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Review

The research-based balance in early childhood mathematics: A response to Common Core criticisms

Douglas H. Clements[a,*], Karen C. Fuson[b], Julie Sarama[a]

[a] Dept. of Teaching & Learning Sciences, University of Denver, Morgridge College of Education, United States
[b] Professor Emerita, School of Education and Social Policy, Northwestern University, United States

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ABSTRACT

We address common criticisms of the Common Core State Standards—Mathematics, evaluating them based on comprehensive reviews of existing documentation and research to better ground future debates and to ameliorate negative effects of possible misconceptions or misinterpretations. The four main criticisms follow. (1) No one who helped develop the standards had any expertise in the education of young children. (2.) The CCSSM dictates scripted curricula and didactic instruction rigidly applied to all children at the same pace. (3.) The standards emphasize academic skills and leave no time for play, exploratory approaches, or social-emotional development. (4.) The standards are too early and therefore developmentally inappropriate for children in the early grades. We conclude that these criticisms are not valid, and that, given the importance of mathematics to academic success in all subjects, all children need and deserve to build a robust knowledge of mathematics in their earliest years and can do so if we use the research knowledge and research-based standards and programs presently available. We summarize and exemplify the research-based balanced approach to teaching based on learning trajectories that can provide guidance for engaging and developmentally appropriate mathematical experiences that have been demonstrated to help all children learn to high standards.

1. Introduction

> Snow was falling in Boston and preschool teacher Sarah Gardner's children were coming in slowly, one bus at a time. She had been doing high-quality mathematics all year, but was still amazed at her children's ability to keep track of the situation: The children kept saying, "Now 11 are here and 7 absent. Now 13 are here and 5 absent. Now… ." (Clements & Sarama, 2014; p. 1).

To highlight the importance of high-quality mathematical experiences in the preschool and primary school years (preschool through G2) and to facilitate closing the achievement gap resulting from differences in access to such experiences, the National Research Council (2009) issued a research-based report entitled "Mathematics in early childhood: Paths toward excellence and equity". Its research and recommendations were used in developing the Common Core State Standards—Mathematics. However, blogs, newspapers, and other media, including some documents written by researchers, have criticized the Common Core State Standards Mathematics (CCSSM) as being inappropriate for young children in various ways. In this article, we provide information about the research background of the CCSSM and describe and examine four of the most common criticisms in the light of research.

Although the CCSSM do not include preschool, we include research about preschool at certain points because states and documents about standards (e.g., Scott-Little, Kagan, Reid, & Castillo, 2012) are beginning to apply all or some of the Kindergarten standards to preschool. Furthermore, the preschool years can make a major contribution to closing the gap in opportunity to learn mathematical ideas. Therefore, we want to help educators in preschool early childhood shift their perspectives and embrace the potential of this new knowledge (e.g., as called for by Hachey, 2013; Stipek, 2013) so that all children enter school prepared with foundational mathematical knowledge.

2. The research background of the CCSSM

Preschool mathematics knowledge predicts achievement even into high school (National Mathematics Advisory Panel, 2008; NRC, 2009; Stevenson & Newman, 1986). It also predicts later reading achievement as well as early reading skills do (Duncan et al., 2007; see also Farran, Aydogan, Kang, & Lipsey, 2005; Lerkkanen, Rasku-Puttonen,

* Corresponding author at: Morgridge College of Education, Marsico Institute for Early Learning and Literacy, Katherine A. Ruffatto Hall 154, 1999 East Evans Avenue, University of Denver, Denver, CO 80208-1700, United States.
E-mail address: Douglas.Clements@du.edu (D.H. Clements).

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Aunola, & Nurmi, 2005). Early number sense predicts later functional literacy, as measured by an instrument linked to future economic and life outcomes (Geary, Hoard, Nugent, & Bailey, 2013). Thus, mathematical thinking appears to be cognitively foundational (Baroody & Purpura, in press; Clements & Sarama, 2009; Purpura & Reid, 2016; Sarama & Clements, 2009). Given the importance of mathematics itself and to academic success across subjects (Sadler & Tai, 2007), all children need and deserve a robust knowledge of mathematics in their earliest years.

However, opportunities to learn early mathematics are more frequent in some communities and families than in others (Baroody & Purpura, in press; Blevins-Knabe & Musun-Miller, 1996; Ginsburg & Russell, 1981; Griffin et al., 1995; Jordan, Huttenlocher, & Levine, 1992; Levine, Suriyakham, Rowe, Huttenlocher, & Gunderson, 2010; Sanachter, Rambaud, Fuller, & Eggers-Pierola, 1995; Saxe, Guberman, & Gearhart, 1987). This opportunity gap can negatively affect children who live in poverty and who are members of linguistic and ethnic minority groups (Brooks-Gunn, Duncan, & Britto, 1999; Campbell & Silver, 1999; Denton & West, 2002; Entwisle & Alexander, 1990; Halle et al., 1997; Mullis et al., 2000; National Research Council, 2001; Natriello, McDill, & Pallas, 1990; Rouse, Brooks-Gunn, & McLanahan, 2005; Secada, 1992; Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2005; Thomas & Tagg, 2004), starting in the preschool years (Arnold & Doctoroff, 2003; Chernoff et al., 2007; Denton & West, 2002; Ginsburg & Russell, 1981; Griffin et al., 1995; Jordan et al., 1992; Saxe et al., 1987; Sowder, 1992). Fortunately, high-quality learning experiences result in greater school readiness in kindergarten (Magnuson, Meyers, Rathbun, & West, 2004; National Research Council, 2001; National Research Council and Institute of Medicine, 2000) and help all children to use multiple strategies, with similar accuracy, speed, and adaptive reasoning (Clements & Sarama, 2014; Rouse et al., 2005; Siegler, 1993).

A major goal of the NRC research-based report (2009) was identifying and summarizing research-based foundational and achievable goals for preschool and for grades K, 1, and 2. These goals form learning trajectories across these ages. Learning trajectories (Clements & Sarama, 2014; Sarama & Clements, 2009) show how goals relate to and build on each other and provide ways for mathematics teaching to build related understandings that can help all children move forward. This approach emphasizes the individual learning trajectories each child needs to traverse but provides a cohesive view that permits learning experiences to address groups of children.

The NRC report also found that little mathematics was being taught in pre-school (cf. Piasta, Pelatti, & Miller, 2014) and the early grades and that teaching incidentally through play or integrated with other topics, though sometimes useful, was not sufficient. It concluded that sustained focused teaching and learning time for mathematics is essential. The report summarized research about appropriate teaching-learning practices in early childhood, envisioning an engaging and encouraging climate for children's early encounters, particularly because this develops their confidence in their ability to understand and use mathematics. These positive experiences help children to develop dispositions such as curiosity, imagination, flexibility, inventiveness, and persistence, which contribute to their future success in and out of school (e.g., Clements, Sarama, & DiBiase, 2004). These developmentally appropriate teaching-learning practices are summarized in Table 1, which appeared in various related forms in books about teaching mathematics in preschool to grade 2 jointly published by the National Council of Teachers of Mathematics and the National Association for the Education of Young Children (see bottom of Table 1). Stipek (2013, p. 434) succinctly summarized this approach as "purposeful instruction that supports the development of deep mathematical understandings and that children enjoy".

The NRC foundational and achievable goals were used in developing the CCSSM for grades K to 2. The major professional organizations concerned with the mathematical education of young children–the National Association for the Education of Young Children, the National Council of Teachers of Mathematics, and the National Council of Supervisors of Mathematics—all endorsed the CCSSM. Thus, these standards and their embedded learning trajectories can guide educators about what foundational mathematics they need to help young children learn.

Table 1
Effective and Developmentally Appropriate Teaching-Learning Practices (Adapted from NCTM, 2010a, 2010b, 2010c, 2011).

A. The teacher expects and supports **children's ability to make meaning and mathematize** the real world by
- providing **settings that connect** mathematical language and symbols to quantities and to actions in the world,
- **leading children's attention** across these crucial aspects to help them make connections, and
- **supporting repeated experiences** that give children time and opportunity to build their ideas, develop understanding, and increase fluency

B. The teacher creates a nurturing and helping **Math Talk Community**
- within which to **elicit thinking** from students, and
- to help students **explain and help** each other explain and solve problems.

C. For each big math topic, the teacher leads the class through a **research-based learning path** based on children's thinking. This allows the teacher to differentiate instruction within whole-class, small group, and center-based activities. This path provides the repetitive experiencing that young children need.

D. For later pre-K and Kindergarten, children need to follow up activities with real 3-dimensional objects by working with math drawings and other written 2-dimensional representations that **support practice and meaning-making with written mathematical symbols**. Children of all ages also need to see and count groups of things in books, that is, they need to experience and understand 3-dimensional things as pictures on a 2-dimensional surface. Working with and on 2-dimensional surfaces, as well as with 3-dimensional objects, supports equity in math literacy because too many children have not had experiences with 2-dimensional representations in their out-of-school environment.

3. Identifying criticisms of and misconceptions about the CCSSM

This background of research and actions of professional groups supporting the CCSSM has been ignored by or is unknown to critics of the standards that have published in blogs, interviews, and position papers in recent years. We respond here because these criticisms are impeding opportunities for young children to learn mathematics and simultaneously develop the competence and positive identity that such opportunities support. We aim to better ground future debates and to ameliorate possible negative effects of invalid criticisms.

3.1. Data sources

To select and organize the criticisms and research relevant to them, we consulted three types of sources. The first two were the research literature (e.g., Tran, Reys, Teuscher, Dingman, & Kasmer, 2016) and Internet sources (see Appendix A for the search procedures and list of blogs and other commentary). We identified research by including published peer-reviewed journal articles from 2000 to 2016 as well as frequently-cited seminal studies conducted before that range. We began by developing a key word search list by brainstorming an initial list of terms to enter when searching for articles. These terms were young children, pre-K, preschool, kindergarten, primary grades, mathematics, math AND < the topic > . The following electronic databases were searched: Medline, PubMed, PsychINFO, PsycArticles, ERIC, Google Scholar, and Applied Social Science Index and Abstract. The search strategy, which aimed to find both studies conducted in the United States and internationally, was limited to the English language. The electronic searches were supplemented by checking the reference lists of included articles, existing systematic reviews and meta-analyses, and hand searching online databases of research. The criteria for the search of social media were determined by the authors and included online commentary and blog posts. The first step taken to initiating a search