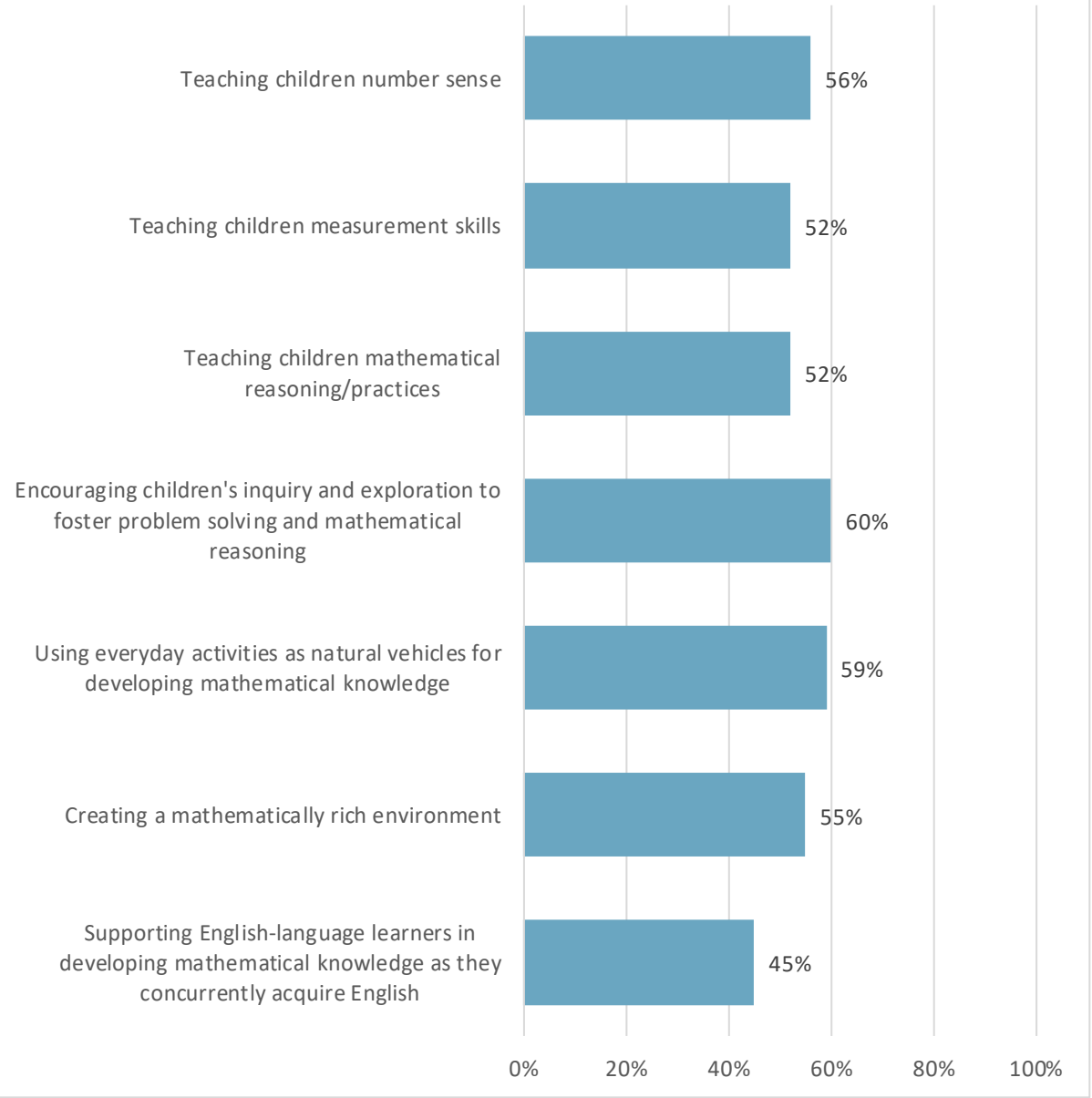
2. As a result of edits to the *Inventory,* this topic and the previous topic were combined into one topics for four states.
3. As a result of edits to the *Inventory,* this topic was included for four states.

Figure 1. Math Topics Required by Degree Programs, by Age-Group Focus



The most common topic required across all states, age groups, and degree levels was "encouraging children's inquiry and exploration to foster problem solving and mathematical reasoning," with an average of 60 percent of all programs across the eight states requiring teachers to take a course covering this topic (see **Figure 2**). The topics least often required for teachers of all age levels and at all degree levels were "operations and algebraic thinking for children" and "supporting English-language learners in developing mathematical knowledge as they concurrently acquire English," which were both required by slightly less than half of the programs.

Figure 2. Percentage of Programs Across Eight States Including Select Topics as Part of Degree Program Requirements



The many standards and requirements for the early childhood workforce are one of the primary influences on the content of degree program course offerings and professional development to prepare early childhood teachers, yet content required as part of an early childhood degree program can vary tremendously across institutions of higher education as it attempts to respond to the multiple roles in the field (direct service, leadership or supervisory roles, and even coaching or other supportive roles). Such differences are especially evident when examining the requirements for those who teach in elementary school settings and those who teach in settings such as early education programs or preschools, child care centers, and family child care (Whitebook, 2014). These differing standards not only make it unlikely that students across programs are consistently receiving sufficient content related to early mathematics for children, but equally unlikely that coursework demonstrating teacher preparedness to teach early mathematical content is valid across states.

> Only one-half of degree programs included key math topics as part of their curricular requirements.

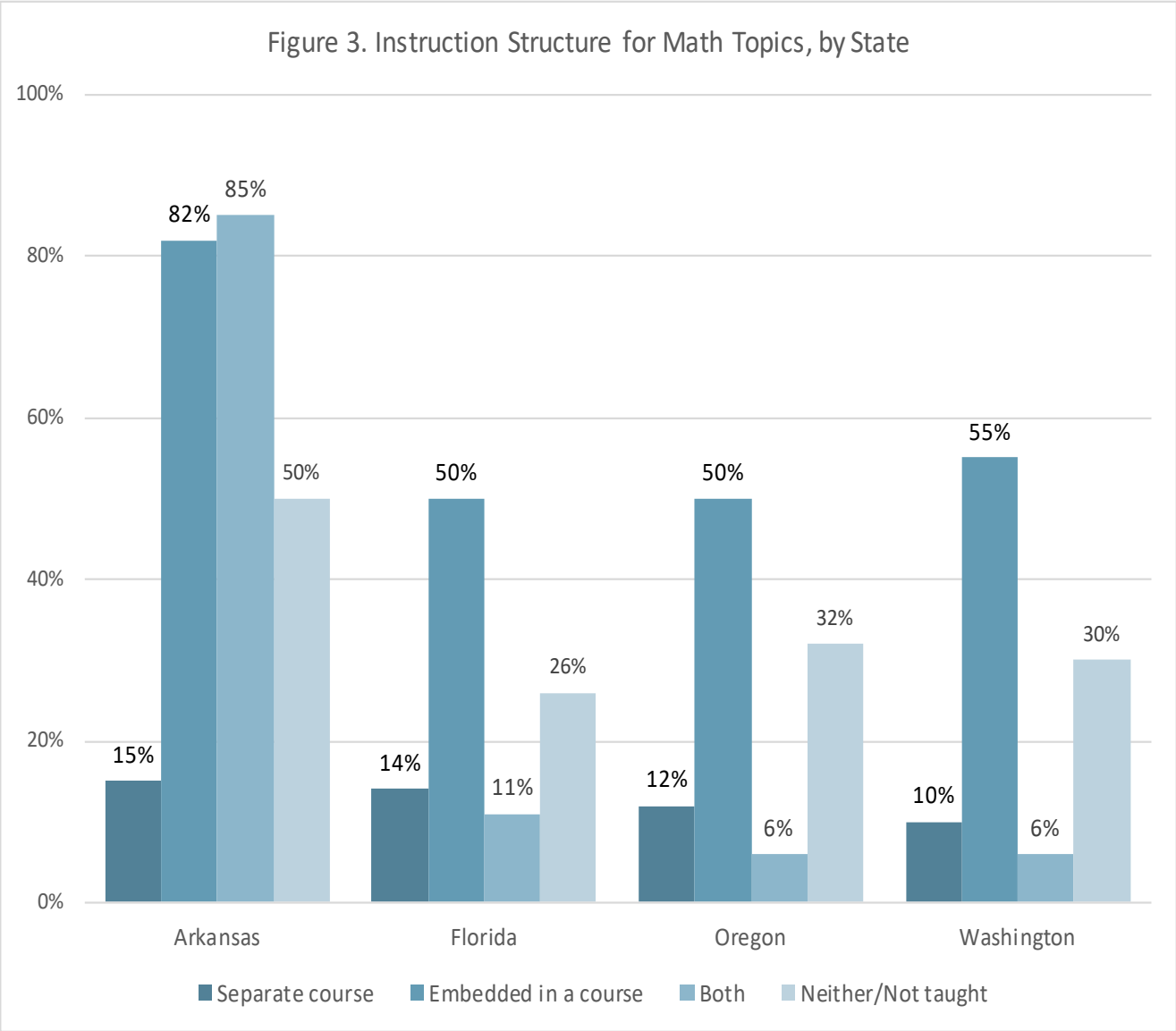
While this issue is problematic beyond the subject of early mathematics, it is particularly important when considering that only about one-half of degree programs in this study included key math topics as part of their curricular requirements. Taken together, this lack of a required focus on key mathematics topics in degree programs and the inconsistency of early childhood degree program requirements based on a variety of early childhood workforce roles makes teacher preparation in early math inconsistent and likely inadequate to prepare students for teaching children in this area.

In four of the eight states analyzed for this brief — Arkansas, Florida, Oregon, Washington — we included additional questions related to early math to develop a deeper understanding of degree programs' treatment of this topic. Findings reveal that among these four states, math topics were most often embedded as part of a course on a broader topic, rather than being addressed in stand-alone courses, such as a methods course for teaching early mathematics (see **Figure 3**).

Some programs also provided coursework using both methods, with topics included both as part of a larger course on child development or teaching methods, for instance, and also as a separate course of its own. When math topics were taught as separate courses within the curriculum, it was typically in bachelor's degree programs.

The structure of topics in most programs (typically within other courses and not as stand-alone classes) means that many teachers may only be getting brief exposure to early math topics. This trend was certainly true across four of the states in this study where topics related to the development of children's mathematical understanding and teaching children math skills were most often taught as sections or elements of a larger course and not as stand-alone courses for pre- or in-service teachers.

In addition, associate degree programs designed for non-elementary school teachers rarely have specific courses for teaching these topics; as a result, infant/toddler and preschool teachers may not be learning these skills as readily as licensed teachers in elementary schools holding a bachelor's or graduate degree. Although not all graduates



of these programs will be directly teaching young children, it is important that anyone who is working in this field should have at least a basic understanding of children's mathematical development and how to support it, particularly if graduates will be entering roles that include leadership or mentoring of teachers or providers.

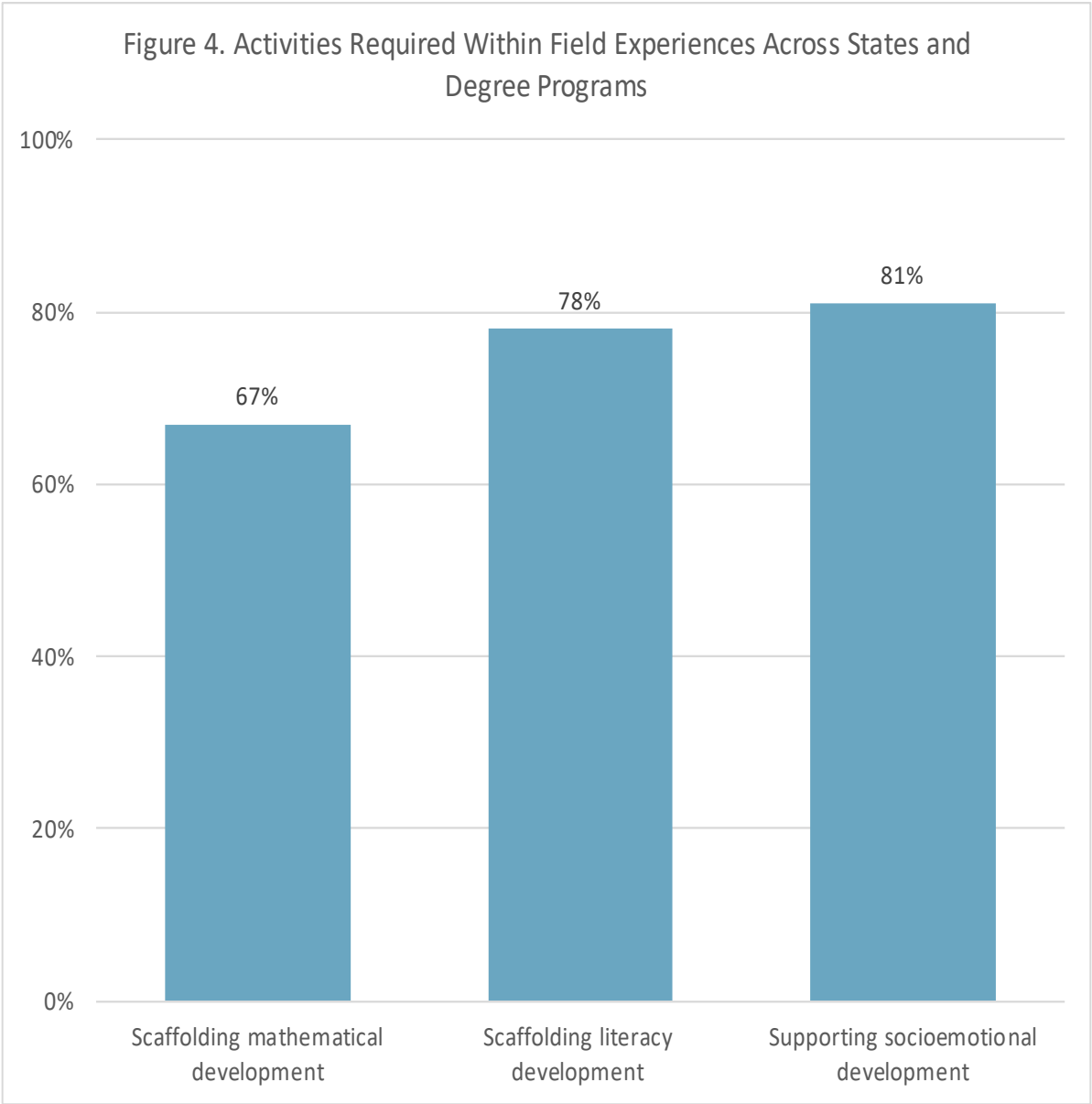
Field-based learning experiences are a particularly important element of early childhood degree programs because they provide an opportunity for students to translate what they have learned about children's development into practical teaching strategies for promoting children's learning.

Since content specifically focused on early math teaching and learning is not always a requirement of course topics, field experience offers another avenue to ensure that early childhood students receive guided, practical experiences teaching mathematical concepts and skills.

Across the four states noted above, scaffolding math development and understanding was also less likely to be required as part of student field experiences (student teaching or practica) than other topics, such as scaffolding children's literacy skills and supporting socioemotional development (see **Figure 4**).

Across all states and degree programs in this study, "scaffolding math development" was a field-experience activity required for early childhood education students in only 67 percent of programs, compared to the 81 percent of programs that required inclusion of practices to support children's socioemotional development.

Figure 4. Activities Required Within Field Experiences Across States and Degree Programs



Even in programs where math topics are a requirement for degree completion, field experiences are still an important way to ensure that students can practice integrating mathematical content into their future teaching practice. Providing a practical field-based learning experience while teaching mathematical content can also ensure that math topics are being taught in ways that support adult learners to fully engage with math materials, confidently and comfortably. This approach helps break the cycle of teachers feeling nervous or unsuccessful at math, which often leads them to avoid mathematical content in their classrooms.

> “In short, having content knowledge and knowing the major developmental milestones in any given subject area does no good if the educator does not know how to link that knowledge to instructional practices and engineer the learning environment to support children’s growth in that subject (IOM & NRC, 2015).

As suggested by Ryan, Whitebook and Cassidy, a creative way to address this issue could also be through contextualized math classes. These classes teach basic mathematics in a context of activities related directly to the day-to-day work of teaching young children (Ryan, Whitebook, & Cassidy, 2014). Contextualized math classes make math meaningful by applying it to concerns that are relevant to early childhood students. For example, planning the spatial layout of a classroom using basic geometry or asking students to calculate teacher-to-child ratios when teaching proportions can be powerful ways to help them master math concepts. In the same way that we ask teachers to make math hands-on and meaningful for children, degree programs can contextualize math to reduce anxiety. Solving for x becomes easier when x is the number of teachers needed in a classroom of 24 children in a state with a 1:10 teacher-child ratio.

Because the use of contextualized math classes can be an important strategy to increase students’ math efficacy, we asked states about whether they offered contextualized math classes in their degree programs. Across the states in our study, we found that only about one-quarter of all programs included contextualized math classes. States were slightly more likely to offer these types of math courses as part of a bachelor’s degree (28 percent) than in associate degree programs (25 percent) (see **Table 2)**.

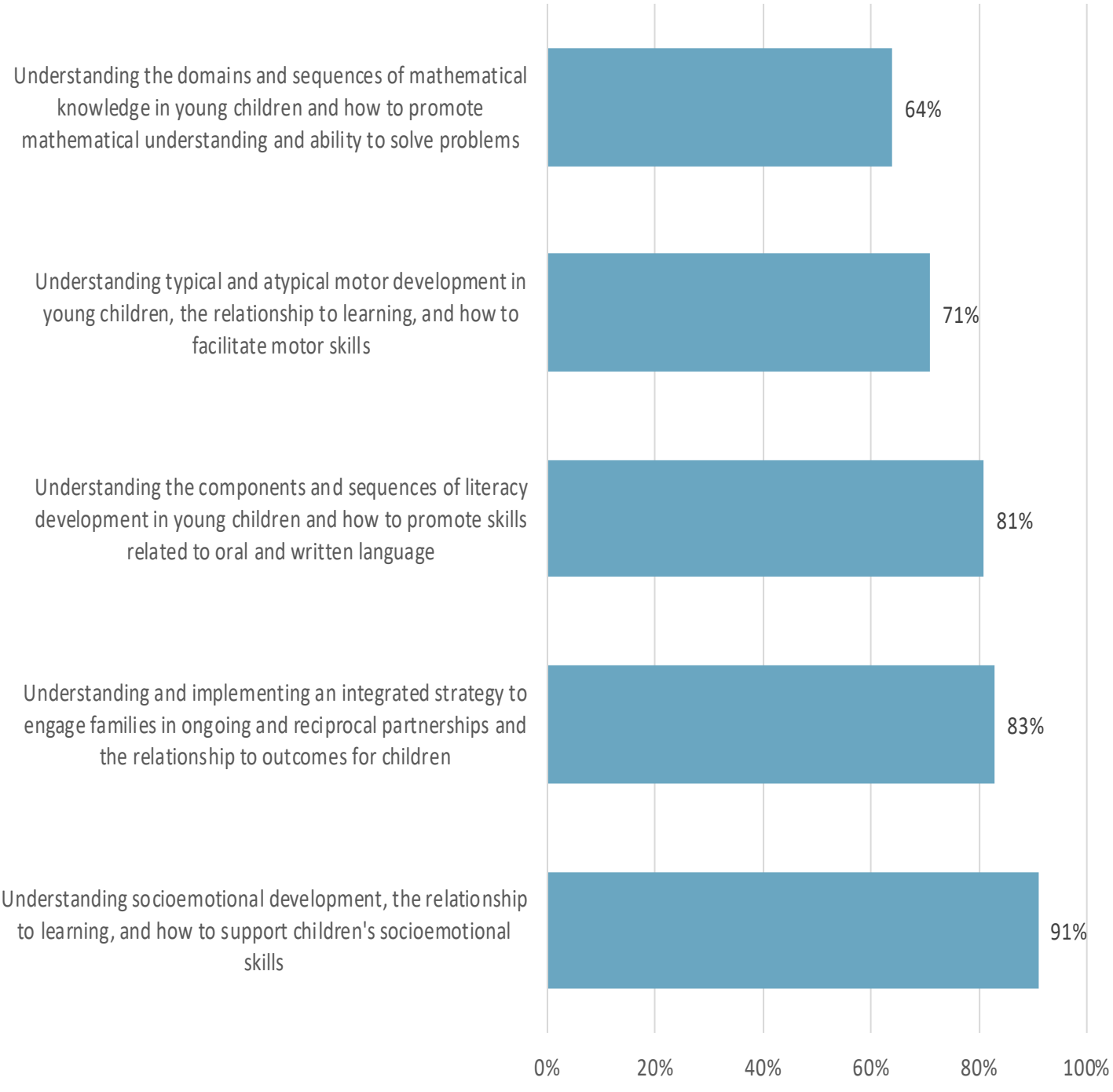
Table 2	Percentage of Programs Offering Contextualized Math Courses	
State	**Associate Degree**	**Bachelor's Degree**
Arkansas (N=11)	36%	38%
California (N=107)	11%	31%
Florida (N=18)	11%	31%
Indiana (N=28)	54%	26%
Nebraska (N=9)	33%	38%
New York (N=26)	23%	21%
Oregon (N=14)	7%	20%
Washington (N=16)	25%	18%
Average Across States	25%	28%

Faculty Beliefs About Early Math Education

> Less than one-third of faculty members believe it is very important to include math topics in programs for teachers of infants and toddlers.

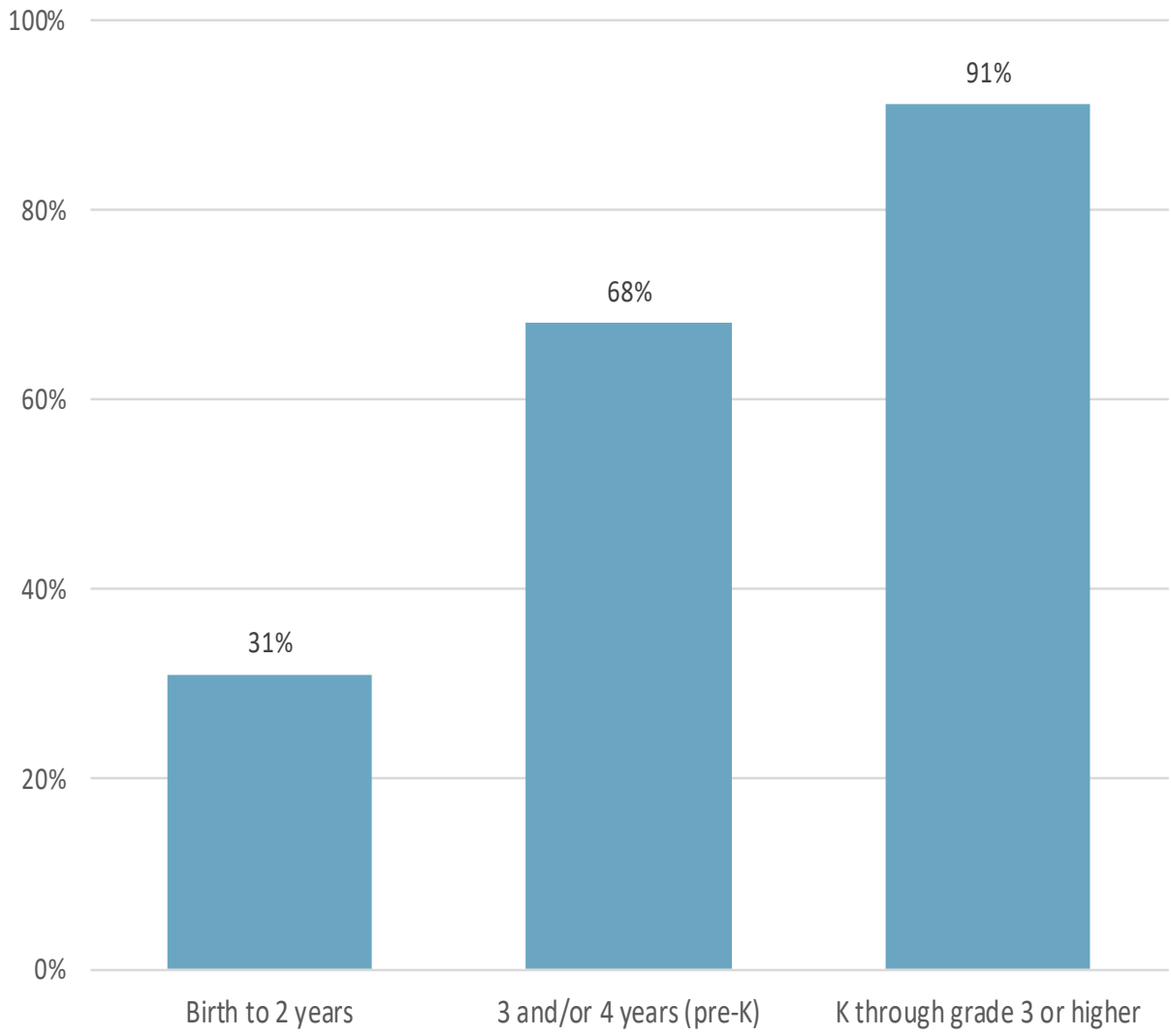
In the survey administered to faculty, we asked faculty members across all eight states about their opinions regarding the importance of including specific topics in the curriculum for ECE teachers. Faculty members across programs and states were less likely to note that early math education was "very important" to include in teacher preparation programs, compared with domains such as language and literacy, socioemotional development, and family engagement. While 92 percent of faculty members across programs and degree levels noted that it was very important to include the topic of socioemotional development in teacher preparation programs, only 64 percent of faculty members responded similarly regarding the inclusion of early math education for pre-service teachers (see **Figure 5**).

Figure 5. Importance of Math Relative to Other Topics: Percentage of Faculty Members Across States Indicating the Topic Is "Very Important"



On average, faculty members were less likely to indicate that math was as important to include in programs focused on teachers of younger children (birth through age four) as for teachers preparing to work with older children (kindergarten through third grade). Faculty members were almost three times more likely to believe that it was “very important” to include math in programs for teachers of kindergarten through third grade, as compared with teachers of infants/toddlers (91 percent and 31 percent, respectively; see **Figure 6**).

Figure 6. Importance of Including Math by Age Group: Percentage of Faculty Members Across States Indicating Math Is "Very Important" for Teachers of Young Children



The lack of importance given to the inclusion of math topics in the course of study for early childhood degree students points to a need to increase faculty commitment to and understanding of the value and necessity of including this topic for students who will be charged with promoting early mathematical understanding in our youngest learners. To address this challenge, some states have been purposeful about aligning assessment of student learning with early mathematical content. Student demonstration of competency in early mathematical teaching as a requirement for degree completion is a strategy that can help build faculty investment in the inclusion of such content. These assessments should confirm students' ability to support children in developing age-appropriate mathematical understanding and skills. For example, in New Mexico, educators are required to "describe and implement developmentally appropriate strategies based on the stages of reading and writing across the developmental continuum and identify ways to effectively implement these strategies" (New Mexico Early Childhood Higher Education Task Force, 2011). Similar competencies that require students to apply their knowledge of early math development (from birth to age eight) with effective teaching strategies and practices could strengthen the content in a degree program whose aim is to prepare students to teach in ECE settings.

Building support for including math in early childhood degree programs is also dependent on the degree to which there is consensus within both the early childhood field and the public at large that inclusion of this content is a priority for the ECE workforce. To build public awareness about the importance of this content area and how to successfully support early mathematics through developmentally appropriate and play-based learning experiences will take coordinated and widespread public awareness efforts both within the field and in the larger community.

One strategy to consider is to build upon recent research about the importance of early math to children's later success in school and life in order to educate the public about this issue. Such a campaign could use lessons learned from the successful focus on early literacy, aimed at improving the school readiness and success of America's children. The ECE field has spent more than a decade focused on early literacy. In fact, many of the current tools used to observe and evaluate teachers' practice were developed out of a body of research about the types of professional development that result in improved child outcomes in language and literacy (Mashburn et al., 2008; Powell, Diamond, Burchinal, & Koehler, 2010; Wasik & Hindman, 2011). In response, the early childhood field has increased its focus on these teaching practices through coaching, mentoring, and coursework to prepare the early childhood workforce to provide the types of learning experiences that promote language and literacy skills.

This focus on early literacy was confirmed by faculty members participating in the *Inventory* and points to the need for a similar concerted focus on early mathematics to increase public awareness and buy-in regarding the importance of children's early mathematical development. Such a campaign can help push the ECE field, and those who prepare our workforce, to increase attention to early math experiences for children in the early childhood years.

Faculty Capacity & Experience Teaching Early Math Education

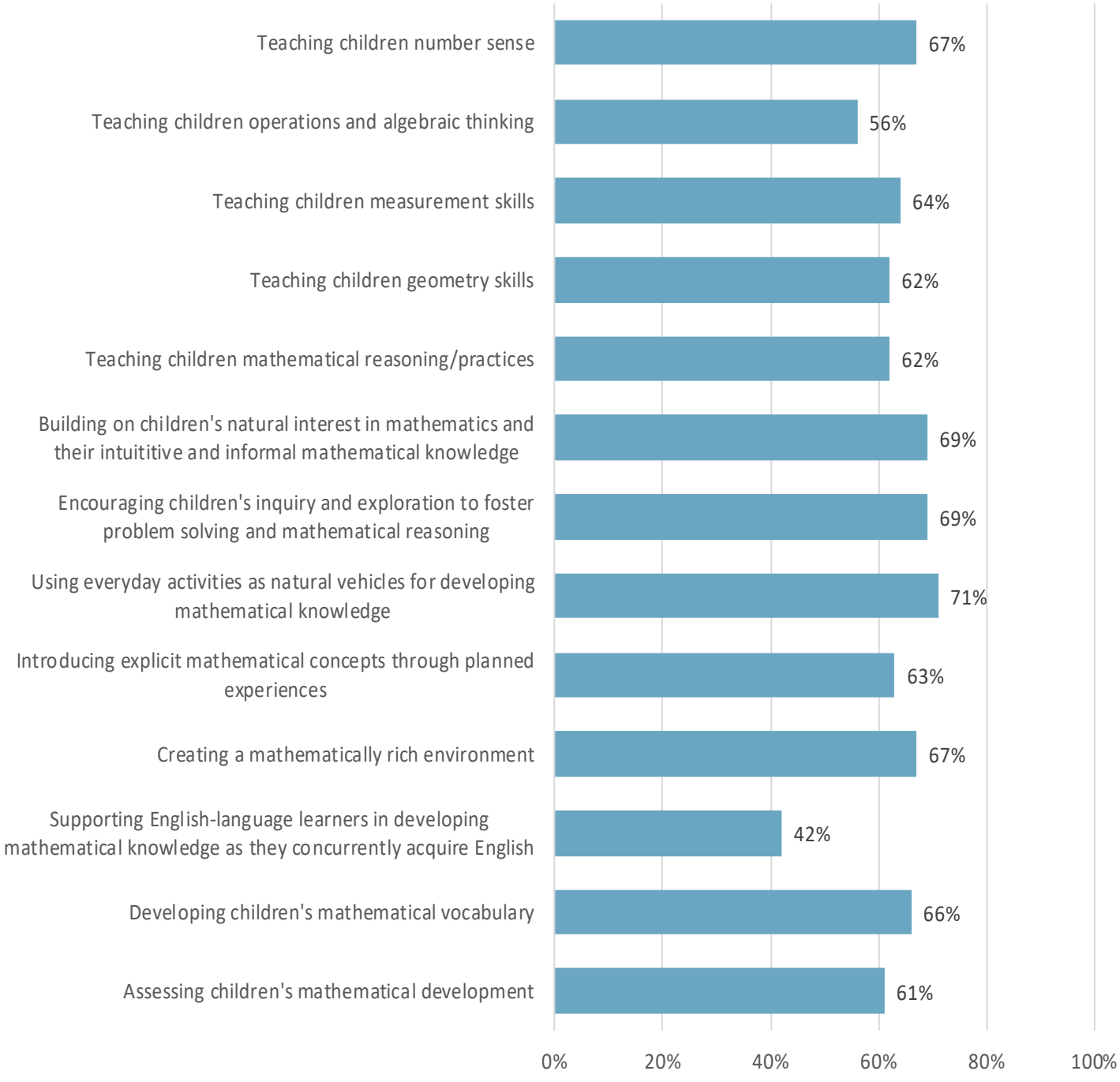
Another key factor in whether or not early math topics are included as a focus of early childhood education degree programs is faculty members' capacity to deliver such content. Faculty members were asked how knowledgeable and capable they felt in preparing teachers to promote young children's mathematical understanding and problem solving. Faculty members in all degree programs noted feeling most competent educating ECE professionals working with preschool-age children, as compared with either younger or older students: this finding was true for all math topics listed on the survey. When looking at specific degree programs, faculty teaching in associate degree programs were slightly more likely than their peers in bachelor's or master's degree programs to note feeling capable of preparing teachers in these topics, regardless of the age of the children upon which the program was focused. This finding was especially true for content focused on very young children (birth through age four). For content focused on this age group, an average of 8 percent more associate degree faculty members felt capable of training teachers in mathematical subjects, compared to faculty members teaching at other degree levels. For content focused on older children (kindergarten through third grade), faculty members responded more similarly across the degree types.

Across all degree types, faculty members varied in their confidence in their ability to cover specific topics in teacher preparation programs. Faculty members across degree types felt most capable with broad, informal topics within math education: using everyday activities to develop children's math knowledge, encouraging children's inquiry and exploration to foster problem solving and math reasoning, and building on children's natural interest and informal math knowledge. Conversely, faculty members generally reported feeling less capable of teaching more concrete or tangible skills (e.g., operations and algebraic thinking, assessment of children's skill development) (see **Figure 7**).

To determine faculty experience with teaching math concepts, faculty members in four states (California, Indiana, Nebraska, and New York) were asked whether they had taught courses that included the 13 early math topics within the past two years. In general, faculty members across all degree types reported having the most experience recently teaching math topics to teachers working with preschool-age children (three- and four-year-olds) than those working with younger (birth to two years) or older children (kindergarten to third grade). An average of 86 percent of faculty members at all degree levels reported teaching each topic in programs focused on preschool-aged children, while an average of 51 percent and 61 percent reported teaching these topics in programs for infants and toddlers and early elementary students, respectively.

Faculty members teaching in associate degree programs were even more likely to have taught these topics recently, with 90 percent or more reporting that they had covered each topic in programs focused on preschoolers (with the exception of supporting dual language learners at 79 percent). At least three-quarters of faculty members in bachelor's and master's programs had taught each of these topics in programs for preschool teachers within the last year, as well.

Figure 7. Faculty Knowledge and Preparedness to Teach Math Topics: Percentages of Faculty Members Across States Indicating the Capacity to Teach Content to Teachers Working With at Least One Age Group of Young Children



> In some cases, more faculty members reported teaching specific topics for specific age groups than feeling capable of doing so, which raises some questions about the potential quality of instruction in these areas and the need for faculty professional development.

For these same four states, faculty members reported teaching each of the topic areas at about the same rates (around 65-70 percent), with the exception of supporting dual language learners and operations and algebraic thinking, both of which were taught by slightly fewer faculty members (61 percent). It is interesting to compare the percentage of faculty members who noted feeling capable of teaching these topics with the percentage who said they have taught the topics in the past two years. In some cases, more faculty members reported teaching specific topics for specific age groups than feeling capable of doing so, which raises some questions about the potential quality of instruction in these areas and the need for faculty professional development. In particular, faculty members reported teaching courses for practitioners working with preschool-age children at higher rates than they reported feeling capable of teaching that content.

Faculty Experience With & Interest in Early Math Education Professional Development

To assess ongoing learning for faculty in early childhood higher education programs, the faculty module included questions around prior experiences with professional development and interest in future professional development opportunities. Faculty members were asked to indicate which professional development experiences they had participated in during the past three years (see **Figure 8** for topics). Across all eight states, few faculty members noted having participated in early math-related professional development activities within the past few years. In general, less than one-third of faculty members across degree types (and usually far fewer) said that they had participated in professional development in each of the topics listed.

Among all faculty members, the most common topics addressed in recent faculty professional development included “teaching practitioners to implement instructional strategies that support mathematical understanding in children ages three and four,” “teaching practitioners how to effectively use assessment to inform and individualize their instruction,” and “teaching practitioners to create mathematically rich environments for young children.” When asked about their interest in future professional development opportunities in the realm of early math education, faculty members in associate degree programs noted the greatest interest in these opportunities, followed by bachelor’s degree faculty. Master’s degree faculty were least likely to say that they were “very interested” in professional development related to early math education.

In general, faculty members were most interested in topics to help ECE teachers integrate math into the curriculum and children's daily activities, create a mathematically rich environment, teaching practitioners to implement instructional strategies that support mathematical understanding in children ages three and four (pre-K), and learning strategies to assist teachers who struggle with math to build confidence in their ability to teach math to their students (see **Figure 8** for topics).

Figure 8. Percentage of Faculty Members Across States Indicating They Are "Very Interested" in Select Professional Development Topics

Recommendations for Program Practice & Policy

Studying the eight states included in this brief offers a window into the types of math topics that early childhood education higher education programs are requiring across degree programs as well as the teaching efficacy of faculty related to these topics. Across these studies, we found that degree programs within these states required a number of topics related to key early mathematical development and that faculty members indicated that they include these topics in their courses. However, these topics were more prevalent in course content focused on preschool-age children than for children birth to age two or for older children (K-3 grade). As part of this analysis, we also learned about the professional development needs of faculty members in this area and how competent they feel teaching early mathematical content. The following section includes recommendations for program and policy considerations based on our findings.

Program Recommendations

Early childhood education degree programs should align required content with the core competencies teachers need to provide effective instruction in early mathematics. To promote the inclusion of mathematical topic content that addresses children's mathematical development — from infancy through third grade — programs should ensure that the content of their early childhood degree program coursework is aligned with the core competencies needed by teachers to support instruction in early mathematics not only for preschool-age children, but also for infants and toddlers and for children in grades K-3. Degree content should ensure that graduates not only understand the developmental milestones of early mathematics, but also the early math learning trajectories, which include the developmental progression of mathematical understanding and skills as well as the instruction that helps young children develop and refine those skills.

> "Given its central role in children's development and in prediction of school success, more emphasis is needed on training educators to teach mathematical concepts, reasoning, problem solving, and communication (IOM & NRC, 2015).

Degree program assessments should include a focus on demonstrated competency in early mathematics. Where programs of study require students to complete assessments like a teaching portfolio to demonstrate competence, including a focus on the demonstration of mathematics teaching competency would underscore the value of mathematics as a key subject-matter area for faculty and students.

Field-based experiences should be embedded throughout the students' course of study and occur while students are simultaneously learning about mathematical development and instructional methods. In most degree programs, early childhood education students are required to complete multiple practicum courses, and these courses often focus on specific skills or areas of development. Ideally, students should complete their field-based experiences alongside their learning of these skills and areas of development, so that they have the opportunity to apply what they are learning to their classroom practice (Whitebook et al., 2009). To help ECE professionals understand how to apply their knowledge of early math development into effective teaching practices, programs should ensure that that high-quality field placements during student teaching are embedded throughout their course of study and occur while they are simultaneously learning about mathematical development and methods for developmentally appropriate instruction.

Programs preparing early childhood education students to work directly with children in early childhood settings should offer accessible, contextualized coursework on early mathematical development and how to support it. Another way to promote accessible course content related to mathematics is for early childhood education degree programs to consider using clinical or practice faculty with current experience in early math curriculum and instruction in ECE settings in order to make the content meaningful to students who are already teaching or plan to teach in an ECE program after graduation.

Policy Recommendations

Increase awareness about the importance of math in infant/toddler programs and classrooms — both within the ECE field and in the larger community. Similar to the national campaign that shed light on the importance of early language and literacy, a focus on the importance of early math is necessary to ensure that this content is included in early childhood education degree programs across the country. Building public awareness of the importance of early math can also act as a catalyst for increased attention to the topic in the related areas of ECE curriculum and assessment. Strong teacher preparation and ongoing professional learning in early mathematical content can help ensure that early math teaching and learning is commonplace in ECE settings across the country. Increasing awareness in the public at-large as well as within the field of early childhood education is critical to moving the needle on the inclusion of early mathematical content in early childhood degree programs. Such a campaign should build on the success the field has experienced in garnering support for early literacy and should focus on recent findings that math development begins in infancy and that math and play-based learning go hand in hand.

Ensure alignment of early math standards across programs meant to prepare teachers and other ECE professionals (within and across states). In the states included in this study, only about one-half of degree programs included key math topics as part of their curricular requirements. Given the limited inclusion of early math topics, it is even more important to ensure that the content being delivered is consistent and aligns with what we know teachers need to support children's mathematical development and learning. Early childhood education degree content should meet the

standards for the preparation of Early Childhood Teachers of Mathematics from the Association of Mathematics Teacher Educators (AMTE) and also align with national teacher preparation standards, such as those from the National Association for the Education of Young Children (NAEYC) Early Childhood Associate Degree Accreditation (ECADA) and the Council for the Accreditation of Educator Preparation (CAEP). Aligning content with national standards for educator preparation programs can help to ensure that early childhood teachers are receiving consistent content related to early mathematical development and learning and that degrees that lead to teacher certification prepare teachers to work across state lines.

Provide professional development that is accessible and builds upon faculty members' existing knowledge, experience, and strengths. Investing in professional development for faculty in early math development and learning, including appropriate methods for teaching such content to early childhood education students, is essential if we are to increase the level of preparedness faculty members feel regarding this content. Faculty members' lack of confidence in their ability to support students in this area is consistent with research that identifies a broader issue in ECE and higher education related to math anxiety (Copley, 2004; Ginsburg, Lee, & Boyd, 2008). This situation is exacerbated by issues of gender, since the majority of early childhood education faculty are female. Studies have consistently concluded that girls and young women show less confidence and more anxiety around math content and coursework than their male peers, even from a young age (Ganley & Lubienski, 2016). This reality results in less exposure to math content and fewer choices by women to pursue education or employment in math-related fields. Taken together, these issues of lack of confidence in and exposure to math content point to the need for strong professional development supports for faculty.

Supporting faculty members to feel competent in early mathematical content is not unlike the supports needed for students: hands-on and meaningful professional development on mathematical content to build understanding and confidence in teaching early math concepts. In addition to content, faculty as well as early childhood students and practitioners can benefit from coaching or mentoring on the topic of teaching math. The chance to observe clinical or practice faculty, who are fresh from teaching math in early childhood settings, as they teach practicum or math methods courses, can provide powerful modeling for faculty members who struggle with how to embed math content into their courses in meaningful ways.

Concluding Thoughts

Support for early math development begins in infancy as adults engage infants in learning about mathematics in the world around them. Preparing early educators to optimize that learning requires degree programs with robust early math content and faculty members who feel prepared to teach that content in ways that build early childhood education students' mathematical teaching efficacy. Reaching this goal will require a concerted effort to engage faculty around the importance of early math and offer professional development that builds their confidence and skills in this area. Providing children with teachers who understand how to design early math learning experiences in developmentally appropriate ways also requires that we ensure hands-on, adult learning-centered approaches in their teacher preparation programs. With institutes of higher education already facing significant financial challenges, enhancing the ability of degree programs to provide more robust content and more prepared faculty will require increased public investment in early childhood education higher education programs.

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This report is part of *By Design: Preparing Early Educators*, a series of briefs exploring strategies to support effective and accessible early childhood teacher preparation in institutions of higher education. The briefs take a closer look at the content of curricula and experiences that are offered to students in early childhood degree programs across states that participated in the *Early Childhood Higher Education Inventory*, carried out by the Center for the Study of Child Care Employment from 2012 to 2017. Future reports in this series will examine other topics of interest related to the preparation of early educators.

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Center for the Study of Child Care Employment
Institute for Research on Labor and Employment
University of California, Berkeley
2521 Channing Way #5555, Berkeley, CA 94720
(510) 643-8293
cscce.berkeley.edu

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