# Research-to-Practice Summary
# What do we know? Reflecting on changes in knowledge of mathematical development in pre- and in-service early childhood teachers

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## ABSTRACT

This study examines whether students in early childhood teacher education programs gained more knowledge of early math development in 2017-2018 when compared to 2008. I compare data from each period on pre- and in-service teachers' knowledge of mathematical development as measured by the Knowledge of Mathematical Development Survey (KMDS). I found that the KMDS mean scores of students in each of the education groups (beginning versus seniors versus math course) differed within each collection year. In a statistical comparison between the two collection periods, there was no significant difference between the mean scores from 2008 and 2017-2018 for the beginning group. However, there was a significant difference between 2008 and 2017-2018 in mean scores in the seniors and math course groups. Overall, all mean KMDS scores were lower in 2017-2018 when compared to 2008.

## KEYWORDS
Early mathematics, early childhood education, preservice, in-service, teachers

How much the world has changed over the last few decades. The phenomenal progress in science, technology, engineering, and mathematics (STEM) is unprecedented. We now live in a world where there are gene-editing cures for inherited diseases (Yang et al., 2024), computing power that continually increases in speed and capacity (Markoff, 2016, 2023), and solar panels that are integrated into building materials (Vijayan et al., 2023). Mathematics has been at the core of all of these advancements.

The use of mathematics is also an essential part of everyday life outside of these professions. Financial knowledge is differentially distributed in the United States resulting in socioeconomic disparities. Those individuals with more knowledge are more likely to apply for and acquire loans with lower interest rates,

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manage credit card debt efficiently, obtain financially effective insurance, and save for retirement (Lusardi & Mitchell, 2023). The foundation of these skills is numeracy (Lee & Nam, 2023).

Mathematical development and skills, similar to many other learning domains, builds upon prior knowledge. Research in early mathematical development supports the idea that even infants possess rudimentary mathematical abilities (Visibelli et al., 2024). This knowledge continues to build through the years prior to formal schooling. However, this knowledge is also highly dependent on environmental influences (Gashaj et al., 2023; Silver & Libertus, 2022).

In 2007, Duncan and colleagues published a meta-analysis of influences of preschool-level skills on academic success at 3rd and 5th grade. This and other prior and concurrent studies (Baroody, 2004, Foster, 2010; Grimm et al., 2010; Hooper et al., 2010; Pagani et al., 2010) illustrated the considerable influence of early math knowledge on later academic skills. In the last decade more research has been conducted to determine the influences of early mathematical skills (Duncan & Magnuson, 2011; Geary et al., 2013; Jordan et al., 2009; Kwok et al., 2021). These studies and more continue to support the theory that early and sustained high quality support for mathematical development is a vital part of curriculum. Relatedly, in 2007 new legislation was passed requiring, by 2013, at least 50% of Head Start teachers to possess a bachelor's degree in early childhood education (Improving Head Start for School Readiness Act). The implication was that this education would better ensure that teachers were prepared to support children's intellectual and physical development, including their "understanding of early math" (Section 19, p. 121).

In 2023, the percentage of the U.S. population enrolled in state-funded preschools reached an all-time high of 35% of four-year-olds and seven percent of three-year-olds (Friedman-Krauss et al., 2024). If we broaden the lens to include all non-parental care, almost 70% of families with young children utilize some external early education and care resource, including Head Start (National Academies of Sciences, Engineering and Medicine, 2018, p. 57). These statistics, combined with the knowledge that mathematical development is greatly dependent on environmental influences, highlight the need for these early education and care settings to provide supports for mathematical development.

In fact, studies have shown that early childhood programs that provide a rich mathematics curriculum can result in increases in math, language and literacy skills in young children (Gormley et al., 2018; Joo et al., 2020; Mattera et al., 2021; Sarama et al., 2012; Wang et al., 2016). Black and Latino students may benefit from these programs even more than their peers (National Academies of Sciences, Engineering, and Medicine, 2023). However, many early childhood programs do not provide a rich environment (p. 67).

Many state early learning standards have undergone revisions in the decade under review (Gable & Fozi, 2023; p. 1844), seeking to improve children's early education experiences. However, supporting mathematical development in centers and preschool classrooms requires that teachers are prepared to provide that support. Research evidence prior to and post 2008 indicate that teachers may not be provided with the education and experiences that result in the ability to extend support in their classrooms (Bachman et al., 2018 Cerezci, 2021; Ginsburg et al., 1999; Klibanoff et al., 2006; Sarama et al., 2004). Relatedly, instructors in teacher education programs may not be prepared themselves to provide this essential instruction (Copeman Pettig, et al., 2018; Ginsburg et al., 2006; Wright et al., 2021).

Given this research on the importance of early mathematical development, the influences of its supports in the environment, the preparedness of early childhood teachers to provide that support, and the ability of college and university professors in teacher preparation programs to provide related pedagogical instruction, it is of interest to know whether pre- and in-service early childhood teachers were better prepared to support children in their classrooms in 2017-2018 when compared to 2008. Specifically, do these teachers have more knowledge of mathematical development than those from the previous decade?

## Purpose of the Study

Drawing from a dataset gathered in 2008 (Platas, 2008) and data gathered in 2017-2018, I sought

to ascertain whether pre- and in-service teachers' levels of knowledge of mathematical development in young children had changed over the decade. Given that many teacher preparation programs were drastically altered during COVID in 2020-2021 (VanLone et al., 2022; especially with a lack of in-person instruction and student internships), the timing of the research provides a window in which teacher preparation programs were conducted as business-as-usual.

### Summary of Research Methods

The participants were recruited through a stratified purposeful sampling method in 2008 (N= 346) and 2017-2018 (N = 338) from community colleges and universities in three states in the western and eastern United States. Three categories of pre- and in-service students in early childhood education teacher preparation programs were created from the pool of participants: beginning (first- and second-year students enrolled in child development entry courses at community colleges and four-year universities), seniors (seniors with no math course), and math course (graduate master's and undergraduate upper division students who had completed a 3-semester unit math development course). Students who did not fit one of these categories were excluded from the analyses.

Participants completed a short demographics survey and the Knowledge of Mathematical Development Survey (KMDS; Platas, 2008; 2014), a 20-item survey on young children's mathematical development. The KMDS was developed in 2007; instrument validation and reliability were supported through several pilots and a validation study (Platas, 2014). It has since been used in several studies (Cox, 2011, Kim, 2013; Lange, Nayfield, et al., 2022). The demographics survey included questions on ethnicity, age, education and teaching experience.

### Findings

An analysis of variance (ANOVA) test showed that there were statistically significant differences in 2008 between all KMDS mean scores of the three categories (beginning, seniors, and math course) of pre- and in-service teachers (11.18, 12.81, and 15.30, respectively). In 2017-2018 there were statistically significant differences only between the mean scores of the beginning group (10.58) and seniors group (11.63) when compared to the math course group mean (13.54). This meant that there was no statistically significant difference in 2017-2018 between the beginning and seniors groups.

When comparing 2008 and 2017-2018, there was no statistically significant difference between the beginning group means (11.18 and 10.58, respectively). There was a significant difference between the seniors group means (12.81 and 11.63, respectively; $p = 02$). There was a larger significant difference between the math course group means from each of the years (15.30 and 13.54, respectively; $p < 0.001$). Note that in all comparisons from 2008 and 2017-2018, mean scores from 2008 were significantly higher.

Because the math course groups were drawn from undergraduate, graduate, and mixed undergraduate/graduate courses whereas the beginning and senior groups were drawn from only undergraduate programs, it was important to ascertain whether there was a difference that resulted from enrollment in graduate-level programs (e.g., perhaps the graduate programs were more exclusive in enrollment than the undergraduate programs, resulting in selection bias). However, in a comparison of mean KMDS scores across all eight math courses, there were only significant differences between math course A (graduate course) and courses G and H (undergraduate courses). The remaining 25 comparisons between math courses (undergraduate, graduate, and mixed) showed no differences. In conclusion, results showed that education level did not significantly affect the mean scores across these math courses.

A univariate analysis showed that two or more years of classroom experiences significantly increased mean KMDS scores for only those participants in the math course groups (an increase of 1.02/20 possible points). KMDS scores of the beginning and senior participant groups did not significant increase with two or more years of classroom experience.

### Implications for Practice

In 2008, it was quite difficult to find math

courses in preschool teacher preparation programs. However, the courses I was able to survey were of quite good quality, with all instructors having published research on early math development and teaching. On the contrary, in 2017-2018, it was much easier to find courses to survey. However, of the instructors in 2017-2018, only one had published on math development (the only overlapping math instructor from 2008).

Given the increasing importance of math development in early childhood research and new standards, it could be expected that early childhood teacher preparation program students in the decade following 2008 would graduate better equipped to support mathematical development in centers and classrooms. But the analyses did not support that hypothesis. We know that teachers and teacher educators want what is best for young children. So where is the breakdown?

In Copeman Pettig and colleagues' (2018) study across eight states, teacher educators reported being ill-prepared themselves to teach math in their curriculum. Yet, according to the research, feel compelled to teach it anyway. It appears that the desire is there, but the knowledge is not.

There are resources that could make inroads in remedying this mismatch in desire and knowledge. Head Start itself has rich resources at least going back to 2010. High Five Mathematize (National Head Start Family Literacy Center for the Office of Head Start, 2010) was an early extensive training guide for teachers and those who support them (instructors, mentors, directors). The Head Start Performance Standards are being updated, but the Interactive Head Start Early Learning Outcomes Framework: Age Birth to Five (Office of Head Start, 2015) still contains valuable resources on mathematical development and how to support it.

A multi-university network, the Development and Research in Early Mathematics Education (DREME; n.d.) has free resources specifically for teacher educators. Modules include information on supporting counting, spatial relations, operations, patterns and algebra, and measurement and data in early childhood classrooms. The modules contain short and practical research background readings, descriptions of development, activities for the classroom, and ideas for assessment.

The National Association for the Education of Young Children (NAEYC; n.d.) publishes both teacher- and educator-friendly articles and books on early math. Many of their publications provide information on mathematical understanding and practical applications for center and preschool classrooms (Turrou et al., 2021).

States also have been legislating support for their early learning math standards (Education Commission of the States, n.d.). These include professional development, coaching resources, teacher preparation program standards, and more.

Finally, as we know, public policies can promote or challenge efforts in the classroom. Policies that come to mind that promote more effective and sustainable math development in the preschool classroom and beyond are better instilling coherence, alignment, and coordination in teacher education programs, school districts, and state standards. Early childhood and elementary teacher education programs can coordinate their instruction so that teachers graduate understanding the full scope of development from birth through elementary and how to support such practices in the classroom (Lange, Robertson, et al., 2022).

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School districts and their early childhood partners, whether within or outside the district, can share knowledge about children's progress and teaching pedagogy (Stein & Coburn, 2023). Head Start has examples of this (Cook & Coley, 2019). States can examine their early childhood standards and elementary standards (usually based on the Common Core State Standards; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) to better ensure that both content and pedagogy are aligned (Whitaker et al., 2022)

Perhaps I am optimistic, but I am hopeful that we will see improvements in all of the preceding policy areas, and that they will result in richer mathematical environments and experiences for our young children. I believe interest and ability are there at all levels, from children to teachers to teacher educators.

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