Equity and Mathematics Education

A kindergartner stepped up to research assistant grinning and showing her "Happy Birthday" crown. The assistant asked how old she was. The girl stared without responding. "Can you show me on your fingers?" The girl slowly shook her head "no."

As we saw in our first Kennedy Institute position paper ("Education and Equity"), students in some groups, such as those from low-income communities, demonstrate significantly lower levels of achievement. This is especially true of achievement in the domain of mathematics (1-5). In this position paper, we address issues regarding equity in mathematics achievement and education, including students who live in poverty and who are members of linguistic and ethnic minority groups (the next position paper will address students who have mathematical disabilities or difficulties).

Poverty and Minority Status

The U.S. mathematics education system needs substantial improvement. The mathematics achievement of American students compares unfavorably with the achievement of students from many other nations, even as early as first grade and kindergarten (6). Some cross-national differences in informal mathematics knowledge appear as early as three to five years of age (7, 8). Children in East Asia and Europe learn more advanced math than most children in the U. S. are taught (9).
Further, children from some groups come to school with fewer experiences in mathematics than others. Yet they have full potential to learn.

Further, children from some groups come to school with fewer experiences in mathematics than others. For too many, these differences do not disappear. In the U.S., they increase (10). That is, the "achievement gap" does not close; it widens (9). This gap is most pronounced in the performance of U.S. children living in economically deprived urban communities (11-15). There is no age so young that equity is not a concern. The achievement gaps have origins in the earliest years, with low-income children possessing less extensive math knowledge than middle-income children of pre-K and kindergarten age (3, 14, 16-20). As one example, the ECLS-B found that the percentage of children demonstrating proficiency in numbers and shapes was 87% in higher SES families but only 40% among lower socioeconomic status (SES) families (21, but this involved simply reading numerals and so the report does not provide useful details). These differences start early and widen (22).

Equity demands that we establish guidelines for quality mathematics education for all children.
What Accounts for These Differences?

It is not parents’ IQ or children’s ability to learn (see our Position Paper #1.) The key factors in one study were the educational level attained by the child's mother and the level of poverty in the child's neighborhood (23). These are distinct factors, with income having a direct effect on the child and also an effect that is mediated by the parents’ interaction with children (e.g., higher, compared to lower, income parents providing more support for problem solving, 24, 25). Similarly, an analysis of the ECLS data shows that SES indicators and the number of books in the home both strongly predict math (as well as reading) test scores (26, also controlling for these substantially reduces ethnic differences). Low SES children score .55 standard deviations below middle-SES children and 1.24 standard deviations below high-SES children. Differences in parents’ beliefs may also play a role. Compared to middle-income parents, lower-income parents believe that math education is the responsibility of the preschool and that children cannot learn aspects of math that research indicates they can learn (7). Also, low-income families more strongly endorsed a skills perspective than middle-income families, and the skills and entertainment perspectives were not predictive of later school achievement. What was predictive was the “math in daily living” perspective adopted by more middle-income parents (27). Such deleterious effects of living in low-resource communities are more prevalent and stronger in the U.S. than other countries and stronger in early childhood that for other age ranges.

Equity Concerns Start Early

Consider these two children. Peter was at the highest levels of competence in number. He could count beyond 120, state the number word before or after any given number word, including those in the hundreds. He could also read those number words.
Finally, he could use counting strategies to solve a wide range of addition and subtraction tasks. Tom could not count. The best he could do is say “two” for a pair of objects. Asked for the number after "six," said "horse." After one, he said, come "bike." He could not read any numerals.

*Both Peter and Tom were beginning their kindergarten year (28).*

Some children have acquired number knowledge before the age of 4 that other children will not acquire before the age of 7 (29).

A large-scale study of this gap, a survey of U.S. kindergartners found that 94% of first-time kindergartners passed their Level I test (counting to 10 and recognizing numerals and shapes) and 58% passed their Level 2 test (reading numerals, counting beyond 10, sequencing patterns, and using nonstandard units of length to compare objects). However, 79% of children whose mothers had a bachelor's degree passed the Level 2 test, compared to 32% of those whose mothers had less than a high school degree. Large differences were also found between ethnic groups on the more difficult Level 2 test (30). Differences appear even in the preschool years.

Other analyses from the same large ECLS showed that children who begin with the lowest achievement levels show the lowest growth in mathematics from Kindergarten to the 3rd grade (31). The authors conclude that more time on mathematics for these children in preschool is essential.
These studies have a clear message. *If high-quality mathematics education does not start in preschool and continue through the early years, children are trapped in a trajectory of failure* (32). Another study combined the two types of comparisons. Results showed that mathematical knowledge is greater in 3- and 4-year-old Chinese children than in American middle-class children and greater in American middle-class children than in 3- and 4-year-olds from low-income families (7).

Young children from low-income families show specific difficulties in mathematics. Too often, they do not understand the relative magnitudes of numbers and how they relate to the counting sequence (12). They have more difficulty solving addition and subtraction problems. Working-class children in the U.K. are a year behind in simple addition and subtraction as early as 3 years of age (33). Similarly, U.S. low-income children begin kindergarten behind middle-income children and, although they progressed at the same rate on most tasks, they ended behind and made no progress in some tasks. For example, although they performed adequate on nonverbal arithmetic tasks, they made no progress over the entire kindergarten year on arithmetic story problems (34). Further, lower-class children were more likely to show a “flat” growth curve for the year.

A recent survey of preschoolers’ competencies (35) revealed that children from preschools serving middle-SES populations outperformed those serving low-SES populations on the total number score and most individual subtests. The particular subtests that showed significant differences were, with few exceptions, those that measure more sophisticated mathematical concepts and skills. In number, there we no significant differences for simple verbal counting or recognition of small numbers (36, 37).
were significant differences on object counting and especially more sophisticated counting strategies, comparing numbers and sequencing, number composition, arithmetic, and matching numerals to dot cards. In geometry, there were no significant differences on the simple tasks involving shape and comparison of shapes. There were significant differences on representing shapes, composing shapes, and patternning.

Other research from across the world confirms the finding that there is greater variation in number knowledge among young children of lower SES background (29) and that there is a definite trend for students from lower SES backgrounds to perform at a lower level, and this was more apparent for the difficult items (38, see also 39). This was especially so for beginning kindergartners in the verbal counting and numeral recognition. On the other hand, the most advanced children were the least well served. They were learning nothing throughout the entire kindergarten year. They did not advance in reading multi-digit numerals throughout their first grade year.

Similarly, lower-income preschoolers lag behind higher-income peers in the earliest form of subitizing, spontaneous recognition of numerosity (40). They often lack foundational abilities to classify and seriate (41). Older children entering first grade showed a smaller effect of familial factors on computation than on mathematics concepts and reasoning. Majority-minority contrasts were small, but parents’ economic and psychological (e.g., high school graduation) resources were strong influences (42).

Early research indicated that such problems have existed for decades, with serious negative effects (22). The first year of school has a substantial influence on the trajectories of young children’s knowledge of number. Black children gained less than white children in this study, and the gap widened over a two-year period. Transitions to
school, and recovering from initial gaps in learning, may be more problematic for black children than white children.

Into kindergarten and the primary grades, lower-income children use less-adaptive and maladaptive strategies more than middle-class children, probably revealing a deficit in intuitive knowledge of numbers and different strategies (12, 15). Most 5- and 6-year-old low-income children are unable to answer the simplest arithmetic problems, where most middle-income kindergartners could do so (12). In one study, 75% of children in an upper middle class kindergarten were capable of judging the relative magnitude of two different numbers and performing simple mental additions, compared to only 7% of lower-income children from the same community (12, 43). As another example, about 72% of high, 69% of middle and 14% of low-SES groups can answer an orally-presented problem, “If you had 4 chocolate candies and someone gave you 3 more, how many chocolates would you have altogether?” Low-income children often guess or use other maladaptive strategies such as simple counting (e.g., $3 + 4 = 5$). They often do this because they lack knowledge of strategies and understandings of why they work and what goal they achieve (15) However, given more experience, lower-income children use multiple strategies, with the same accuracy, speed, and adaptive reasoning as middle-income children.

In summary, the SES gap is broad and encompasses several aspects of mathematical knowledge: numerical, arithmetic, spatial/geometric, patterning, and measurement knowledge (35, 44). The reason for this gap appears to be that children from low-income families receive less support for math development in their home and school environments (7, 14, 45, 46). Public pre-K programs serving low-income,
compared to those serving higher-income, families provide fewer learning opportunities and supports for mathematical development, including a narrower range of mathematical concepts (47, 48). Lack of resources is the main problem, but research indicates it is not the only explanation. There are also differences in attitudes, motivations, and beliefs that need to be addressed (10). For example, "stereotype threat" — the imposition of societal biases such as the lower ability mathematics of Blacks or woman to learn mathematics — can have a negative influence on the performance of the threatened groups (10). We need research on whether this affects young children and how this and other problems can be avoided.

Further, quality is lower in classrooms with more than 60% of the children from homes below the poverty line, when teachers lacked formal training (or a degree) in early childhood education, and held less child-centered beliefs (49). An analysis of the large ECLS data set found that black children had made real gains in mathematics knowledge upon entering kindergarten—*but that over the first two years of school, they lost substantial ground relative to other races* (26). These differences are on arithmetic — addition, subtraction, and even multiplication and division — rather than lower-order skills. There are insufficient resources in these settings to address the needs of the children.

**Conclusions and Implications**

Thus, there is an early developmental basis for later achievement differences in mathematics: Children from different sociocultural backgrounds are provided different foundational experiences (7). Programs need to recognize sociocultural and individual differences in what children know and in what they bring to the educational situation.
Knowledge of what children bring should inform planning for programs and instruction. Extra support should be provided those from low-resource communities. We must meet the special needs of all children, especially groups disproportionately under-represented in mathematics, such as children of color and children whose home language is different that that of school. All these children also bring diverse experiences on which to build meaningful mathematical learning (50). The younger the child, the more their learning is enhanced by contexts that they find relevant and meaningful. There is no evidence that such children cannot learn the mathematics that other children learn. Too often, children are not provided with equivalent resources and support (13). They have different and inequitable access to foundational experiences, mathematically-structured materials such as unit blocks, technology, and so forth. The settings in which children from different sociocultural backgrounds are served too often have fewer resources and lower levels of high-quality interaction. They also have less to support their physical and mental health (51). The needs of children with physical difficulties (e.g., hearing impaired) and learning difficulties (e.g., the mentally retarded) must also be considered. There is a critical need for everyone involved with education to address this problem, so that children at risk receive equitable resources and additional time and support for learning mathematics. This does not mean we should treat children as if they were the same; it means equivalent resources should be available to meet the needs of children who differ in myriad ways, including socio-culturally and individually (e.g., developmentally delayed and gifted children). This is important, as knowledge of mathematics in preschool predicts later school success (52-54). Specific quantitative and numerical knowledge is more predictive of later achievement than are tests of intelligence or memory abilities (55). Those with
More children are in deep poverty in the U.S. than other countries. The effects are devastating (24).

Students in Linguistic and Ethnic Minority Groups

Children who are members of linguistic minority groups also deserve special attention (58). Although teaching specific vocabulary terms ahead of time, emphasizing cognates, is a useful approach, vocabulary alone is insufficient. Teachers need to help students see multiple meanings of terms in both languages (and conflicts between the two languages), and address the *language* of mathematics, not just the "terms" of mathematics. Building on the resources that bilingual children bring to mathematics is also essential. For example, all cultures have "funds of knowledge" that can be used to develop mathematical contexts and understandings (50). Further, bilingual children can often see general mathematical idea more clearly than monolingual children, because, after expressing it in two languages, they understand that the abstract mathematical idea is not "tied" to given terms (see 5). In general, then, "talking math" is far more than just using math vocabulary.

Final Words

Children who live in poverty and who are members of linguistic and ethnic minority groups need more math and better math programs (32). They need programs that emphasize the higher-order concepts and skills at each level, as well as base knowledge and skills (26, 35). What programs address these problems? We will describe several research-based programs in a future position paper (for the early years, see 59).
References


