

NUMERACY

Mathematics Instruction for Preschoolers

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Introduction

Teaching mathematics to young children, prior to formal school entry, is not a new practice. In fact, early childhood mathematics education (ECME) has been around in various forms for hundreds of years.¹ What has altered over time are opinions related to why ECME is important, what mathematics education should accomplish, and how (or whether) mathematics instruction should be provided for such young audiences.

Subject and Research Context

Is ECME necessary?

A concern among many early childhood experts, including educators and researchers, is the recent trend toward the “downward extension of schooling”² such that curricula, and the corresponding focus on assessment scores that were formally reserved for school-aged children, are now being pushed to preschool levels.³ The motivation behind this downward push of curriculum appears to be largely political, with an increasing emphasis on early success, improving test scores, and closing gaps among specific minority and socio-economic groups.⁴

Despite the concern related to the downward extension of school-aged curricula in general, there are persuasive factors encouraging the presence of at least some type of mathematical instruction for preschoolers, or at least for some groups of preschoolers. As Ginsburg et al. point out, learning mathematics is “a ‘natural’ and developmentally appropriate activity for young children”,¹ and through their everyday interactions with the world, many children develop informal concepts about space, quantity, size, patterns, and operations. Unfortunately, not all children have the same opportunities to build these informal, yet foundational, concepts of mathematics in their day-to-day lives. Subsequently, and because equity is such an important aspect of mathematics education, ECME seems particularly important for children from marginalized groups,³ such as special needs children, English-as-additional-language (EAL) learners, and children from low socio-economic status (SES), unstable, or neglectful homes.⁴

Recent Research Results

Equity in education is one major argument for the presence of ECME, but intimately tied to equity is the aspect of helping young mathematical minds move from informal to formal concepts of mathematics, concepts that have names, principles and rules. Children’s developing mathematical concepts, often building on informal experiences, can be represented as learning trajectories⁵ that highlight how specific mathematical skills can build upon preceding experiences and inform subsequent steps. For example, learning the names, order and quantities of the “intuitive numbers” 1-3, and recognizing these values as sets of objects, number words, and as parts of wholes (e.g., three can be made up of 2 and 1 or $1 + 1 + 1$), can help children develop an understanding of simple operations.⁶ “Mathematizing,” or providing appropriate mathematical experiences and enriching those experiences with mathematical vocabulary, can help connect children’s early and naturally occurring curiosities and observations about math to later concepts in school.³ Researchers have found evidence to suggest very early mathematical reasoning,^{1,6,7} and ECME can help children formalize early concepts, make connections among related concepts, and provide the vocabulary and symbol systems necessary for mathematical communication and translation (for an example, see Baroody’s paper⁶).

ECME may be important for reasons beyond equity and mathematization. In an analysis of six longitudinal studies, Duncan et al.⁸ found that children’s school-entry math skills predicted later academic performance more strongly than attentional, socioemotional or reading skills. Similarly, early difficulty with foundation mathematical concepts can have lasting effects as children progress through school. Given that math skills are so important for productive participation in the

modern world (Platas L, unpublished data, 2006),⁹ and that specific mathematical domains, such as algebra, can serve as a gatekeeper to higher education and career options,¹⁰ early, equitable and appropriate mathematical experiences for all young children are of critical importance.

What is “appropriate” ECME?

Views differ with respect to what ECME should consist of and how it should be infused into preschoolers’ lives, with a continuum that represents the amount of intervention or instruction proposed. On one end of the continuum is a very direct, didactic, and teacher-centered approach to ECME, while the other end of the spectrum represents a play-based, child-centered, non-didactic approach to ECME.⁴ Individual children, and perhaps different groups of children, may benefit from varying levels of instruction throughout the continuum, and much research remains to be done to better understand best practices for all children and all aspects of mathematics. One example of a research-based mathematics curriculum for young children is Building Blocks, a program designed to support and enhance children’s developing mathematical thinking (i.e., learning trajectories) through the use of computer games, everyday objects (i.e., manipulatives such as blocks), and print.¹¹ Building Blocks represents an attempt to align content and instructional activities with the learning trajectories of well-researched domains such as counting. The learning trajectories of other domains, such as measurement and patterning, are not yet well understood.⁵

Ginsburg et al.¹ described six components that should be present in all forms of ECME (e.g., programs such as Building Blocks), including environment, play, teachable moments, projects, curriculum, and intentional teaching. For example, regardless of where a particular mathematics curriculum falls on the playful–didactic continuum, environment is a vital component of early education. Specifically, providing preschool children with materials that inspire mathematical thinking, such as blocks, shapes, and puzzles, can facilitate the development of foundational skills such as patterning, making comparisons, and early numeracy. Another important component is that of the teachable moment: recognizing and capitalizing on children’s spontaneous math-related discoveries by asking questions that require children to reflect and respond, by providing vocabulary and representational support, and by demonstrating extension activities that elaborate on and further support mathematical ideas.

Perhaps the most popular component of ECME in the current literature is play. Many proponents of play-based learning, or learning through play, argue that children learn a great deal when they

discover mathematical ideas on their own in natural or minimally contrived situations.^{12,13} Some argue that play is being taken out of preschools in reaction to the downward extension of schooling and testing,¹⁴ and they provide data to suggest that children in early grades (including kindergarten) now spend far more time on test preparation than they do on play-based activities.⁴ Even many educational toys appear marketed more toward early learning of academic concepts (i.e., literacy for toddlers) than toward playful learning per se. This approach may be driven in part by parents' views on the importance of early education for future academic success. Much research remains to be done on the impact of educational toys, technology, play (or lack thereof), and various ECME curricula on preschoolers' mathematical development.

Research Gaps and Implications

What are the barriers to effective early education?

Mathematics for preschool children is complicated by several factors, including political pressure (i.e., achievement scores, funding, varying curriculum standards), individual differences among preschoolers (i.e., individual children may benefit from different mathematical opportunities), ideological differences regarding education (i.e., playful-didactic continuum), and gaps in developmental research (i.e., uncertain learning trajectories for some mathematical concepts). Complicating ECME further are barriers that affect the implementation of mathematical instruction (regardless of curriculum), such as teachers' own fears or misunderstandings of mathematics. Unfortunately, many preschool educators lack training directly related to mathematics for young children (Platas L, unpublished data, 2006). Teachers need knowledge of what children know, knowledge of how children learn new concepts, knowledge of most effective teaching strategies, and the mathematical concepts themselves (Platas L, unpublished data, 2006).³ Improving the mathematical training opportunities for early educators may help to improve the quality (and quantity) of mathematics instruction for young children.

Conclusion

The debate surrounding ECME does not appear to be about whether early exposure to mathematical experiences and ideas is important; the general consensus is that it is important. Rather, the issue is how, when, why and for whom specific approaches to ECME should be presented. Opinions differ regarding the amount of structure versus free-play and specific curriculum versus teachable moments. Yet as evidence accumulates regarding very young

children’s developing mathematical ideas (i.e., learning trajectories), attempts to align cognitive development with best instructional practices (or with the best environments to support natural mathematical discoveries) may help pave the way for equitable and appropriate mathematical experiences for all preschool children.

References

1. Ginsburg HP, Lee JS, Boyd JS. Mathematics education for young children: What it is and how to promote it. *Social Policy Report* 2008;223-23.
2. Elkind D. Foreword. In: Miller E, Almon J, eds. *Crisis in the kindergarten: Why children need to play in school*. College Park, MD: Alliance for Childhood; 2009: 9.
3. Clements DH. Major themes and recommendations. In: Clements DH, Sarama J, DiBiase A, eds. *Engaging young children in mathematics: Standards for early childhood mathematics education*. Mahwah, NJ: Erlbaum; 2004: 7-72.
4. Miller E, Almon J, eds. *Crisis in the kindergarten: Why children need to play in school*. College Park, MD: Alliance for Childhood; 2009:1-72.
5. Clements DH, Sarama J. Learning trajectories in early mathematics – sequences of acquisition and teaching. *Encyclopedia of Language and Literacy Development*. London, ON: Canadian Language and Literacy Research Network; 2009: 1-7.
6. Baroody AJ. Fostering early numeracy in preschool and kindergarten. *Encyclopedia of Language and Literacy Development*. London, ON: Canadian Language and Literacy Research Network; 2009: 1-9.
7. Sophian C. Numerical knowledge in early childhood. In: Tremblay RE, Barr RG, Peters RDeV, Boivin M, eds. *Encyclopedia on Early Childhood Development* [online]. Montreal, Quebec: Centre of Excellence for Early Childhood Development; 2009:1-7.
8. Duncan GJ, Dowsett CJ, Claessens A, Magnuson K, Huston AC, Klebanov P, Pagani LS, Feinstein L, Engel M, Brooks-Gunn J, Sexton H, Duckworth K, Japel C. School readiness and later achievement. *Developmental Psychology* 2007;43:1428-1446.
9. Baroody AJ, Lai M, Mix KS. The development of young children’s early number and operation sense and its implications for early childhood education. In: Spodek B, Olivia S, eds. *Handbook of research on the education of young children*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc; 2006:187-221.
10. Knuth EJ, Alibali MW, McNeil NM, Weinberg A, Stephens AC. Middle school students’ understanding of core algebraic concepts: Equality and variable. *Zentralblatt für Didaktik der Mathematik* 2005;37:1-9.12.
11. Sarama J. Technology in early childhood mathematics: Building Blocks as an innovative technology-based curriculum. In: Clements DH, Sarama J, DiBiase A, eds. *Engaging young children in mathematics: Standards for early childhood mathematics education*. Mahwah, NJ: Erlbaum; 2004: 361-375.
12. Polonsky L, Freedman D, Leshner S, Morrison K. *Math for the very young: A handbook of activities for parents and teachers*. New York, NY: John Wiley & Sons; 1995.
13. Seo K, Ginsburg HP. What is developmentally appropriate in early childhood mathematics education? Lesson from new research. In: Clements DH, Sarama J, DiBiase A, eds. *Engaging young children in mathematics: Standards for early childhood mathematics education*. Mahwah, NJ: Erlbaum; 2004: 91-104.
14. Hirsh-Pasek K, Golinkoff RM, Berk LE, Singer DG. *A mandate for playful learning in preschool: Presenting the Evidence*. Oxford, UK: University Press; 2009