Preschool Math Matter: The Most Powerful Predictor of Later Learning
Justine Wong
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Below is a list of the files that are combined into this document:

- Math Matters Even For Little Kids
- NAEYC Common Core
- Summary of Children’s Early Academic and Attention Skills Best Predict Later School Success
- School Readiness Study
- The Five Strands of Mathematics Proficiency
- Mean Math Blues Quiz
- Mean Math Blues Challenge Your Negative Beliefs
Math Matters, Even for Little Kids

By Deborah Stipek, Alan Schoenfeld, and Deanna Gomby

Everyone knows that children who are not reading at grade level by 3rd grade are fated to struggle academically throughout school. Concerns about early literacy skills are justified because reading skills at kindergarten entry predict later academic achievement.

But guess what predicts later academic success better than early reading? Early math skills. In "School Readiness and Later Achievement," a widely cited 2007 study of large longitudinal data sets, University of California, Irvine, education professor Greg Duncan and his colleagues found that in a comparison of math, literacy, and social-emotional skills at kindergarten entry, "early math concepts, such as knowledge of numbers and ordinality, were the most powerful predictors of later learning." A large-scale Canadian study from 2010 echoes those findings: Math skills at school entry predicted math skills and even reading skills in 3rd and 2nd grade, respectively, better than reading skills at school entry. Although the mechanisms underlying such associations are not yet understood, the importance of early mathematics, and thus of access to it for all students, is clear.

We have a long way to go. Vanderbilt University education professor Dale Farran reports in her recent study of preschool classrooms that math was intentionally taught by teachers only 2.5 percent of the day. Increasing the amount of time children spend engaged in instruction involving math conversation from 2 percent to only 4 percent led to significant math gains. Young children will take advantage of the opportunities we give them to develop their understanding of math.

The time is right for increasing our attention to early math. The K-12 common-core standards offer a clear and nearly universal target for the math skills U.S. children will need to master in the beginning elementary grades.

How do we create a pragmatic agenda to enhance children's early mathematical experiences and prepare them for the standards-based math they will encounter when they enter school? We have a number of suggestions.
"We need pre-K standards that are aligned with the common core, and having 50 states do that work independently is inefficient."

We urge states to create prekindergarten standards using the same collective strategy that produced the Common Core State Standards. We need pre-K standards that are aligned with the common core, and having 50 states do that work independently is inefficient. Common-core pre-K standards, developed by the nation's best experts in early learning and child development, could serve as the backbone for efforts to develop greater alignment between children's preschool and K-12 experiences. They could also guide policies on teacher preparation, curricula, and assessments of children and programs.

Increasing young children’s math learning opportunities will not come easily. If you think it is difficult to create broad-scale changes in K-12, try pre-K, where there is huge diversity in institutional contexts.

The education of preschool-age children occurs in Head Start, state preschools, family childcare homes, child-care centers, and public and private schools—each with its own sources of funding and management structures, and teaching staffs with varying levels of training and experience and persistently high rates of turnover.

Perhaps the biggest hurdle is getting past resistance to academically focused instruction in early-childhood settings. Some of the resistance is due to legitimate concerns about bringing K-12 accountability methods to preschool and using developmentally inappropriate methods to teach isolated skills. The resistance also reflects an assumption that attention to math will crowd the curriculum and result in less time for play, literacy activities, or social-emotional development.

To overcome these concerns, the field needs developmentally appropriate, child-friendly curricula and materials. Teacher training is needed to help early-childhood educators understand that learning is not a zero-sum game: Meaningful math activities in the context of play can foster crucial aspects of children's development. The goals in math instruction are to build on what young children know in ways that children enjoy. For example, playing mathematical or strategy games such as Chutes and Ladders or tic-tac-toe can build math and problem-solving skills while also developing social skills (e.g., turn taking and cooperation), early-language skills, and cognitive self-regulation. Developing a solution to sharing a plate of cookies both builds rudimentary division skills and helps promote social skills.
The most commonly encountered activities in preschool are among the least effective for teaching children math. Learning to count by rote teaches children number words and their order, but it does not teach them number sense, any more than singing the letters L-M-N-O-P in the alphabet song teaches phonemic awareness. Knowing that "four" follows "three" is of minimal value if a child doesn't know what "four" means. Paper-and-pencil tasks (e.g., drawing a line from the numeral 4 to a picture of four apples; coloring in an outline of the numeral 4) are fine for practice, but they don't teach children a sense of number.

The goal of math instruction is to help children develop, discuss, and use efficient, accurate, and generalizable methods to solve mathematical problems. To achieve this goal, young children need problems to solve and latitude to construct their own strategies. Teaching math effectively requires a focus on children's understanding of the core foundational concepts in mathematics. Such teaching can take place in the context of puzzles and games. Children using a shape sorter, for instance, learn the properties of geometric objects (e.g., three-sided or round figures don't fit in four-sided holes), not simply their names.

Typical assessments of young children's math understanding include a very limited number of math concepts, and children can often reach the right answer without genuine understanding. New instruments should be developed that assess critical early math concepts and also tap deep understanding. Summative assessments designed for program accountability should be supplemented with and aligned to formative assessments. All assessments should be developmentally appropriate in content and form. The purpose of assessment is to help identify what children know to help them build new knowledge. It is not appropriate to subject young children to extended formal testing.

Few early-childhood educators are prepared to teach math. For young children to have access to meaningful opportunities to learn math, new requirements for preschool teachers will need to be developed. Requirements should include opportunities to learn what is known about young children's development related to mathematics, as well as strategies for assessing children's understanding and teaching math to young children.

Increasing preservice requirements related to teaching math to young children will necessitate expanded offerings in institutions that provide preservice training. States should review the curriculum and training opportunities offered by two- and four-year colleges to ensure that students learn to teach mathematics effectively to young children. To support current preschool teachers, early-childhood programs should build internal capacity, such as
by hiring coaches with expertise in teaching math to young children, or investing in the development of expertise in a teacher who can serve as a mentor to other teachers.

Mathematics has been neglected in educational settings for young children, but change is possible. The shift in recent years to focus on the importance of early literacy has successfully increased investment in reading and bolstered capacity among teachers and teaching institutions. That change began with research findings that demonstrated the importance of early reading and the strategies that can be implemented in homes and at schools to help children develop their reading skills. We need analogous concerted efforts to bring the importance of early math learning to the attention of policymakers, educators, and the public.

Deborah Stipek is a professor and former dean of the school of education at Stanford University. Alan Schoenfeld is the Elizabeth and Edward Conner professor of education and affiliated professor of mathematics at the University of California at Berkeley. Deanna Gomby is the vice president for education at the Heising-Simons Foundation, which is based in Palo Alto, Calif.

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RELATED STORIES

- “Advocates See Pre-K-3 as Key Early Education Focus,” June 15, 2011.
The Common Core State Standards: Caution and Opportunity for Early Childhood Education
The Common Core State Standards: Caution and Opportunity for Early Childhood Education

As of fall 2012, 45 states have adopted the Common Core State Standards for English language arts and mathematics. The development and adoption of these standards has drawn a great deal of debate in both the K-12 and early education fields. As states adopting the Core standards are moving towards implementation, the National Association for the Education of Young Children (NAEYC) has developed this paper to provide a frame for this ongoing dialogue. This frame is built around the four central themes articulated in NAEYC’s position statement on early learning standards. These themes have guided the development and implementation of learning standards in early childhood, and are used here to underscore the potential contributions that that early childhood field can continue to make in implementing learning standards for children as they enter school. In addition to providing a framework for dialogue, this paper encourages dialogue so that early childhood education can work in concert with K-12 education to ensure that learning standards for young children, before they enter school and as they progress through the early elementary years, are consistent with our accumulated knowledge and experience as a field. The paper closes with a summary of activities being undertaken by NAEYC and actions that may be taken by early educators to meet this goal.

Suggested citation:


An earlier draft of this paper was reviewed by Kathy Hirsh-Pasek (Temple University), Sam Meisels (Erikson Institute), Ben Russell (Boston Public Schools), Jason Sachs (Boston Public Schools), and Kathy Thornburg (University of Missouri). Their extensive comments and questions greatly improved the quality of this paper. However, the content of this paper is solely the responsibility of NAEYC.
The Common Core State Standards: Caution and Opportunity for Early Childhood Education

The Common Core State Standards (CCSS) Initiative is a state-led effort coordinated by the National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) in partnership with Achieve. According to the CCSS Initiative website (http://www.corestandards.org/about-the-standards), the goal of the initiative is to:

- provide teachers and parents with a common understanding of what students are expected to learn. Consistent standards will provide appropriate benchmarks for all students, regardless of where they live...These standards define the knowledge and skills students should have within their K–12 education careers. (n.p.)

While the focus of the initiative is to ensure college and career readiness, the application of the project reaches across the K–12 spectrum.

The Common Core State Standards (commonly referred to as the “Common Core”) have begun to dominate the landscape in K–12 education and have attracted commentary from the early childhood education community as well. As states move toward implementation, the National Association for the Education of Young Children (NAEYC) is launching an effort to consider both the concerns and opportunities being raised within the field. This paper outlines the reasons for NAEYC’s interest in the Common Core, and it attempts to provide a framework for the early education field to consider not only the aspects of the Common Core that may pose threats to early childhood education, but also those aspects that may provide early childhood education with the opportunity to exert its...
The Common Core State Standards: Caution and Opportunity for Early Childhood Education

collected research and experience upward into K–12 education. NAEYC maintains that the establishment of clear, attainable learning goals is critical in ensuring that all children receive the highest quality of educational experiences.

FOCUSING ON THE COMMON CORE IN EARLY CHILDHOOD EDUCATION

The Common Core is of particular interest to NAEYC for two reasons. First, the application of the Common Core to K–3 overlaps with NAEYC’s interest in the latter years of early childhood during which children enter school and progress through the early elementary grades. For these children, the development and implementation of the Common Core will have a direct and immediate impact. Second, there is the potential for the Common Core to impact programs for young children prior to kindergarten entry. Together, these two systems capture the early years of children’s continuum of learning. Along this continuum there may be positive effects (e.g., providing consistent learning benchmarks for all children across the country) as well as negative effects (e.g., the potential for pressure on early childhood programs to focus more on English language arts and mathematics). Therefore, NAEYC is launching an effort to identify potential advantages and highlight potential dangers to early childhood education as the Common Core moves into implementation.

In April 2010, NAEYC and the National Association of Early Childhood Specialists in State Departments of Education (NAECS/SDE) issued a joint statement to coincide with the announcement of the CCSS Initiative. While NAEYC applauded the launch of the Common Core and the inclusion of standards for kindergarten through third grade, several concerns and cautions were also noted. At the time, these concerns were primarily focused on the restricted range of domains included in the initial launch of the Common Core, which focused exclusively on language arts and mathematics (though the potential for standards in other academic areas was also indicated). In noting the limited range of attention, the statement issued by NAEYC and NAECS/SDE “expressed concern...that effort on only two content domains could result in the unintended consequence of narrowing curriculum and instructional practice to the detriment of student learning.” Of particular concern was the absence of social and emotional development and approaches to learning, although the lack of attention to the whole child was generally noted.

The Common Core State Standards Initiative has received criticism on these and a number of philosophical, political, and practical grounds. It is not the purpose here to revisit these. Instead, NAEYC recognizes that nearly all states (46 as of September 25, 2012) have committed to adopting the Common Core, so our focus is on ensuring that the implementation of the Common Core, especially its continued development, expansion, and evaluation, moves to address the
concerns of the NAEYC membership and the early childhood education field. As states have adopted the Common Core, there has been growing discussion within the early childhood community about the “unintended consequences” noted in NAEYC’s initial response to the Common Core. These consequences include concerns about the allocation of time and resources to support the content of the Common Core relative to areas not included in these standards, and about the means by which schools will assess children’s progress in meeting the standards.3

However, the Common Core may also provide opportunities for the early childhood community to add to the discourse about educational reform and work to ensure that research and practical experience within the early childhood education field can, and should, contribute to the shape of the Common Core during the early years of schooling. The implementation of the Common Core provides a unique opportunity for the early childhood education field to be “present and vocal,” as Ryan and Goffin (2008) encourage, not just within early childhood education but also in the broader education system (see also Hyun 2003), through its promotion of the use of evidence-based best practices at all levels of education. At the same time, though, as Halpern (forthcoming) notes, more closely connecting early childhood education with traditional K–12 educational practices also poses threats to the central ideas in early education as the K–12 system exerts a downward pressure of increased academic focus and more narrowed instructional approaches. This threat also provides an opportunity, however, for early education to exert “upward pressure” toward the K–12 system by advocating for practices successfully used in early childhood education to be adopted into the K–12 space. This, of course, means advocating for the use of developmentally appropriate practices (Copple & Bredekamp 2009; NAEYC & NAECS/SDE 2003), and it also allows for the opportunity to underscore the fundamental features of early childhood education, including the focus on the whole child and consideration of the larger social and cultural world in which the child lives.

THE ROLE OF LEARNING STANDARDS IN EDUCATION

NAEYC has long promoted excellence in early childhood education for all young children from birth through age 8. Through its accreditation systems for programs serving young children and programs preparing teachers of young children, NAEYC has advanced a goal of equity in opportunity for all children to reduce or eliminate disparities in learning and educational outcomes. The Common Core initiative was launched to meet a similar goal—to ensure that all children are prepared for success in college at the completion of their K–12 education.

There is a long history of education reform in the United States that addresses disparities in achievement through the development of standards that, if universally applied, should produce equity in opportunities to learn (e.g., Harris & Herrington 2006). However, some experts question the effect
of variations in standards—and variations in how students’ proficiencies are identified through assessment—on explanations of students’ achievement (e.g., Reed 2009). Likewise, changes in standards and their assessment alone may not be adequate interventions to improve performance and close achievement gaps (Darling-Hammond 1994). Addressing uneven standards may set the stage for common expectations, but placing too much responsibility on uneven curriculum standards obscures disparities in other critical areas, including funding allocations for materials, opportunities to learn, and wide variation in teacher and school quality (e.g., Akiba, LeTendre, & Scribner 2007; Darling-Hammond 2006). Indeed, in the NAEYC and NAECS/SDE (2002) position statement concerning early learning standards, the content of the standards is considered to be only one piece of the larger early education system, which must be coupled with providing necessary supports to teachers (in training and ongoing learning opportunities, as well as developmentally appropriate curriculum materials) and valid assessment systems aligned to the standards to ensure that expectations for children’s learning are developmentally appropriate.

NAEYC and NAECS/SDE (2002) support standards for young children, and the benefits of these standards extend into the early elementary years and beyond. For example, NAEYC and NAECS/SDE (2002, p. 4) note, “Clear, research based expectations for the content and desired results of early learning experiences can help focus curriculum and instruction, aiding teachers and families in providing appropriate, educationally beneficial opportunities for all children.” However, the NAEYC and NAECS/SDE statement articulates four conditions under which early learning standards should be developed and implemented. Comparing these conditions against the development and implementation of the Common Core may provide avenues for early education and K–12 education systems to become more closely aligned in purpose. Each of these four conditions is briefly summarized and discussed in connection with the Common Core in the sections that follow.

1. **Early learning standards should emphasize significant developmentally appropriate content and outcomes.**

The initial set of Common Core standards speaks to young children’s development in English language arts and mathematics, as previously noted. While there is movement toward common standards in other cognitive or academic domains (e.g., science, see http://www.nextgenscience.org/), there has not yet been systematic consideration given to critical domains outside of these areas. This is at odds with the importance given to six domains of child development included as part of the kindergarten entry assessments (KEAs) called for by the Race to the Top and Early Learning Challenge, as well as the early childhood education focus on the whole child.

Even within the limited domains covered by the Common Core, there is room to legitimately question the degree to which the standards are developmentally
appropriate. While there may be a research basis for their content, critical content and age validation of the Common Core has yet to be realized. Elements of the Common Core may represent changes in state standards, for example an increased focus on nonfiction text in earlier grades, the impact of which has yet to be fully explored. It is worth noting, as well, that although (at the time of this writing) the Common Core excludes domains other than English language arts and mathematics, their absence in the Common Core does not preclude states (or districts) from maintaining or adopting standards in other developmental areas, individually or in collaboration. However, these standards will not likely be common across states, which suggests that they will be variable both in their content and in the degree to which they align with the content in the Common Core. These standards should also be considered for their appropriateness.

2. Early learning standards are developed and reviewed through informed, inclusive processes.

The Common Core standards were developed at a remarkably fast pace that some early childhood professionals have criticized. The process of developing early learning standards calls upon multiple stakeholders with possibly differing points of view to consider the content of standards not only at the time of the their launch but also as they are implemented over time. This allows standards to persist over time to become better at guiding opportunities to optimize children’s learning. Therefore, as states move toward implementation of the Common Core, experts in early education and K–12 education can ensure that the standards are continually reviewed for appropriateness to the diversity of children beginning public schooling, and for consistency with emerging research.

Some of the early critiques of the Common Core (e.g., Meisels 2011; Zubrzycki 2011) should be further developed and explored, and become the focus of critical analysis as states implement the Common Core. While there may have been a limited voice for early childhood education in the development of the Common Core, this voice can and should be encouraged and heard as part of an ongoing process of examination of the Common Core as it is implemented. If such an ongoing review process is not apparent, the early childhood education field can exert its voice by holding the developers and implementers accountable for such an ongoing review.

This is perhaps most critical at the points where the Common Core standards intersect with early learning standards. Aligning standards for K–12 with early learning standards presents a number of challenges, including the very real potential for “push-down,” where the K–12 standards may exert pressure on states to modify their oftentimes well-developed early learning standards to align with those for programs serving older children. The early childhood field should not allow for alignment to flow only downward but should advocate for the “push-up” of early childhood standards to inform ongoing development of K–12 standards, including those in areas not part of the Common Core.
3. Early learning standards gain their effectiveness through implementation and assessment practices that support children’s development in ethical, appropriate ways.

Learning standards, or content standards, provide the “what” of education, but they do not describe the “how” of education. The content standards set the goal toward which teaching and learning opportunities are directed for young children. The “how” of learning should be aligned to the content standard through our understanding of best practices to increase the chances of attaining the goal, even as the goal itself needs to be aligned with our knowledge of children’s learning processes. Likewise, content standards should inform how children’s learning is assessed so that children can show proficiency—this is often called performance standards for children. Setting the curriculum standards is but one piece of the educational enterprise, and work on other elements within the frame provided by the Common Core is only just beginning. Especially critical is maintaining methods of instruction that include a range of approaches—including the use of play as well as both small- and large-group instruction—that are considered to be developmentally appropriate for young children. Likewise, approaches to assessing young children and the appropriate use of assessment data will increasingly become concerns as the Common Core moves from design to implementation.

Standards are meant to ensure that we set high yet achievable goals for all children. As such, we are ethically bound to ensure that these standards (the “what”) and their implementation (the “how”) and their assessment are free from bias and are developmentally appropriate for all children entering school. The tremendous diversity among children, including those from diverse cultural and linguistic backgrounds and those with disabilities, warrant special consideration in ensuring that the standards and their implementation and assessment work to close gaps and disparities rather than widen them. Likewise, assessment of progress in meeting standards should be governed by long-standing practices and beliefs that recognize the importance of appropriate assessment while also recognizing the challenges in building accountability systems for young children around high-stakes testing (e.g., NAEYC & NAECS/SDE 2001, 2003; Snow & Von Hemel 2008).

4. Early learning standards require a foundation of support for early childhood programs, professionals, and families.

Researchers in early education and in K–12 education point out that establishing appropriate and challenging content standards is one element of a high-performing education system, but these standards require a system of supports for implementation. As noted previously the Common Core provides the “what,” but its success in moving children toward college and work readiness relies upon a foundation of supports. Schools need to ensure that there is adequate time for implementation of the Common Core without jeopardizing time for activities that address children’s needs not included in the current
standards. Teachers need appropriate tools to address each standard, including aligned curricula and related resources; they may need additional training as well. Finally, families need to be provided with necessary information in order to be able to understand the learning goals established by the standards and identify roles that they may take to support their children’s education.

THE EARLY CHILDHOOD EDUCATION VOICE IN THE COMMON CORE

Based upon the long history of early learning standards—and lessons learned by the early learning community throughout the course of their development and implementation—NAEYC urges early childhood education professionals to actively engage in the dialogue about the Common Core State Standards and their implementation. Critical to this dialogue will be informed voices who can join their deep understanding of standards in general, and early learning and Common Core standards in particular, with knowledge of research and practice in early childhood education. The early childhood education field is uniquely able join this knowledge and experience with that provided by our colleagues working in K–12 education to ensure that the Common Core meets its goals of promoting college and career readiness for all children.

WHAT IS NAEYC DOING?

In the coming months, NAEYC will be undertaking a number of activities to encourage and support this dialogue. At our Annual Conference and National Institute for Early Childhood Professional Development, sessions developed by NAEYC staff as well as those submitted by experts in the field will be readily identified. A series of webinars is being developed by NAEYC, alone and in conjunction with other partnering organizations, to ensure that there is a clear understanding about the intent and content of the Common Core, as well as the possibility for thoughtful dialogue about potential concerns. Finally, NAEYC is developing a series of issue briefs that, we hope, will act to spark discussion within the early childhood education community about what we know (and do not know) about early childhood education and how we can create meaningful connections between what have historically been two separate education models: early childhood education and K–12 education.

WHAT CAN I DO?

As the Common Core begins to be implemented, there are many potential opportunities for us in the early childhood education community to engage in the process with our colleagues in K–12 education. First, the early childhood education community should take advantage of all available opportunities to encourage those in K–12 education to consider the collected
experience and research knowledge from the early childhood education field in the implementation of standards, including the view that content standards do not exist in isolation (as noted previously). Especially in states, districts, or schools where implementation of the Common Core threatens other areas of children’s development, the early childhood education community must share research on the importance of other domains of child development that are not only important in their own right but are also important because the interrelatedness of child development also supports children’s development in Common Core content areas. Early childhood education professionals, especially those already working within elementary school settings as teachers, administrators, or providers of teacher training or professional development, can work directly with those in the K–12 setting to bring fundamental early childhood education principles to be on implementing the Common Core, especially developmentally appropriate practice.

Those working in programs serving children before kindergarten should become familiar with the Common Core and other k-12 content standards as well as their early learning standards, not only to prepare children for school, but also to identify potential mismatches (or lack of alignment) that undermine the potential of early childhood education to nurture children’s learning and development. Professionals who are working in early childhood education policy and research can engage CCSSO, NGA, Achieve, and others nationally, within each state, and possibly within each district that has begun implementation by monitoring and commenting on developments through web updates, and participating in scientific and implementation meetings where possible.

In this call for early childhood education to find its voice, it is also imperative to suggest that this voice should be as strong in its critical appraisal of the Common Core as it is in vocalizing its positives. Combining deep knowledge of early childhood education with an accurate understanding of the Common Core is critical in ensuring that the early childhood education field continues to work in support of the highest quality education for all children as they progress along the continuum of learning.

CONCLUSION

Our goal, as always, is focused on providing the highest quality of early childhood educational experiences that are appropriate to children’s developmental status and respectful of diversity. There is much about the Common Core that can contribute to this goal, much that can be further enhanced with the guidance provided through experts in the early childhood education field, and perhaps some things that may arise as critical concerns that need immediate attention. The reality is that the Common Core State Standards are present in K–12 education. The early childhood education community can work to ensure that long-held ideals and evidence-based approaches to supporting the development of young children operate in concert with common standards to ensure equity in educational opportunity and achievement for all children.
The Common Core State Standards: Caution and Opportunity for Early Childhood Education

References


The Common Core State Standards: Caution and Opportunity for Early Childhood Education


Zubrzycki, J. 2011.  “Common Core Poses Challenges for Preschools: Kindergarten pupils Piper Stephan, left, and Delaney Lane read to each other at Triadelphia Ridge Elementary School in Glenelg, Md. Maryland is one of 46 states to adopt new common standards in math and English/language arts for K-12.

—Matt Roth for Education Week


(ENDNOTES)

1 While generally associated with early childhood education, NAEYC focuses on programs serving children from birth to age 8. During this time children may encounter recognized systems of early childhood care and education which serve children from birth until school entry (sometimes referred to as 0–5) as well as the earliest years of K–12 education (referred to as K–3). Early childhood education is used to define programs that serve children until they enter school, but the early education field as represented by NAEYC also includes professionals working with, and programs designed for, children in the early elementary grades as well.


3 Both of these concerns may also be fueled by provisions within federal education funding that give priority to adoption of the Common Core.

4 The key starting points in following developments related to the Common Core include the Common Core State Standards Initiative website (http://www.corestandards.org) and Achieve (http://www.achieve.org/achieving-common-core). Two groups working on developing assessments related to the Common Core are the Partnership for Assessment of Readiness for College and Careers (http://www.parcconline.org/achieving-common-core) and Smarter Balanced Assessment Consortium (http://www.smarterbalanced.org/k-12-education/common-core-state-standards-tools-resources/).
The Common Core State Standards: Caution and Opportunity for Early Childhood Education
Children's Early Academic and Attention Skills Best Predict Later School Success, According to Analysis of Large-Scale Studies

Behavior problems, lack of social skills not linked with later achievement

WASHINGTON-- Children entering kindergarten with elementary math and reading skills are the most likely to do well in school later, even if they have various social and emotional problems, say researchers who examined data from six studies of close to 36,000 preschoolers. Children's attention-related skills also mattered, the researchers found.

These findings are reported on in the November issue of Developmental Psychology, published by the American Psychological Association (APA).

For the first time, researchers compared results from six large-scale longitudinal studies comprising two national representations of U.S. children, two multi-site studies of U.S. children, one study focusing on children from Great Britain and one study focusing on children from Canada to assess what school-entry skills and behaviors best predicted higher teacher ratings and reading and math test scores as the children progressed through school. Children's preschool cognitive abilities and socio-demographic characteristics were held constant to rule out their influences.

From a meta-analysis of the results, economist Greg J. Duncan, PhD, of Northwestern University, and 11 co-authors found that mastering early math concepts, such as knowledge of numbers and understanding the order of numbers, best predicted later success. Mastering early language and reading skills that included vocabulary, knowing letters and understanding phonetics were next in predicting later achievement. Also contributing to later achievement were children's attention-related skills, including the ability to control hyperactive behavior, to concentrate while completing a task, and to be motivated for learning. Surprisingly, difficulty getting along with classmates, aggressive or disruptive behaviors, and sad or withdrawn behaviors did not detract from later learning.

Read the journal article

- School Readiness and Later Achievement (PDF, 204KB)

School readiness skills and behaviors were measured at school entry (around age 5) and later achievement was measured between the ages of 7 and 14. Even after controlling for children's prior cognitive ability, the authors found that early math skills were strong predictors of later math achievement and predicted later reading achievement as well as early reading skills. These and other patterns were similar for boys and girls and for children from both upper-middle-class and poor families.

The authors also found that early attention skills had a role in later achievement. But early behavior problems and lack of social skills did not affect later achievement measures in this sample. They caution that their studies were
drawn from general populations and that children diagnosed with clinical levels of these problems may not conform to these patterns.

The lack of associations between social and emotional behaviors and later learning was the biggest surprise and could not be attributed to differences in the way early social and academic skills were measured, the researchers found. “Perhaps teachers are able to ensure that a child’s problem behaviors do not affect his or her achievement,” noted Duncan, but added, “we were unable to assess whether a child’s behavior problems affected the amount that classmates learned.”

The results are consistent with recommendations from expert panels of early mathematics and reading professionals to bolster the teaching of math and reading skills during the preschool years. “Our results did not address what types of preschool curricula are most effective in promoting these school readiness skills,” said Duncan. “But we do know that play-based, as opposed to ‘drill-and-practice,’ curricula designed with children’s developmental needs in mind can foster academic and attention skills in ways that are engaging and fun.”

**Article:** “School Readiness and Later Achievement,” Greg J. Duncan, PhD, Amy Claessens, PhD, Mimi Engel, Northwestern University; Chantelle J. Dowsett, PhD, and Aletha C. Huston, PhD, University of Texas-Austin; Katherine Magnuson, PhD, University of Wisconsin-Madison; Pamela Klebanov, PhD, Princeton University, Linda S. Pagani, PhD, Universite de Montreal; Leon Feinstein, PhD, and Kathryn Duckworth, University of London; Jeanne Brooks-Gunn, PhD, Columbia University; Holly Sexton, University of Michigan; Crista Japel, Universite de Quebec a Montreal; *Developmental Psychology*, Vol. 43, No. 6.

**Dr. Greg J. Duncan** can be reached at e-mail or by phone at (847) 894-2032. **Dr. Amy Claessens** can be reached at e-mail or by phone at (312) 259-1975.

*The American Psychological Association (APA), in Washington, DC, is the largest scientific and professional organization representing psychology in the United States and is the world's largest association of psychologists. APA's membership includes more than 148,000 researchers, educators, clinicians, consultants and students. Through its divisions in 54 subfields of psychology and affiliations with 60 state, territorial and Canadian provincial associations, APA works to advance psychology as a science, as a profession and as a means of promoting health, education and human welfare.*
School Readiness and Later Achievement

Greg J. Duncan
Northwestern University

Amy Claessens
Northwestern University

Aletha C. Huston
University of Texas at Austin

Katherine Magnuson
University of Wisconsin–Madison

Pamela Klebanov
Princeton University

Leon Feinstein
University of London

Mimi Engel
Northwestern University

Jeanne Brooks-Gunn
Columbia University

Holly Sexton
University of Michigan

Kathryn Duckworth
University of London

Crista Japel
Université deQuébec à Montréal

Using 6 longitudinal data sets, the authors estimate links between three key elements of school readiness—school-entry academic, attention, and socioemotional skills—and later school reading and math achievement. In an effort to isolate the effects of these school-entry skills, the authors ensured that most of their regression models control for cognitive, attention, and socioemotional skills measured prior to school entry, as well as a host of family background measures. Across all 6 studies, the strongest predictors of later achievement are school-entry math, reading, and attention skills. A meta-analysis of the results shows that early math skills have the greatest predictive power, followed by reading and then attention skills. By contrast, measures of socioemotional behaviors, including internalizing and externalizing problems and social skills, were generally insignificant predictors of later academic performance, even among children with relatively high levels of problem behavior. Patterns of association were similar for boys and girls and for children from high and low socioeconomic backgrounds.

Keywords: school readiness, socioemotional behaviors, attention, early academic skills

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Early childhood programs and policies that promote academic skills have been gaining popularity among politicians and researchers. For example, President George W. Bush (2002) endorsed Head Start reforms in 2002 that focus on building early academic skills, observing that “on the first day of school, children need to know letters and numbers. They need a strong vocabulary. These are the building blocks of learning, and this nation must provide them” (p. 12). The National Research Council’s Committee on the Prevention of Reading Difficulties in Young Children recommends providing environments that promote preliteracy skills for all preschool children (Snow, Burns, & Griffin, 1998). Similarly, the National Association for the Education of Young Children and the National Council of Teachers of Mathematics (2002) issued a joint statement that advocated for high-quality mathematics education for children ages 3–6.

Others, however, maintain that a broad constellation of behaviors and skills enables children to learn in school. Asked to identify factors associated with a difficult transition to school, kindergarten teachers frequently mentioned weaknesses in academic skills, problems with social skills, trouble following directions, and difficulty with independent and group work (Rimm-Kaufman, Pianta, & Cox, 2000). Researchers too have made this point. The National Research Council and Institute on Medicine argued that “the elements of early intervention programs that enhance social and emotional development are just as important as the components that enhance linguistic and cognitive competence” (Shonkoff & Phillips, 2000, pp. 398–399).

These two views have emerged in the current debate about what constitutes school readiness and in particular about what skills predict school achievement. Many early education programs, including Head Start, are designed to enhance children’s physical, intellectual, and social competencies on the grounds that each domain contributes to a child’s overall developmental competence and readiness for school. However, if early acquisition of specific academic skills or learning-enhancing behaviors forecasts later achievement, it may be beneficial to add domain-specific early skills to the definition of school readiness and to encourage interventions aimed at promoting these skills prior to elementary school. Thus, understanding which skills are linked to children’s academic achievement has important implications for early education programs.

We adopted a child-centered model of school transition, which is nested within a broader ecological framework but focuses on the set of individual skills and behaviors that children have acquired prior to school entry (Rimm-Kaufman & Pianta, 2000). A child’s individual characteristics contribute to the environments in which the child interacts and the rate at which the child may learn new skills; in turn, the child receives feedback from others in the environment (Meisels, 1998). Thus, because they affect both the child and the social environment, early academic skills and socioemotional behaviors are linked to subsequent academic achievement because they provide the foundation for positive classroom adaptation (Cunha, Heckman, Lochner, & Masterov, 2006; Entwisle, Alexander, & Olson, 2005).

For example, a child who enters kindergarten with rudimentary academic skills may be poised to learn from formal reading and mathematics instruction, receive positive reinforcement from the teacher, or be placed in a higher ability group that facilitates the acquisition of additional skills. Similarly, a child who can pay attention, inhibit impulsive behavior, and relate appropriately to adults and peers may be able to take advantage of the learning opportunities in the classroom, thus more easily mastering reading and math concepts taught in elementary school. For these reasons, the skills children possess when entering school might result in different achievement patterns in later life. If achievement at older ages is the product of a sequential process of skill acquisition, then strengthening skills prior to school entry might lead children to master more advanced skills at an earlier age and perhaps even increase their ultimate level of achievement.

Although there are strong theoretical reasons to expect that individual differences in children’s early academic skills and behavior are linked to subsequent behavior and achievement, surprisingly little rigorous research has been conducted to test this hypothesis. Consequently, the purpose of this article is to assess as precisely as possible, using six longitudinal, nonexperimental data sets, the association between skills and behaviors that emerge during the preschool years and later academic achievement. As with Robins’s (1978) classic study of adult antisocial behavior, our approach consists of comparable analyses of a number of different longitudinal developmental studies.1 We are especially interested in identifying academic, attention, and socioemotional skills and behaviors that may be learned or improved through experiences prior to school entry. In the following sections, we draw from developmental literature to identify key dimensions of school readiness and to derive theoretical predictions about how children’s school-entry skills and behaviors contribute to short- and long-term academic success.

**Associations Between Early Skills and Later Achievement**

Academic achievement is a cumulative process involving both mastering new skills and improving already existing skills (Entwisle & Alexander, 1990; Pungello, Kuperschmidt, Burchinal, & Patterson, 1996). Information about how children acquire reading and math skills points to the importance of specific academic skills but also indicates that more general cognitive skills, particularly oral language and conceptual ability, may be increasingly important for later mastery of more complex reading and mathematical tasks. Basic oral language skills become critical for understanding texts as the level of difficulty of reading passages increases (NICHD Early Child Care Research Network, 2005b; Scarborough, 2001; Snow et al, 1998; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). Likewise, mastery of foundational concepts of numbers allows for a deeper understanding of more complex mathematical problems and flexible problem-solving techniques (Baroody, 2003; Ferrari & Sternberg, 1998; Hiebert & Wearne, 1996).

Although children’s academic achievement is largely stable throughout childhood, children do demonstrate both transitory fluctuations and fundamental shifts in their achievement trajectories (Kowaleski-Jones & Duncan, 1998; Pungello et al., 1996). Nonexperimental data show that children’s achievement test

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1 Robins (1978) justified her approach as follows: “In the long run, the best evidence for the truth of any observation lies in its replicability across studies. The more the populations studied differ, the wider the historical eras they span; the more the details of the methods vary, the more convincing becomes that replication” (p. 611).
scores are related to prior cognitive functioning and the attainment of basic skills in math and literacy such as number and letter recognition (Stevenson & Newman, 1986). In their meta-analysis, La Paro and Pianta (2000) found middle-range correlations in cognitive/academic skills both from preschool to kindergarten (.43) and from kindergarten to first or second grade (.48).

Attention-related skills such as task persistence and self-regulation are expected to increase the time during which children are engaged and participating in academic endeavors. Research has shown that signs of attention and impulsivity can be detected as early as age 2.5 but continue to develop until reaching relative stability between ages 6 and 8 (Olson, Sameroff, Kerr, Lopez, & Wellman, 2005; Posner & Rothbart, 2000). Studies linking attention with later achievement are less common, but consistent evidence suggests that the ability to control and sustain attention as well as participate in classroom activities predicts achievement test scores and grades during preschool and the early elementary grades (Alexander, Entwisle, & Dauber, 1993; Raver, Smith-Donald, Hayes, & Jones, 2005). These attention skills, which are conceptually distinct from other types of interpersonal behaviors, are associated with later academic achievement, independent of initial cognitive ability (McClelland, Morrison, & Holmes, 2000; Yen, Konold, & McDermott, 2004) and of prior reading ability and current vocabulary (Howse, Lange, Farran, & Boyles, 2003). Examining attention separately from externalizing problems has clarified the role of each in achievement, suggesting that attention is more predictive of later achievement than more general problem behaviors (Barriga et al., 2002; Hinshaw, 1992; Konold & Pianta, 2005; Ladd, Birch, & Buhs, 1999; Normandeau & Guay, 1998; Trzesniewski, Moffitt, Caspi, Taylor, & Maughan, 2006).

Children’s socioemotional skills and behaviors are also expected to affect both individual learning and classroom dynamics. Inadequate interpersonal skills promote child–teacher conflict and social exclusion (Newcomb, Bukowski, & Pattee, 1993; Parker & Asher, 1987), and these stressors may reduce children’s participation in collaborative learning activities and adversely affect achievement (Ladd et al., 1999; Pianta & Stuhlman, 2004). Correlational evidence linking problem behaviors to academic achievement is found in the Beginning School Study. First-grade ratings on items describing a cheerful, outgoing temperament (roughly the opposite of internalizing problems) predicted adult educational attainment better than preschool or first-grade achievement scores (Entwisle et al., 2005). Other studies yield similar results. For example, children with consistently high levels of aggression from ages 2–9 were more likely than other children to have achievement problems in third grade (NICHD Early Child Care Research Network, 2004).

Experimental Evidence and Crossover Effects

Many nonexperimental studies find associations between early achievement, attention, and behavior and later achievement, yet few of these studies are designed to determine which of these skills can be modified prior to school entry or whether these changes predict later achievement. In theory, intervention research should shed light on this gap by demonstrating ways to improve children’s skills and by testing whether improvements in early skills are associated with better adjustment in the long term. Indeed, a small number of experimental interventions provide encouraging evidence that high-quality programs for preschool children “at risk” for school failure produce gains in cognitive and academic skills and reduce behavior problems (Conduct Problems Prevention Research Group, 2002; Karoly, Kilburn, & Cannon, 2005; Love et al., 2003). Early educational interventions have also been found to result in long-term reductions in special education services, grade retention, and increases in educational attainment (Campbell, Ramey, Pungello, Sparling, & Miller-Johnson, 2002; Lazar et al., 1982; Reynolds & Temple, 1998).

As is the case with nonexperimental studies, few intervention studies are designed to isolate the relative contributions of changes in achievement, attention, and behavior to later school achievement. A first problem is that behavioral interventions tend to measure behavioral but not achievement outcomes, whereas reading and math interventions tend to measure achievement but not behavioral outcomes. Interesting exceptions are a small number of experimental behavior-based interventions that tested for achievement impacts (Coie & Krehbiel, 1984; Dolan et al., 1993). For example, a random-assignment evaluation of a behavioral intervention targeting both aggressive and shy behaviors among first graders found short-run improvements in both teacher and peer reports of aggressive and shy behavior but no crossover impacts on reading achievement (Dolan et al., 1993; Kellam, Mayer, Rebok, & Hawkins, 1998). Given evidence, albeit limited, that behavioral interventions succeed at improving behavior but not achievement, behavior would appear to play a limited role in academic success.

A second problem is that many intervention programs target both children’s academic skills and their socioemotional behaviors, rendering it impossible to assess their separate impacts through simple experimental contrasts. For example, the Fast Track prevention program provided a number of services to children who were identified as disruptive in kindergarten, including direct tutoring in reading skills in first grade (Conduct Problems Prevention Research Group, 1992, 2002). It is possible to estimate nonexperimental mediated models to determine whether program effects are more likely to be due to children’s improved achievement, attention, or behavior skills (e.g., Reynolds, Ourl, & Topitzes, 2004). This is rarely done, however.

The Present Study

This study builds on previous school readiness research in several ways. First, the scope of the study is unprecedented. We estimated a carefully specified set of models with data from six large-scale longitudinal studies, two of which were nationally representative of U.S. children, whereas two were drawn from multisite studies of U.S. children, with one each focusing on children from Great Britain and Canada. Second, we included as predictors a wide representation of school readiness indicators used in previous research and carefully distinguished between related but conceptually distinct skills (e.g., oral language vs. preliteracy skills, attention vs. externalizing problems) wherever possible. Third, we examined multiple dimensions of academic achievement outcomes, including grade completion and math and reading achievement as assessed by both teacher ratings and test scores. Fourth, we implemented rigorous analytic methods that attempted to isolate the effects of school-entry academic, attention, and socioemotional skills by controlling for an extensive set of prior child, family, and contextual influences that may have been...
related to children’s achievement. Finally, we assessed whether the predictive power of school readiness components differs by gender or socioeconomic status, which would indicate that some children are at heightened risk of low achievement.

We tested a number of hypotheses related to how school-entry academic, attention, and socioemotional skills are associated with later school achievement. Developmental theory suggests that children’s informal, intuitive knowledge of early language and math concepts plays an important role in the acquisition of more complex skills formally taught in elementary school (Adams, Treiman, & Pressley, 1998; Baroody, 2003; Griffin, Case, & Capodilupo, 1995; Tummer & Nesdale, 1998). Theoretically, children’s attention and socioemotional skills should also affect achievement because they influence children’s engagement in learning activities and facilitate (or disrupt) classroom processes (Ladd, Birch, & Buhs, 1999; Fianta & Stuhlmans, 2004). However, some scholars point out that it is important to distinguish between behaviors that are directly relevant for learning, such as attention, and those that may be correlated with attention but are less likely to be directly linked with achievement, such as interpersonal skills and problem behavior (Alexander et al., 1993; Cooper & Farran, 1991; McClelland et al., 2000; McWayne, Fantuzzo, & McDermott, 2004).

Therefore, we expected early academic and attention-related skills to predict subsequent test scores and teacher achievement ratings, and we expected attention skills to predict achievement more consistently than do socioemotional behaviors.

In seeking a better understanding of the extent to which our broad set of early skills is associated with later achievement, it is important to consider how outcomes are being measured. Although test performance provides a key independent assessment of academic achievement, teacher ratings also lend insight into children’s everyday performance in the classroom. Teachers’ evaluations are probably based on a broad picture of children’s accomplishments, which include their academic skills as well as whether they complete assignments on time, work independently, get along with others, and show involvement in the learning agenda of the classroom. Moreover, previous research has found that children’s behavior can play a role that is equal to, if not greater than, prior cognitive ability in predicting teacher-rated attainment or achievement (Lin, Lawrence, & Gorrell, 2003; Schaefer & McDermott, 1999) and academic skills (National Center for Education Statistics, 1993). Consequently, we expected a stronger relationship between school-entry socioemotional behaviors and subsequent teacher-rated achievement than with subsequent test scores.

Although many previous studies have examined the association between early academic, attention, and socioemotional skills and subsequent achievement, few have systematically considered the extent to which these associations differ by gender (Trzesniewski et al., 2006). On average, boys receive poorer grades and have more difficulties related to school progress (e.g., grade retention, special education, and drop out) than do girls (Dauber, Alexander, & Entwisle, 1993; McCoy & Reynolds, 1999), and these differences are especially pronounced among low-income children (Hinshaw, 1992). Children from low-income families enter school with lower mean academic skills, and the gap tends to increase during the school years (Lee & Burkam, 2002). These groups also have higher rates of problems with attention and externalizing behavior (Entwisle et al., 2005; Miech, Essex, & Goldsmith, 2001; Raver, 2004).

Despite differences in children’s behavior linked to gender and family socioeconomic status, few studies have considered whether gender and socioeconomic status moderate the association between these early skills and behaviors and subsequent achievement. We expected early academic skills, attention, and socioemotional behaviors to matter more for these subgroups, particularly when children enter school with very low levels of these skills.

To estimate the associations between early academic skills and socioemotional behaviors and later school achievement, we summarize results from a coordinated series of analyses across six longitudinal data sets in two ways. First, we relate early academic, attention, and socioemotional skills to later achievement, each of the six data sets and provide a basic summary of these results. Second, we formally summarize the findings from these studies in a meta-analysis, again focusing on the extent to which this collection of early skills predicts later achievement.

**Method**

In this section, we describe the data sets used in this study and the common analytic procedures that were implemented across studies. Detailed information about the measures, descriptive statistics, and regression results from each study is presented in Appendices A–F, which can be found online. As the goal of our study was to relate early academic, attention, and socioemotional skills and behaviors to later achievement, each data set has measures of these constructs, although there is variation across the studies with respect to when and how each skill or behavior is assessed.

Table 1 provides an overview of data sources and measures available in each study. All six data sets provide measures of children’s academic skills as well as assessments of attention and socioemotional behaviors at about age 5 or 6. Because most children enter elementary school at this age, we refer to the timing of these measures as school entry but alert the reader that the precise timing varies considerably across studies. To facilitate comparison of findings across studies, we standardized all measures to have a mean of 0 and standard deviation of 1.

We measured achievement outcomes using teachers’ reports, test scores, and grade retention in early elementary school and, in some studies, middle childhood. In terms of the timing of the measurement of achievement outcomes, the children of the National Longitudinal Survey of Youth (NLSY) measures are assessed as late as early adolescence, the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) as late as fifth grade, and the 1970 British Birth Cohort Study (BCS) at age 10, whereas none of the other studies measures achievement beyond third grade. As for measurement methods, two studies have both test-score-based and teacher reports of reading and mathematics achievement (the Early Childhood Longitudinal Study–Kindergarten Cohort [ECLS-K] and NICHD SECCYD).

We measured attention and socioemotional behaviors on the basis of mothers’ reports, teachers’ reports, and observation. Table 1 provides an overview of the similarities and differences in measurement across the six studies. One of our data sets, the Infant Health and Development Program (IHDP), has observer reports of
<table>
<thead>
<tr>
<th>Measure</th>
<th>ECLS-K Grade 3</th>
<th>NLSY age 13–14</th>
<th>NICHD SECCYD Grade 5</th>
<th>IHDP age 8</th>
<th>MLEPS Grade 3</th>
<th>BCS age 10</th>
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<tbody>
<tr>
<td><strong>Outcomes</strong></td>
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<tr>
<td><strong>Math</strong></td>
<td>Achievement Test Math</td>
<td>IRT “advanced” subscales: Multiplication/division, Place-value, Word problems</td>
<td>Academic Skills Ratings Scale: Teacher Report</td>
<td>Number Knowledge Test: Number sequence, addition, subtraction, multiplication, division, fractions, decimals</td>
<td>University of Bristol Math Test: Rules of arithmetic, place value, fractions, measurement, algebra, geometry, and statistics (α = .93)</td>
<td></td>
</tr>
<tr>
<td><strong>School entry skills</strong></td>
<td>Fall of kindergarten</td>
<td>Age 5–6</td>
<td>Age 4.5</td>
<td>Age 5</td>
<td>Junior and senior kindergarten</td>
<td>Age 5</td>
</tr>
<tr>
<td><strong>Achievement Reading</strong></td>
<td>Achievement Test Reading</td>
<td>IRT “early” subscales: Letter recognition, beginning and ending word sounds</td>
<td>PIAT Reading Recognition</td>
<td>WJ-R Reading: Letter-Word Identification (α = .84)</td>
<td>Peabody Picture Vocabulary Test (PPVT), Forms A and B, French adaptation: Split-half reliability .66 and .85 for A and B, respectively; test-retest at 1 week = .72</td>
<td>English Picture Vocabulary Test: Verbal intelligence</td>
</tr>
<tr>
<td><strong>Language/Verbal ability</strong></td>
<td></td>
<td></td>
<td>Preschool Language Scale–3: Expressive communication</td>
<td>WPPSI: Verbal IQ (α = .94)</td>
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<tr>
<td><strong>Math</strong></td>
<td>Achievement Test Math</td>
<td>IRT “early” subscales: Counting, ordinality and relative size</td>
<td>PIAT Math</td>
<td>WJ-R Math: Applied problems (α = .84)</td>
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<tr>
<td><strong>Attention skills</strong></td>
<td>Approaches to Learning (α = .89): Teacher Report</td>
<td></td>
<td>Continuous Performance Task: Attention</td>
<td>Attention: Child concentrates, listens attentively, etc. (α = .82): Teacher Report</td>
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<tr>
<td><strong>Attention problems</strong></td>
<td></td>
<td></td>
<td>Hyperactivity (difficulty concentrating, restless, etc.): Maternal Report</td>
<td>Attention: Child seems agitated, impulsive, etc. (α = .90): Teacher Report</td>
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</tr>
</tbody>
</table>

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Table 1: Study Measures of Outcomes, School Entry and Preschool Achievement, Attention and Socioemotional Behaviors
Table 1 (continued)

<table>
<thead>
<tr>
<th>School entry skills</th>
<th>Fall of kindergarten</th>
<th>Age 5–6</th>
<th>Age 4.5</th>
<th>Age 5</th>
<th>Junior and senior kindergarten</th>
<th>Age 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socioemotional behaviors</td>
<td>Externalizing problems</td>
<td>(α = .90): Teacher Report</td>
<td>CBCL, Aggressive behavior (α = .93); Fall of Kindergarten Teacher Report</td>
<td>Aggression: Child fights, bullies others, etc. (α = .72); Teacher Report</td>
<td>Rutter Scale, Externalizing: Child bullies others, is disobedient, etc. (α = .72); Maternal Report</td>
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<tr>
<td></td>
<td>Internalizing problems (α = .80): Teacher Report</td>
<td>CBCL: Internalizing (α = .93); Fall of Kindergarten Teacher Report</td>
<td>Anxiety/Depression: Child worries, cries often, etc. (α = .80); Teacher Report</td>
<td>Rutter Scale, Internalizing: Child worries, seems miserable, etc. (α = .54); Maternal Report</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social skills</td>
<td>(I) Self Control (α = .79); Teacher Report</td>
<td>Social Skills Rating System (SSRS): Cooperation, assertion, self-control (α = .93); Fall of Kindergarten Teacher Report</td>
<td>Prosocial: Child is helpful, sympathetic to others, etc. (α = .92); Teacher Report</td>
<td></td>
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</tbody>
</table>

Prior child controls

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<thead>
<tr>
<th>Prior cognitive/achievement</th>
<th>Age 3–4</th>
<th>Age 3</th>
<th>Age 3</th>
<th>Junior and senior kindergarten</th>
<th>Age 42 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior cognitive/achievement</td>
<td>Peabody Picture Vocabulary Test—Revised (PPVT-R; split-half reliability of .80)</td>
<td>Bracken Basic Skills (colors, letters, numbers, etc., α = .93)</td>
<td>Stanford-Binet IQ Test</td>
<td>Peabody Picture Vocabulary Test (PPVT), Forms A and B, French adaptation: Split-half reliability .66 and .85 for A and B, respectively; test-retest at 1 week = .72</td>
<td>Counting (α = .95)</td>
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<td></td>
<td></td>
<td>Reynell Developmental Language Scale (vocabulary comprehension, α = .93; expressive language, α = .86)</td>
<td></td>
<td>Number Knowledge Test: Informal number knowledge, shapes, colors, counting, number sequence, addition</td>
<td>Speaking &amp; Vocabulary (α = .79)</td>
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<td></td>
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<td></td>
<td>Copying designs (α = .83)</td>
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<td></td>
<td></td>
<td></td>
<td>Age 22 months: Cube stacking, Language (α = .93), Copying designs test (α = .46)</td>
</tr>
<tr>
<td>Prior attention skills/socioemotional behavior</td>
<td>Compliance (α = .59); Maternal Report Sociability (α = .93); Interviewer ratings of child's cooperation during the assessment</td>
<td>CBCL, Externalizing, internalizing: Maternal Report Forbidden toy laboratory task: Impulsivity</td>
<td>CBCL, Overall behavior problems (α = .94); Maternal Report Attention (α = .94); Test observer's report</td>
<td>Cooperation: Interviewer ratings of child's cooperation during the assessment</td>
<td>Age 22 months: Personal development (α = .82)</td>
</tr>
</tbody>
</table>

Note. Early Childhood Longitudinal Study-Kindergarten Cohort (ECLS-K) includes a school entry test of general knowledge. National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) includes age 4.5 WJ-R Cognitive Ability measure. Infant Health and Development Program (IHDP) includes age 5 Wechsler Preschool and Primary Scale of Intelligence (WPPSI) Performance IQ (α = .93) and age 5 Achenbach Child Behavior Profile Maternal Report: Overall behavior problems (α = .93). British Birth Cohort Study (BCS) includes age 5 Human Figure Drawing, Copying Designs Test, and Profile Drawing. Roman numerals index measures consistently in Tables 1 and 2. NLSY = National Longitudinal Survey of Youth; MLEPS = Montreal Longitudinal-Experimental Preschool Study.
attention, another (NICHD SECCYD) has both test-based and teacher-rated measures of attention, and three (NLSY, IHDP, and BCS) have parent rather than teacher reports of socioemotional behaviors. In addition, two of the studies (NICHD SECCYD and the Montreal Longitudinal-Experimental Preschool Study [MLEPS]) measure both attention skills and problems, whereas three (NLSY, IHDP, and BCS) have measures of attention problems but not skills, and one study (ECLS-K) has a measure of attention skills but not attention problems. In addition, with one exception, all of the studies provide measures of academic, attention, and socioemotional skills prior to the point of school entry, which we used as key control variables in our analyses.

The Studies and Samples

The Early Childhood Longitudinal Study–Kindergarten Cohort (ECLS-K). The ECLS-K follows a nationally representative sample of 21,260 children who were in kindergarten in 1998–1999. We used data from kindergarten, first grade, and third grade. Data were collected from multiple sources, including direct achievement tests of children and surveys of parents, teachers, and school administrators (see Table 1; National Center for Education Statistics, 2001).

Achievement tests were administered in the fall of kindergarten and in the spring of kindergarten, first grade, and third grade. We used teacher reports of children’s “approaches to learning” (which measure both attention skills and achievement motivation) and socioemotional behaviors, including internalizing and externalizing problems, self-control with peers, and interpersonal skills, collected in the fall and spring of kindergarten.

The battery of achievement tests given as part of the ECLS-K kindergarten and first-grade assessments covered three subject areas: language and literacy, mathematical thinking, and general knowledge. For third grade, the achievement tests included mathematics, reading, and science. We used item response theory scores for the first two of these as key dependent variables. These third-grade assessments required students to complete workbooks and open-ended mathematics problems. As detailed in Appendix A, a host of family- and some child-level controls are available in the data.

The children of the National Longitudinal Survey of Youth (NLSY). The NLSY is a multistage stratified random sample of 12,686 individuals age 14 to 21 in 1979 (Center for Human Resource Research, 2004). Black, Hispanic, and low-income youth were overrepresented in the sample. Annual (through 1994) and biennial (between 1994 and 2000) interviews with sample members and very low cumulative attrition in the study contribute to the quality of the study’s data.

Beginning in 1986, the children born to NLSY female participants were tracked through biennial mother interview supplements and direct child assessments. Given the nature of the sample, it is important to note that early cohorts of the child sample were born disproportionately to young mothers. With each additional cohort, the children become more representative of all children, and NLSY children younger than age 14 in 2000 share many demographic characteristics of their broader set of age mates.

The sample used in the present analysis consists of 1,756 children whose academic achievement was tracked from age 7–8 to age 13–14 and whose achievement and behavior was assessed at age 5–6. Consequently, our sample comprises children who were age 5 or 6 in 1986, 1988, 1990, or 1992. The age 13–14 achievement and behavior of these children were assessed in the respective 1994, 1996, 1998, and 2000 interviews.

School readiness measures, including math and reading test scores (Peabody Individual Achievement Test; Dunn & Markwardt, 1970) and maternal reports of children’s behavior problems (adapted from the Achenbach Behavior Problems Checklist; Baker, Keck, Mott, & Quinlan, 1993) were collected at age 5 or age 6. Academic achievement outcome measures were collected biennially for children between the ages of 5 and 14. In addition, key control variables include children’s receptive vocabulary (Peabody Picture Vocabulary Test—Revised; Dunn & Dunn, 1981) and children’s temperament (compliance and sociability) at age 3 or 4. Additional family- and child-level control variables are described in Appendix B.

The NICHD Study of Early Child Care and Youth Development (SECCYD). Longitudinal data from the NICHD SECCYD are drawn from a multisite study of births in 1991 (NICHD Early Child Care Research Network, 2005a). Participants were recruited from hospitals located at 10 sites across the United States. During 24-hr sampling periods, 5,265 new mothers met the selection criteria and agreed to be contacted after returning home from the hospital. At 1 month of age, 1,364 healthy newborns were enrolled in the study. Although it is not nationally representative, the study sample closely matches national and census tract records with respect to demographic variables such as ethnicity and household income. The majority of children in the sample are White, 12% are African American, and 11% are Hispanic or of another ethnicity. About 30% of mothers had a high school education or less, and 14% were single parents (NICHD Early Child Care Research Network, 1997). The analysis sample had valid data on the achievement outcome measures and at least three sources of information on the key independent variables (approximately 981 at first grade, 928 at third grade, and 907 at fifth grade).

School readiness measures, including achievement tests and attention/impulsivity tasks, were administered in a controlled laboratory setting at age 4.5, and attention problems, aggression, internalizing behavior, and social skills were measured by teacher report in the fall of the kindergarten year. Outcomes at first, third, and fifth grades include achievement in math and reading according to teacher ratings and Woodcock–Johnson Tests of Achievement—Revised test scores (Woodcock & Johnson, 1990; see Table 1). Key control variables at age 3 include children’s cognitive ability, language skills, impulsivity, externalizing problems, and internalizing problems. The NICHD SECCYD also collects information from infancy about children’s early environments, including child-care type and quality, home environment, and parenting; these and other child- and family-level covariates are described in Appendix C.

The Infant Health and Development Program (IHDP). The IHDP is an eight-site randomized clinical trial designed to evaluate the efficacy of a comprehensive early-intervention program for low birth weight (LBW) premature infants. Infants weighing 2,500 g (5.51 lb) or less at birth were screened for eligibility if their postconceptional age between January and October 1985 was 37 weeks or less and if they were born in one of eight participating medical institutions. A total of 985 infants was randomly assigned either to a medical follow-up only or to a comprehensive early
school intervention group immediately following hospital discharge.

Infants in both the comprehensive early childhood intervention and medical follow-up only groups participated in a pediatric follow-up program of periodic medical, developmental, and familial assessments from 40 weeks of conceptional age (when they would have been born if they had been full term) to 36 months of age corrected for prematurity. The intervention program, lasting from hospital discharge until 36 months, consisted of home visits, child-care services, and parent group meetings. A coordinated educational curriculum of learning games and activities was used both during home visits and at the center.

The primary analysis group consisted of 985 infants. Of these 985 infants, cognitive assessments are available for 843 children at age 3, 745 children at age 5, and 787 children at age 8. In addition, 76 children who were born at an extremely low birth weight (ELBW; 1,000 g [3.27 lb] or less) were excluded from the sample because ELBW children differ markedly from other LBW children in cognitive and behavioral functioning (Klebanov, Brooks-Gunn, & McCormick, 1994a, 1994b). Thus, this study focuses on a subsample of 690 children who were not born ELBW and for whom cognitive assessment and family background data were available.

Data come from a variety of sources: questionnaires, home visits, and laboratory tests (see Table 1). School readiness measures include preschool performance and verbal test scores, parental reports of children’s mental health and aggressive behavior, and observer reports of children’s attention and task persistence. We assessed reading and math achievement using the Woodcock-Johnson Tests of Achievement—Revised broad reading and math tests and the Wechsler Intelligence Scale for Children—Third Edition (Wechsler, 1991) performance and verbal tests at 8 years of age. Key control variables include cognitive ability, sustained attention, and behavior problems at age 3. Additional family- and child-level control variables are described in Appendix D.

The Montreal Longitudinal-Experimental Preschool Study (MLEPS). The MLEPS comprises several consecutive cohorts launched from 1997 to 2000. The original sample of 4- and 5-year-old children (N = 1,928), representing one third of its population base, was obtained after a multilevel consent process involving school board administrators, local school committees, parents, and teachers. Given that its final cohort (2000) does not meet all the data requirements for the research objective examined here, we limited ourselves to the sample of children beginning kindergarten in the fall of 1998 and the fall of 1999.

Incomplete data reduced the sample from 1,369 to 767 children. Students in the final sample had a valid value on any of the four outcome measures of interest (first- and third-grade achievement measures) and on at least four of the six socioemotional measures. Of the 767 participants in the final sample, 439 began kindergarten in 1998 and 328 began kindergarten in the fall of 1999. Additionally, for 350 of the 767 students, initial data were collected during the fall of junior kindergarten (332 who began junior kindergarten in 1997 and 18 who began junior kindergarten in 1998).

Initial and follow-up data were collected from multiple sources, including direct cognitive assessments of children and surveys of parents and teachers. Early academic assessments include individually administered number knowledge and receptive vocabulary tests at the end of senior kindergarten. Teachers rated children’s behavioral development, including physically aggressive, anxious, depressive, hyperactive, inattentive, and prosocial behavior. Third-grade assessments include a group-administered math test and teacher ratings of children’s French language skills (see Table 1). Key control variables include number knowledge and vocabulary measured on entry into junior kindergarten (age 4) for Cohort 1 and on entry into senior kindergarten (age 5) for Cohort 2. Additional family- and child-level control variables are detailed in Appendix E.

The 1970 British Birth Cohort Study (BCS). The U.K. 1970 BCS, a nationally representative longitudinal study, has followed into adulthood a cohort of children born in Great Britain during 1 week in 1970 (Bynner, Ferri, & Shepherd, 1997). The birth sample of 17,196 infants was approximately 97% of the target birth population. Attrition has reduced the original sample to 11,200 participants. Nevertheless, the representativeness of the original birth cohort has largely been maintained, although the current sample is disproportionately female and highly educated (Ferri & Smith, 2003). Missing data on key variables reduce the sample size for most analyses to between 9,000 and 10,000 cases.

At each wave, cohort members were given a battery of tests of intellectual and behavioral development (see Table 1). School readiness measures include vocabulary and copying skills tests, and maternal reports of attention, externalizing behavior, and internalizing behavior were collected when the children were 5 years of age. Reading and mathematics achievement tests were administered at age 10. Key control variables include measures of basic skills and behavior at ages 22 and 42 months for a 10% subsample of the data. Additional family- and child-level controls are described in Appendix F.

Analysis Plan

We begin our analysis by estimating a similar set of regression models across all six studies, in which school-entry academic, attention, and socioemotional skills are related to later academic achievement. For example, in ECLS-K data, the school-entry skills and behaviors are measured in the fall of kindergarten (referred to hereafter as FK), whereas math and reading achievement are measured in the spring of third grade (referred to hereafter as 3rd). The resulting equation is as follows:

\[ \text{ACH}_{3rd} = \beta_1 \text{ACAD}_{FK} + \beta_2 \text{ATTN}_{FK} + \beta_3 \text{SE}_{FK} + \gamma_1 \text{FAM}_i + \gamma_2 \text{CHILD}_i + e_i \]  

where \( \text{ACH}_{3rd} \) is the math or reading achievement of child \( i \) in the spring of third grade; \( \text{ACAD}_{FK} \) is the collection of math, reading, and general knowledge skills that child \( i \) has acquired at school entry, assessed by achievement tests in the fall of the kindergarten year; \( \text{ATTN}_{FK} \) is a teacher-reported measure of attention; \( \text{SE}_{FK} \) is the collection of socioemotional skills that child \( i \)’s teacher reports; \( \text{FAM} \) and \( \text{CHILD} \), are sets of family background and child characteristics, respectively, included in analyses to control for individual differences that might influence child achievement before and after school entry; \( \beta_1 \) is a constant; and \( e_i \) is a stochastic error term.

\(^2\) We use reading as shorthand for the set of reading, language, and verbal ability skills measured in our data sets.
Our interest is in estimating $\beta_1$, $\beta_2$, and $\beta_3$, which, if correctly modeled, can be interpreted as the impact of school-entry academic, attention, and socioemotional skills on subsequent achievement. A key challenge in this approach is ensuring that we have accounted for the possibility of omitted variable bias, which is likely to arise if unobserved family or child characteristics are correlated with both children’s school entry skills and their later achievement. Our principal strategy for securing unbiased estimation of $\beta_1$, $\beta_2$, and $\beta_3$ is to estimate a model of the form of Equation 1 that includes as many prior measures of relevant child and family characteristics as possible.

All of the studies contain important measures of child and family characteristics that may be confounded with children’s achievement, attention, and behavior. Although the specific set of covariates varies across studies, most studies include measures of the child’s race and ethnicity, maternal education, family structure, and family income or economic well-being. In some studies, measures of child health, maternal depressive symptoms, parenting, and quality of the home environment, as well as children’s participation in early child care and education during early childhood were also included as controls. Details about the specific controls used in each study are provided in the appendices, and a complete list of covariates for each study can be found in Tables A6, B6, C6, D5, E6, and F5.

Our analysis was designed to examine the relations between early skills and later achievement, irrespective of the characteristics of the classroom/school the child attends. The ECLS-K is an exception, owing to a sample design that selects an average of 4 students per kindergarten classroom to be enrolled in the study. We took advantage of this classroom clustering by adjusting our ECLS-K estimates for classroom fixed effects. Thus, all of the variation used in the regression stems from within-classroom differences, which holds constant school and classroom characteristics.

Of course, we cannot be certain that even a comprehensive set of control variables captures all of the important confounds, which leaves open the possibility that this approach will still produce biased estimates of $\beta_1$, $\beta_2$, and $\beta_3$. For example, an obvious bias of this sort would arise if scores on a kindergarten mathematics test reflected both math skills and underlying cognitive ability.

To further reduce the possibility of biases, we include measures of a child’s attention and socioemotional behaviors and either cognitive ability or preacademic skills assessed prior to school entry, which are available in all but two studies (ECLS-K and MLEPS). With these prior measures, our model becomes

$$AC{H}_{i\text{std}} = a_1 + \beta_1ACAD_{FK} + \beta_2ATTN_{FK} + \beta_3SE_{FK} + \beta_4ACAD_{Pre-FK} + \beta_5ATTN_{Pre-FK} + \beta_6SE_{Pre-FK} + \gamma_1FAM_i + \gamma_2CHILD_i + \epsilon_i.$$  

Equation 2) across all of the studies. For each study, reading and math outcomes measured as late in the data set as possible were regressed on school-entry achievement, attention, and socioemotional behaviors, with controls for important family and child characteristics also included in the regression. In all but two cases, our regressions include measures of both cognitive ability and either attention or socioemotional behaviors.

5 Our list of child and family control variables is more extensive than in most developmental studies. In selecting these variables, we were careful to include only variables measured prior to or concurrently with our school-entry measures of achievement and behavior. We were also mindful that added controls might introduce multicollinearity into our regression estimation, but there was no indication that this might be the case. And finally, our appendix tables compare models run with and without our child and family controls and show that the results of our analyses depend little on adjustments for these factors; concurrent controls for the other achievement and behavioral measures matter much more.

4 The MLEPS provides preschool cognitive measures but not attention or socioemotional behaviors (see Table 1).

The decision of which type of measure should serve as the omitted dummy variable category is noteworthy, because the coefficients on the included measure categories represent differences from the omitted category. We selected internalizing behavior problem coefficients as the omitted category because the simple average of their regression coefficients was very close to zero (−.01 for reading outcomes and −.01 for math outcomes).

6 We remind the reader we use the term school entry somewhat loosely. It refers to age 5 in four cases, age 5–6 in one case, and the fall of the kindergarten year in only one case.

Regression Results

To consider whether school entry achievement, attention, and socioemotional skills are predictive of subsequent achievement, we first estimated a comparable set of regressions (Equation 2) across all of the studies. For each study, reading and math outcomes measured as late in the data set as possible were regressed on school-entry achievement, attention, and socioemotional behaviors, with controls for important family and child characteristics also included in the regression. In all but two cases, our regressions include measures of both cognitive ability and either attention or socioemotional behaviors.

$$AC{H}_{i\text{std}} = a_1 + \beta_1ACAD_{FK} + \beta_2ATTN_{FK} + \beta_3SE_{FK} + \beta_4ACAD_{Pre-FK} + \beta_5ATTN_{Pre-FK} + \beta_6SE_{Pre-FK} + \gamma_1FAM_i + \gamma_2CHILD_i + \epsilon_i.$$  

Equation 2) across all of the studies. For each study, reading and math outcomes measured as late in the data set as possible were regressed on school-entry achievement, attention, and socioemotional behaviors, with controls for important family and child characteristics also included in the regression. In all but two cases, our regressions include measures of both cognitive ability and either attention or socioemotional behaviors.

$$AC{H}_{i\text{std}} = a_1 + \beta_1ACAD_{FK} + \beta_2ATTN_{FK} + \beta_3SE_{FK} + \beta_4ACAD_{Pre-FK} + \beta_5ATTN_{Pre-FK} + \beta_6SE_{Pre-FK} + \gamma_1FAM_i + \gamma_2CHILD_i + \epsilon_i.$$  

Equation 2) across all of the studies. For each study, reading and math outcomes measured as late in the data set as possible were regressed on school-entry achievement, attention, and socioemotional behaviors, with controls for important family and child characteristics also included in the regression. In all but two cases, our regressions include measures of both cognitive ability and either attention or socioemotional behaviors.
Standardized regression coefficients and standard errors from models predicting achievement from the school-entry academic, attention, and socioemotional behaviors are presented in Table 2. Complete regression results using all available reading and math outcomes are presented in appendix tables and are summarized below in our meta-analysis.

As expected, the regression results indicate that school-entry reading and math skills are almost always statistically significant predictors of later reading and math achievement, with standardized coefficients ranging from .05 to .53. Not surprisingly, school-entry reading skills predict subsequent reading achievement better than subsequent math achievement, just as early math skills are more predictive of later math than reading achievement.

In the case of attention skills and attention problems, coefficients are usually smaller than those for math skills, but they are statistically significant for more than half of the coefficients. In contrast, coefficients for socioemotional behaviors—externalizing and internalizing behavior problems and social skills—rarely pass the threshold of statistical significance.

This general pattern—relatively strong prediction from school-entry reading and math skills, moderate predictive power for attention skills, and few to no statistically significant coefficients on socioemotional behaviors—is also found for reading and math achievement measured at earlier points in the studies and in logistic regressions in which grade retention is the dependent variable (results shown in Tables A3, B3, C3, D3, E3, and F3 but not in Table 2).

To consider whether the effects of school-entry skills differ by children’s gender or socioeconomic status (SES), we ran regressions (Equation 2) but also included gender interactions with school-entry achievement, attention, and socioemotional skills for all six data sets and SES interactions for all but the NICHD SECCYD and MLEPS (results shown in Appendices A–F). In the case of gender interactions, 10 of 76 relevant interaction coefficients were .05 or larger and statistically significant, but there was no consistent pattern in the direction of effects. In the case of SES interactions, only 2 of the 30 interaction coefficients were .05 or greater and statistically significant. It appears that the influences of school-entry achievement, attention, and socioemotional skills are broadly similar for both boys and girls and for children from both low- and high-SES families.

**Meta-Analytic Results**

To summarize findings across the six studies more systematically, we first averaged the 102 bivariate correlations between school-entry achievement, attention, and socioemotional skills and the latest available reading and math achievement available in each of the data sets. (Detailed correlation tables are shown in Tables A2, B2, C2, D2, E2, and F2.) As shown in the first column of Table 3, the absolute value of these correlations average between .40 and .50 for school-entry reading and math achievement, average .25 for the collection of attention measures, and average between .10 and .21 in absolute value for the three sets of socioemotional measures.

Next, we conducted a formal meta-analysis of the standardized regression coefficients emerging from the individual study regressions. We used two sets, with the first comprising the 102 coefficients shown in Table 2, and drew from regressions based on Equation 2 and achievement outcomes measured as late in childhood as possible. These results are shown in the second column of Table 3. The second meta-analytic regression is based on the 228 coefficients taken from regressions with outcomes measured at all possible points in a given study. These coefficients are shown in the appendix tables and produce the results shown in the third, fourth, and fifth columns of Table 3.

A clear conclusion from the first meta-analytic regression is that only three of the school-entry skill categories predict subsequent reading and math achievement: reading/language, math, and attention. Moreover, rudimentary mathematics skills appear to matter the most, with an average standardized coefficient of .33. The association of reading skill with later achievement was less than half as large (.13), and, at .07, the average standardized coefficients on the attention-related measures was less than one quarter the size of the mean math-skills coefficient. As expected from Table 2, the meta-analysis results confirm that behavior problems and social skills are not associated with later achievement, holding constant achievement as well as child and family characteristics. Indeed, none had a standardized coefficient that averaged more than .01 in absolute value.

Turning to the other coefficients listed in the second column of Table 3, one can see that the school-entry skills coefficients decreased a little (.010 per year) with each additional year between school entry and the point of assessment of the math or reading outcome. As for whether teacher-report outcomes or direct skill assessments are more likely to be predicted by early skills, our meta-analytic results suggest that both types of measures performed about the same.

Our appendices (Tables A3, B3, C3, D3, E3, and F3) provide standardized coefficients from regressions of achievement outcomes measured at different ages, which constitute the 228 observations used for the meta-analytic regression results shown in the remaining columns of Table 3. The advantage of using outcomes at several ages is that it enables us to control for the study from which a given standardized coefficient was estimated, which we do by including a set of study indicator variables. The third column of Table 3 summarizes the results across domains, and the fourth and fifth columns show

7 Coefficients were excluded from our summary calculations if the standard errors for the gender or SES interactions were too large to detect differences of .15.

8 The ECLS-K, NLSY, and HDP studies provided enough observations on Black and White children to enable us to test for race interactions as well. We found no consistent evidence of race-based interactions.

9 Technically speaking, the .33 coefficient reflects the regression-adjusted difference between the average school-entry math and the omitted-group internalizing problem behavior standardized coefficient. Recall that the simple average of regression coefficients on internalizing behavior problems was −.01 for both math and reading outcomes. The large sample sizes available in the ECLS-K push weighted meta-analytic results closer to the ECLS-K study coefficients than when the coefficient-variance weights are not used. Unweighted, the coefficients on school-entry reading and math are .12 and .20, respectively; the coefficient on attention is .05, the coefficient on externalizing is .00, and the coefficient on social skills is −.01.

10 With study dummies in the regression, we have what amounts to a fixed-effects regression in which coefficients are averaged within rather than across studies. Dropping the study dummies produced few changes in the remaining coefficients.
### Table 2

**Coefficients From Regressions of Individual Study Achievement Outcomes on School Entry Achievement, Attention, and Socioemotional Behaviors From Models With Full Controls**

<table>
<thead>
<tr>
<th>ECLSK Grade 3</th>
<th>NLSY age 13–14</th>
<th>NICHD SECCYD Grade 5</th>
<th>IHDP age 8</th>
<th>MLEPS Grade 3</th>
<th>BCS age 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Achievement</td>
<td>Teacher-rated</td>
<td>Achievement</td>
<td>Teacher-rated</td>
<td>achievement</td>
</tr>
<tr>
<td></td>
<td>test score</td>
<td>achievement test</td>
<td>test score</td>
<td>achievement test</td>
<td>test score</td>
</tr>
<tr>
<td>Independent variable</td>
<td>Reading</td>
<td>Math</td>
<td>Reading</td>
<td>Math</td>
<td>Reading</td>
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<td>Achievement</td>
<td>Reading</td>
<td>.18***</td>
<td>.05***</td>
<td>.15***</td>
<td>.09***</td>
</tr>
<tr>
<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(02)</td>
<td>(02)</td>
<td>(02)</td>
</tr>
<tr>
<td>Language/Verbal Ability</td>
<td>Math</td>
<td>.27***</td>
<td>.53***</td>
<td>.31***</td>
<td>.34***</td>
</tr>
<tr>
<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(02)</td>
<td>(02)</td>
<td>(02)</td>
</tr>
<tr>
<td>Attention skills</td>
<td>Attention   problems (I)</td>
<td>.04***</td>
<td>.10***</td>
<td>.14***</td>
<td>.12***</td>
</tr>
<tr>
<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(02)</td>
<td>(02)</td>
<td>(02)</td>
</tr>
<tr>
<td>Attention problems (II)</td>
<td>Externalizing problems (I)</td>
<td>.00</td>
<td>-.01</td>
<td>.00</td>
<td>.01</td>
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<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(02)</td>
<td>(02)</td>
<td>(02)</td>
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<tr>
<td>Socioemotional behaviors</td>
<td>Externalizing problems (II)</td>
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<td>-.01</td>
<td>.00</td>
<td>.01</td>
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<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(02)</td>
<td>(02)</td>
<td>(02)</td>
</tr>
<tr>
<td>Internalizing problems</td>
<td>Social skills (I)</td>
<td>.00</td>
<td>.00</td>
<td>-.01</td>
<td>-.02</td>
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<td></td>
<td>(01)</td>
<td>(01)</td>
<td>(01)</td>
<td>(01)</td>
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<tr>
<td>Social skills (II)</td>
<td>Social skills (II)</td>
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<td>-.02</td>
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<td></td>
<td>(02)</td>
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### Prior controls

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<tbody>
<tr>
<td>Observations</td>
<td>10,779</td>
<td>10,833</td>
<td>8,776</td>
<td>8,647</td>
<td>1,756</td>
<td>1,756</td>
<td>859</td>
<td>851</td>
<td>690</td>
<td>690</td>
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<td>R²</td>
<td>.44</td>
<td>.50</td>
<td>.39</td>
<td>.32</td>
<td>.64</td>
<td>.36</td>
<td>.42</td>
<td>.43</td>
<td>.36</td>
<td>.29</td>
<td>.57</td>
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</table>

*Note.* Standard errors are in parentheses. Early Childhood Longitudinal Study—Kindergarten Cohort (ECLSK-K) regressions include a school entry test of general knowledge. National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD) regressions include age 4.5 Woodcock–Johnson Psycho-Educational Battery—Revised Cognitive Ability measure. Infant Health and Development Program (IHDP) regressions include age 5 Wechsler Preschool and Primary Scale of Intelligence Performance IQ and age 5 Achenbach Child Behavior Profile Maternal Report: Overall behavior problems. British Birth Cohort Study (BCS) regressions include age 5 Human Figure Drawing, Coping Designs Test, and Profile Drawing. Incl. = set of measures included in the regression; NLSY = National Longitudinal Survey of Youth; MLEPS = Montreal Longitudinal-Experimental Preschool Study.

*p < .05. * * *p < .01. * * * * *p < .001.
### Table 3
Average Correlations and Meta-Analytic Regression Results for the Standardized Coefficients From the Six Data Sets

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Zero-order correlation coefficients</th>
<th>Most recent reading and math outcomes</th>
<th>Reading and math</th>
<th>All observed outcomes</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Reading</td>
<td>Math</td>
</tr>
<tr>
<td>School-entry measure</td>
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<td></td>
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<tr>
<td>Reading</td>
<td>.44</td>
<td>.13*** (.01)</td>
<td>.17*** (.03)</td>
<td>.24*** (.03)</td>
</tr>
<tr>
<td>Math</td>
<td>.47</td>
<td>.33*** (.06)</td>
<td>.34*** (.04)</td>
<td>.26*** (.02)</td>
</tr>
<tr>
<td>Attention skills</td>
<td>.25</td>
<td>.07 (.02)</td>
<td>.10*** (.01)</td>
<td>.08*** (.02)</td>
</tr>
<tr>
<td>Externalizing problems</td>
<td>-.14</td>
<td>.01 (.00)</td>
<td>.01 (.01)</td>
<td>.01 (.02)</td>
</tr>
<tr>
<td>Internalizing problems</td>
<td>-.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social skills</td>
<td>.21</td>
<td>-.01 (.01)</td>
<td>-.01 (.01)</td>
<td>-.00 (.02)</td>
</tr>
<tr>
<td>Time (years between school entry measure and outcomes)</td>
<td>- .010*** (.001)</td>
<td>-.009 (.005)</td>
<td>-.012*** (.005)</td>
<td>-.005 (.005)</td>
</tr>
<tr>
<td>Outcome source</td>
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<tr>
<td>Test score</td>
<td>- .00 (.01)</td>
<td>- .00 (.02)</td>
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<td>.01 (.02)</td>
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<td>Teacher report*</td>
<td>- .01 (.01)</td>
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<td>Outcome subject</td>
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<tr>
<td>Math</td>
<td>.01** (.00)</td>
<td>- .00 (.02)</td>
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<td>- .01 (.01)</td>
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<td>Data set</td>
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<tr>
<td>ECLS-K*</td>
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<tr>
<td>NLSY</td>
<td></td>
<td>- .01 (.02)</td>
<td>- .01 (.02)</td>
<td>- .01 (.02)</td>
</tr>
<tr>
<td>NICHD SECCYD</td>
<td></td>
<td>- .01 (.02)</td>
<td>- .01 (.03)</td>
<td>.08 (.09)</td>
</tr>
<tr>
<td>IHDP</td>
<td></td>
<td>- .03 (.05)</td>
<td>- .05 (.03)</td>
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</tr>
<tr>
<td>MLEPS</td>
<td>- .01 (.02)</td>
<td>- .01 (.03)</td>
<td>- .01 (.03)</td>
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</tr>
<tr>
<td>BCS</td>
<td></td>
<td>- .00 (.02)</td>
<td>- .01 (.03)</td>
<td>.01 (.02)</td>
</tr>
<tr>
<td>Observations</td>
<td>102</td>
<td>102</td>
<td>228</td>
<td>114</td>
</tr>
<tr>
<td>R²</td>
<td>.75</td>
<td>.74</td>
<td>.74</td>
<td>.80</td>
</tr>
</tbody>
</table>

Note. All coefficients used in these analyses come from the individual study regressions that include full controls. Column 1 shows the simple average correlation between the given measure and the most recent math and reading outcomes. Model 2 standard errors are corrected for within-study clustering using Huber–White methods. Regression coefficient observations are weighted by the inverse of their variances. Robust standard errors are in parentheses. Dashes indicate that this category was omitted. ECLS-K = Early Childhood Longitudinal Study–Kindergarten Cohort; NLSY = National Longitudinal Survey of Youth; NICHD SECCYD = National Institute of Child Health and Human Development Study of Early Child Care and Youth Development; IHDP = Infant Health and Development Program; MLEPS = Montreal Longitudinal-Experimental Preschool Study; BCS = British Birth Cohort Study.

* Omitted in regression models.

results separately for reading and math outcomes. To provide a visual representation of the data underlying the meta-analysis, we plot the 114 coefficients for reading outcomes in Figure 1 and the 114 coefficients for math outcomes in Figure 2.

The general pattern of results found for outcomes measured later in childhood also holds when we also consider the broader set of regression coefficients, which includes outcomes measured earlier in childhood (column 3 of Table 3). With an average standardized coefficient of .34, school-entry math skills are most predictive of subsequent achievement outcomes, followed by reading skills (.17) and attention-related measures (.10). None of the socioemotional behavior categories show predictive power.

Results in columns 4 and 5 of Table 3 confirm that early reading skills are stronger predictors of later reading achievement than of later math achievement. Less expected are the fourth column’s results showing that early math skills are as predictive of later reading achievement as are early reading skills. Children’s attention skills appear to be equally important (and socioemotional behaviors equally unimportant) for reading and math achievement. The separate regressions for reading and math skills also show that the association between school-entry skills and later achievement declines more quickly over time for reading than for math outcomes.

As before, we find no overall difference in the size of the standardized coefficients depending on whether the outcome being predicted is based on teacher reports or direct skill assessments. To answer the more specific question of whether shared method variance might lead to more pronounced associations between school-entry achievement test scores and later achievement (as opposed to school-entry teacher-reported achievement) outcomes, we added to the meta-analytic regressions interactions between the categories of school entry skills and dummy variables for type of achievement measure (results not shown). Surprisingly, we found no evidence that the impact of early reading and math skills mattered more for test-based than for teacher-reported outcomes. Thus, shared method variance does not appear to be biasing our results.

Because some of our skills groupings are quite broad, we explored whether they might be concealing systematic differences among more specific skills. For example, our reading category

11 None of the interactions between type of achievement assessment and school-entry reading and math skills was statistically significant. We did find one statistically significant interaction—between the school-entry assessments of attention and the mode of outcome assessment. The average coefficient on attention skills was nearly twice as large for teacher reports of reading and math achievement (.13) as for reading and math test scores (.07). However, this result does not bear on the issue of whether the explanatory power of school-entry achievement test scores is artificially high owing to shared method variance.
includes measures of school-entry reading achievement as well as language and verbal ability. When we reran the meta-analytic regression in the third column of Table 3 with separate groups for reading achievement and the collection of other language-related measures, we found that we could not reject the hypothesis of equal effects ($p = .11$).

Extensions

Beyond shared method variance, there are a number of other reasons to worry that we may have stacked the deck in favor of our school-entry achievement measures: (a) Attention and socioemotional skills may be more difficult to measure than achievement-related skills; (b) maternal reports available in three of our data sets may be less predictive than teacher reports of later academic achievement, in part because parents do not observe their children in school settings; (c) our models may overcontrol for achievement-related impacts of attention and socioemotional skills; (d) socioemotional skills may matter more for important school-related outcomes such as drop out than do test scores, because drop out reflects some combination of achievement and behavior; (e) most of our outcomes are measured in middle childhood, and the relative importance of school-entry factors may change as schools encourage older children to become independent learners; (f) a number of our socioemotional measures are counts of students’ problems, which restricts their range and perhaps explanatory power relative to the full-scale achievement measures; and (g) substantial attrition in some of our studies may bias results.

A first potential threat to our general conclusion is that children’s behavior is more difficult to measure than their early achievement. Perhaps the lower reliability or validity of the behavioral measures accounts for their weaker explanatory power. It is certainly true that school-entry tests have high internal consistency (e.g., the alphas were at least .74). But the internal consistency of most of the attention and socioemotional skills was also fairly high, particularly in the case of teacher reports, which were all .79 or higher.

To investigate the potential impact of unreliable measurement on our results, we used the reported internal consistencies in the ECLS-K and NLSY data to estimate regression models, using the errors-in-variables reliability adjustment in the EIVREG procedure in Stata (Stata Corporation, 2004). To accord the behavioral measures maximum explanatory power, we included in our regressions school-entry academic test scores as well as family and child control variables but only the given measure of attention or socioemotional behaviors.

For third-grade reading outcomes and with no reliability adjustments in the ECLS-K, the respective standardized coefficients on approaches to learning, self-control, interpersonal skills, externalizing problems, and internalizing problems were .05, .02, .02, -.03, and .00, respectively. Reliability adjustments produced very similar coefficients: .06, .02, .03, -.04, and .00, respectively. Reliability-related changes to the coefficients on these measures predicting math achievement were similarly modest.

For the NLSY early-adolescence reading test score outcome, respective coefficients associated with hyperactivity, headstrong, antisocial behavior, and anxiety/depression were -.06, -.02, -.05, and -.01, respectively. Adjusting for reliability generally increased (the absolute value of) these coefficients somewhat to -.09, -.03, -.08, and -.01, respectively. Reliability-related changes in coefficients predicting early adolescents’ math scores were similar. Although the proportionate increases in these coefficients are substantial in some cases, none of the reliability-adjusted coefficients begins to rival the size of the coefficients on early reading and math skills. In sum, it is unlikely that lower internal reliability explains the low explanatory power of our attention and socioemotional behavior measures. Although test–retest correlations may provide a richer understanding of the reliability of these measures, these data were not readily available. Nevertheless, with
average effect sizes ranging from –.01 to .01 (see Table 3), it is unlikely that even substantial reliability adjustments to our behavior and social skills measures would change our conclusions.

The overall validity of the attention and socioemotional behavior measures is much more difficult to assess. Correlations shown in the first column of Table 3 between later achievement and the attention and socioemotional behavioral measures have the expected signs and range from .10 to .25 in absolute value, suggesting at least some degree of validity. However, there remains the possibility that low validity might lead us to underestimate their predictive power. Of course, the validity of kindergarten-level achievement tests has also been questioned (Hirsh-Pasek, Kochanoff, Newcombe, & de Villiers, 2005; Meisels & Atkins-Burnett, 2004), so validity-based downward bias is also a concern with respect to the coefficients on the early achievement measures.

A second concern is that we relied on maternal reports of socioemotional behaviors in three studies (NLSY, IHDP, and BCS). Because maternal ratings are comparatively (siblings vs. classmates) and contextually (family vs. school) different from teacher ratings, it is possible that our reliance on maternal reports in these data sets leads to a downward bias in the estimated effects of the attention and socioemotional behavior measures (Gagnon, Vitaro, & Tremblay, 1992).

To investigate whether this might be the case, we took data from the ECLS-K and NICHD SECCYD, both of which gathered comparable ratings from parents and teachers of several components of socioemotional behaviors, and substituted parent reports for the teacher-report-based measures of these skills. Using our full set of controls and averaging across latest reading and math outcomes, we found that standardized coefficients on externalizing and internalizing problems and social skills averaged, respectively, .05, .03, and .03 for teacher reports and –.00, .01, and .01 for parent reports. Noting the unexpected direction of effects for the teacher reports of problem behaviors and the very modest coefficients in general, reporter bias does not appear to be driving our results.

The third issue, overcontrol, is complicated. Our regression models control for school-entry achievement, but if early attention and socioemotional skills affect later achievement primarily by affecting school-entry achievement skills, are we not robbing the school-entry nonachievement measures of some of their explanatory power? The pattern of average correlations presented in the first column of Table 3 bears on this issue. Bivariate associations between school-entry attention and socioemotional skills are considerably larger than their regression-adjusted partial associations, suggesting that this might possibly be the case.

To investigate this possibility more systematically, we reestimated our full-control models, using the latest outcomes in each study and omitting our school-entry measures of reading and math skills (but retaining all other control variables). Standardized coefficients on attention, externalizing problems, internalizing problems, and social skills averaged .13, .03, .02, and .03, respectively, without school-entry reading and math skills. Corresponding averages for coefficients from models that included school-entry academic skills were .07, .03, .02, and .02, respectively. Thus, even without including school-entry reading and math skills, only attention skills appear to relate to later reading and math achievement, and this may be due in part to their correlation with the omitted school-entry achievement measures rather than to a true mediation through achievement. That said, it remains the case that our analysis is focused on behavior during the years just before and at the point of school entry. If some types of socioemotional skills are well established before the preschool years, and unchanging during these years, then we will not be able to detect their effects.

Fourth, attention and socioemotional skills may matter more for outcomes such as special education classification or dropping out

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12 Note that an overcontrol argument applies equally to the achievement as to the nonachievement measures, because early success in learning reading and math skills may alter preschool behavior.
of school than for the test scores and teacher-reported achievement outcomes used in our studies. The outcomes of our analyses are indeed limited, and it may well be that these types of measures of school completion and success are more strongly linked to children’s socioemotional behavior and attention skills than to academic skills. Our test for this possibility was to estimate models of the effects of early academic and self-regulatory skills on grade retention, an outcome that includes elements of both academic and behavioral competence. Results in Tables A3, B3, C3, D3, E3, and F3 were quite similar to those from models with purer achievement-related outcomes. Nevertheless, the possibility remains that the predictive power of school-entry skills may differ for other, even more behavior-based educational outcomes.

A fifth concern is that most of the outcomes were measured during children’s elementary-school years. This is important for two reasons. First, teachers and classrooms differ across the extent to which they support learning academic, attention, and behavior skills. Our analysis does not consider how the associations among these skills may differ as a function of classroom and teacher contexts. Moreover, the associations among these skills may change over time as the contexts of classrooms change. Achievement in the middle- and high-school years involves increasingly complex reading and mathematical tasks, and it may be that general cognitive skills, particularly oral language and conceptual abilities, are crucial for comprehension and advanced problem solving (Baroody, 2003; Ferrari & Sternberg, 1998; Hiebert & Wearne, 1996; NICHD Early Child Care Research Network, 2005b; Scarborough, 2001; Snow et al., 1998; Storch & Whitehurst, 2002; Whitehurst & Lonigan, 1998). It is also possible that once children are past learning the basics in the early grades, the relative importance of early attention and socioemotional skills grows as children are increasingly called on to be independent learners, allocate their own time, and complete group work and assignments.

For a general look at the evidence about whether any of the impacts of academic, attention, and socioemotional skill measures are growing over time, we ran our meta-analytic regressions including interactions between each of the school-entry measures and the time between school entry and the outcome assessment. Coefficients on the interactions with early reading, early math, attention, and socioemotional behavior were all negative and ranged from –.023 to –.039 annual decrements in effect sizes, indicating that the explanatory power of reading and math fell. In the case of NICHD SECCYD data, we found little systematic evidence that the most problematic group should be significantly larger (in absolute value) than the slope for the rest of the sample.

We found little systematic evidence that this was the case. In the ECLS-K data, there was some evidence that improving early math skills mattered more for low math achievers, whereas the NLSY showed that hyperactivity mattered more for the most hyperactive children. No significant nonlinearities emerged in the analysis of NICHD SECCYD data. These spline analyses confirm that there are few nonlinear associations between the socioemotional measures included in this study and the outcomes they predict. It does not rule out, however, the possibility that other measures that capture a broader range of behaviors may be more strongly associated with later achievement.

A seventh and final concern is that sample attrition in some of our studies may bias our results. The extent of attrition is documented in our appendices. All of the coefficients used in our meta-analyses come from models in which missing data are accounted for with missing data dummy variables. In the appendices, we present results for three of our data sets (ECLS-K, NICHD SECCYD, and MLEPS) in which missing data are handled with multiple imputation and listwise deletion. In two data sets (ECLS-K and MLEPS), we also used nonresponse weighting adjustments. In the ECLS-K, both multiple imputation and listwise deletion estimates are slightly smaller in magnitude than the results using missing data dummy variables, although the pattern of results is consistent across all the techniques. In the MLEPS, the pattern of results does not change across the different methods; however, listwise deletion produces few statistically significant estimates given the reduction in sample size from 500 to approximately 150. In the NICHD SECCYD, the overall pattern of results is similar across the two missing data techniques; however, the coefficient estimates are most consistent between missing data dummy estimates and multiple imputation. Across the three data sets, the respective coefficients on school entry reading, math, attention, externalizing, internalizing, and social skills averaged .13, .23, .06, .04, .02, and .02, respectively, when we used missing data dummies. Corresponding coefficient averages for multiply-imputed models were .12, .17, .06, .01, .01, and .02, respectively. Corresponding coefficient averages for listwise deletion models were .09, .27, .07, .00, .02, and .00, respectively. Corresponding coefficient averages for nonresponse weighted models were .12, .31, .10, −.00, .01, and −.00, respectively.

13 Only the BCS has followed study participants long enough to measure their completed schooling and early-career labor market earning and, in results not reported in the appendices, we found that school-entry attention problems were a significant predictor of school completion but not labor market success.
Discussion and Conclusions

We have presented results from a coordinated analysis of six longitudinal data sets relating school-entry skills to later teacher ratings and test scores of reading and math achievement, holding constant children’s preschool cognitive ability, behavior, and other important background characteristics. Our meta-analytic results indicate that such early math concepts as knowledge of numbers and ordinality were the most powerful predictors of later learning (the average effect size of school-entry math skills was .34 and every bit as large as early reading skills in predicting later reading achievement). Less powerful, but also consistent, predictors across studies were early language and reading skills such as vocabulary; knowing letters, words, and beginning and ending word sounds (the average effect size across our studies was .17); and attention skills (average effect size .10). The average effect sizes of externalizing and internalizing problem behaviors and social skills were close to zero.

Despite our extensive investigation of the robustness of our key results, any nonexperimental analysis using imperfectly measured cognitive, achievement, and behavioral constructs such as ours cannot rule out all threats to its conclusions. First, although shared method variance, reporter bias, overcontrol, restricted range, and measurement reliability cannot account for the differential predictive power of school-entry achievement and socioemotional measures, we are unable to rule out bias from the lower validity of socioemotional measures. Second, despite our ability to control for cognitive ability prior to school entry in five of our six studies, and despite our controls for concurrent reading skills in all six studies, it remains possible that our surprisingly large school-entry math coefficients overstate causal impacts.

One of our noteworthy results is that early math is a more powerful predictor of later reading achievement than early reading is of later math achievement. Despite our controls for cognitive ability, it remains possible that some of the apparent effects of early math skills is spurious. To the extent that the effects are real, it is important to discover why. Math is a combination of both conceptual and procedural competencies. Although our data do not allow us to examine these competencies separately, future research could focus on this direction. Another productive avenue of research would be to examine efforts to improve math skills prior to school entry. Random-assignment evaluations of early math programs that focus on the development of particular mathematical skills and track children’s reading and math performance across elementary school could help to illuminate missing causal links between early skills and later achievement.

Another finding from our analysis is that attention skills are modestly but consistently associated with achievement outcomes. One explanation for this predictive power is that attention skills increase the time children are engaged and participating in academic endeavors and learning activities. Other studies have shown that attention skills have important associations with school success, independent of cognitive and/or language ability (Alexander et al., 1993; Howe et al., 2003; McClelland et al., 2000; Yen et al., 2004), but few of these studies have controlled for prior levels of academic skills as well as prior levels of behavior. Our results suggest that attention skills, but not problem behavior or social skills, predict achievement outcomes, even after the effects of early achievement knowledge and cognitive ability have been netted out.

Although all of the studies we analyzed were drawn from normative populations, all contain at least some children falling in the clinical ranges of behavior problems. We were surprised that our spline-regression models produced no consistent evidence of nonlinear effects of problem behaviors on later achievement. We caution, however, that it remains possible a more focused analysis, perhaps with clinical samples, might reach different conclusions.

Given that teachers emphasize the importance of attention skills and socioemotional behavior for school readiness and the possibility that these skills shape classroom learning processes, it might be expected that these early skills would have crossover effects on subsequent reading and math achievement. With the important exception of attention skills, we did not find evidence that changes in these skills during the preschool years predict later achievement. However, as noted earlier, academic skills are only one facet of educational success, and improvements in problem behavior or social skills may better predict other important school outcomes, such as a child’s engagement in school and motivation for learning, relationships with peers and teachers, and overall self-concept and school adjustment (Greenberg et al., 2003). It might also be the case that early-grade teachers are somehow able to prevent problem behaviors from interfering with student learning but that problem behaviors would be linked with lower achievement if teachers were less capable. Despite the uniformly small and often insignificant coefficients on these measures in our regressions, we caution against completely dismissing the potential academic benefits of environments or programs that promote positive socioemotional development.

An additional caveat is that any one child’s socioemotional behavior, in particular externalizing problem behaviors, may affect other students’ achievement more than the child’s own individual achievement. For example, problem behaviors may disrupt classroom activities such that even well-behaved children spend less time engaged in instructional and learning activities. Our analyses do not consider this possibility because it requires more complete data about classmates’ behavior than the studies provide. We raise this point, however, because we believe that the topic of peer effects deserves further attention in future research on socioemotional behavior.

Our analyses focus on skills and behaviors that emerge at the time of school entry and not on the effects of socioemotional behaviors that emerge after children enter school. This is important, because it may be that reading achievement and problem behavior develop in tandem during the early elementary years (Trzesniewski et al., 2006). Additional research is necessary to further elucidate the potentially complex and reciprocal relationships between children’s socioemotional behaviors and their academic achievement.

Our conclusions about the importance of early academic and attention skills are consistent with the recommendations endorsed by the National Association for the Education of Young Children and the National Council of Teachers of Mathematics (2002) and the National Research Council’s Committee on the Prevention of Reading Difficulties in Young Children (Snow et al., 1998). However, our results say nothing about the types of curricula that would be most effective in promoting these skills. Play-based, as opposed to “drill-and-practice,” curricula designed with the developmental...
needs of children in mind can foster the development of academic and attention skills in ways that are engaging and fun. Taking early math skills as an example, the Big Math for Little Kids program has been designed to capitalize on children’s interest in exploring and manipulating numbers (Greenes, Ginsburg, & Balfanz, 2004). In addition, play-based curricula may also have the added benefit of fostering attention-related skills (Berk, 1994).

Our findings support three key conclusions for developmental research. First, math and reading skills at the point of school entry are consistently associated with higher levels of academic performance in later grades. Particularly impressive is the predictive power of early math skills, which supports the wisdom of experimental evaluations of promising early math interventions. Second, among attention-related and socioemotional behaviors, only the attention-related skills predicted later academic achievement with any consistency. We find no noteworthy regression-adjusted associations between either interpersonal skills (or problems) or aggression and later achievement. Finally, all of our data sets suggest that reading and math tests that were individually administered to children by trained personnel around the point of school entry can be a highly reliable way of assessing early skills. That said, it was also the case that we could not attribute most of the variation in later school achievement to our collection of school-entry factors, so the potential for productive interventions during the early school grades remains.

References


Hinshaw, S. P. (1992). Externalizing behavior problems and academic...


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The Five Strands of Mathematics Proficiency

DEVELOPING MATHEMATICIANS

(1) *Conceptual understanding* refers to the “integrated and functional grasp of mathematical ideas”, which “enables them [students] to learn new ideas by connecting those ideas to what they already know.” A few of the benefits of building conceptual understanding are that it supports retention, and prevents common errors.

(2) *Procedural fluency* is defined as the skill in carrying out procedures flexibly, accurately, efficiently, and appropriately.

(3) *Strategic competence* is the ability to formulate, represent, and solve mathematical problems.

(4) *Adaptive reasoning* is the capacity for logical thought, reflection, explanation, and justification.

(5) *Productive disposition* is the inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy. (NRC, 2001, p. 116)

QUIZ
Answer True or False before reading on to learn about your math beliefs.

1. Mathematicians do math quickly in their heads.
2. I can't do math.
3. Math is always hard.
4. Only smart people can do math.
5. If I don't understand a problem immediately, I never will.
6. There is only one right way to work a math problem.
7. I am too shy to ask questions.
8. It is bad to count on my fingers.
9. To complete my math requirements quickly, I should skip to the highest level math class that I can.
10. My negative math memories will never go away.

Each statement on this quiz is false. Are you surprised? These misconceptions are negative math beliefs acquired subtly through cultures, families, teachers, and friends. For math students, negative beliefs can be deadly. At the very core of your self-esteem, these negative beliefs keep you uneasy.

Belief in these misconceptions is a stumbling block to learning math because you think and act from your belief system. The following sections explain why I believe the quiz statements are all false and how I reframe them. Notice which statements you marked True. Read those sections first.

Challenge Your Negative Beliefs

1. Mathematicians Do Math Quickly in Their Heads

The only problems mathematicians complete quickly in their heads are the ones they've done many times before. There are math problems that have remained unsolved for hundreds of years, and no speedy mathematician has ever solved them.

How do mathematicians work math at their own level? At their own level—a level that challenges them, and where they can advance—they use scratch paper—usually lots of it. They write down the problem, the ideas in the problem, what they are trying to do, any thoughts they have, possible solutions, and so on. They make many guesses and check out those guesses. They draw pictures and diagrams. They look up definitions of words in the problem. They talk to others. They start at the end of the problem and try to work backward. They begin again on clean paper to think in new ways. They know that working at this level takes patience and time. They don't give up and are willing to begin again and again.
until they achieve success. In Chapter 9, you will learn problem-solving strategies that mathematicians use frequently.

Brain research supports the idea that speed in mathematics comes from practice, which solidifies the connections and pathways in the brain. The key to speed in math is to slow down first, understand the material, and then practice.

Reframe your math work. Change from saying “Mathematicians do math quickly in their heads” to saying “Mathematicians can quickly do problems that they have practiced. When they learn new math ideas, they work slowly and often begin again.”

2. I Can't Do Math

Not true! If you can count, add numbers, recognize circular and rectangular shapes, and point to the front and the back of the classroom, you can do math. All these skills are math. You do math all the time. Knowing your age, comparing sizes and shapes, adding your money, and subtracting to get change are math skills.

You use math every day of your life at home or at work without giving it a second thought. When you drive, you judge distances, speeds, and times. You estimate if you can afford a vacation or a car. You compare volumes as you cook and areas as you rearrange furniture in your home. You use statistics as you watch sports and consider things like RBIs in baseball or field goal percentages in basketball. All of these are mathematical skills taken for granted.

Sometimes students are placed in math classes beyond their skill level and become discouraged. Other students enroll in the appropriate course but don't do the work to keep their skills matching the challenge of the course, and they become discouraged. Discouraged students often generalize and say, “I can't do math.” The way to regain your confidence is to slow down and discover the level of math where you are challenged and learn new concepts, but are not overwhelmed. Then set up all the time and support that will keep you learning.

Reframe your math work. Change from saying “I can't do math” to saying “I can already do some math and I can learn more.”

3. Math Is Always Hard

There are some math concepts that are hard for everyone. There are math problems that have been unsolved for hundreds of years even though they've been attempted by competent, knowledgeable mathematicians who work at them for decades. Those aren't the problems you need to work, unless you are curious. When you work at your appropriate level, you find a combination of easy ideas and hard ideas. If all of the ideas are hard, you may need to seek more support or to spend more time studying in a different way.

You may get discouraged when you compare your speed and understanding in math with your teacher's speed and understanding. Math teachers appear to do math easily in class because they have done these specific problems, or ones like them, many, many times. Also, the problems you see them work are not at the “edge” of their skill level.

You will want to study and progress at your own “growing edge”—the skill level where you have a bit of discomfort with new material but where you are not totally overwhelmed. This is the place where your skills match the math challenges. You can expect challenges that may trouble you at first, but they can be overcome. Credit yourself often by noticing how much more math you know now than you did two weeks ago. We often discredit the math we do easily. And we often berate ourselves for struggling with concepts such as negative numbers. Reportedly, “some of the best mathematicians in history shared those same struggles and frustrations” about negative numbers (Berlinghoff, p. 98).
If you persist, reread your textbook and notes, and ask lots of questions, you can work through problems that are difficult in the beginning. Everyone is different and finds some problems easy and some problems hard. Finally understanding something you’ve struggled over can be satisfying. Paying attention to details and reviewing to find what you’ve missed, as well as asking for help when you need it, are keys to success in math.

Reframe your math work. Change from saying “Math is always hard” to saying “There are both easy and hard math problems for everyone. I will keep a match between my skills and the challenges.”

4. Only Smart People Can Do Math

Being “smart” (whatever that means) could be helpful in math but the most important thing is to keep working. Persistent students are successful. They come to class. They read the textbook. They ask questions. They take notes. They ask questions. They do their homework. They ask questions.

I’ve had many so-called smart students who don’t do these things. Because they think they know it all, they miss concepts, don’t ask questions, become overwhelmed, and drop before the end of class. Often, as class begins, they act as if they already know everything and somehow seem unable to give up that role. Then when they don’t understand, they are probably embarrassed to ask questions. Don’t be influenced or intimidated by these students in your classes. Be persistent regardless of how everyone else acts. You will succeed. In Chapter 3, you will learn about different ways of being smart.

My student Michelle ignored all of the others in class as she sat in the front row of my geometry class asking question after question. Sometimes students sitting behind her snickered and laughed because her questions were so intense and the answers seemed so obvious. She was so concentrated on her own learning that she didn’t even appear to notice the others. I admit that as Michelle’s teacher, I had concerns about her future in math until three semesters later when I saw her in the hallway carrying a calculus book. She reported that she had passed class after class of math requirements and was now completing her final semester.

Michelle taught me a great lesson with her focused style. As a teacher, I learned I could not predict success for my students based on what I saw in class. I learned that persistence counts more, and I wondered how far my snickering students with the higher grades had come.

Reframe your math work. Change from saying “Only smart people can do math” to saying “Persistence in math helps more than smarts. Discovering how I am smart can help me use my strengths to learn math my way.”

5. If I Don’t Understand Immediately, I Never Will

Not true! When you do not understand something, you can say to yourself, “I do not understand yet.” The word “yet” opens the doors in your mind for understanding to still occur.

Productive people know that understanding follows the groundwork of reading, working problems, asking questions, thinking, reworking, and then relaxing for a while. How often have you tried and tried to solve a problem and then, after you finally gave up, had the solution pop into your mind?

One of the most important study skills that you can learn is to expect to not understand immediately! Know that understanding follows working, practicing, reading, asking questions, and living with the ideas for a while.
Some math concepts can be understood immediately. Some of them take mulling over and working with for a time—sometimes for a long time. Mathematical historian Lancelot Hogben said instructors often invite their students to quickly solve math dilemmas that took centuries or more for the human mind to clarify and understand. I can think of math concepts that I finally really understood only as I was discussing them in my classroom as the teacher. Patience with yourself is important.

Reframe your math work. Change from saying "If I don't understand immediately, I never will" to saying "Understanding math takes time. I don't understand this yet."

6. There Is Only One Right Way to Work a Problem

No, there are many right ways to do every math problem that exists. Actually, the “right way” to first work a problem is the way you understand it best. As you increase your understanding, you can be more open to other ways of looking at it. Having an open mind that is flexible and willing to experiment with different methods will increase your problem-solving skills.

When you are learning in a math class, your instructor may request that you work certain problems in specific ways because she knows that those methods will assist your understanding later on or make you more accurate. Remind yourself that your instructor can see the overall view from a broader perspective.

Reframe your math work. Change from saying “There is only one right way to work a problem” to saying “There are many right ways to work and think about each math problem.”

7. I Am Too Shy to Ask Questions

Brains and bodies are dynamic. They change constantly and we have influence over those changes, so be careful about making this generalization about yourself. "Feeling shy" is different from "being shy." Feeling shy is a common experience when we find ourselves in a new or uncomfortable situation. Being shy is a label that many of us give ourselves, which causes us to choose shy behaviors. Your thoughts and your behaviors are the most powerful change agents you own, and they affect your emotions and body sensations. See Chapter 10 to learn more about these interactions. As you practice talking to people and asking questions, choosing safe and supportive places to do that, you will notice your comfort and confidence levels rising.

Believe it or not, the rest of the world has better things to do than watch us all the time. Notice that most people are more concerned with themselves than with you. They wonder how you see them. They busy themselves thinking what they will say next. Fortunately, or unfortunately, you just aren’t so important to others that you become their focus of attention for more than a short time.

Often students find that speaking one on one with the instructor or another student increases their confidence in class. Even asking a question in class to which you already know the answer may increase your confidence. Asking your question before class or putting problems on the board before class will help too.

Colleges and universities have counseling assistance for students. A good counselor can assist you in finding safe campus resources for getting your math questions answered if feeling shy is a severe and disabling problem.
Reframe your math work. Change from saying “I am too shy to ask questions” to saying “Feeling shy or reluctant to ask questions is common. I can seek out safe situations to ask what I need to know. The more I practice asking, the more comfortable I will feel asking.”

8. It Is Bad to Count on My Fingers

Not so! Our number system is based on 10—probably because we have 10 fingers and 10 toes. Consequently, we have a portable model of our number system with us at all times.

When children first learn about numbers, they need concrete models to understand what the abstract ideas mean. Unknowing teachers sometimes skip this concrete model stage.

Cultures in Asia, Europe, and Africa have used ingenious forms of the abacus to do complicated number calculations speedily.

Using sand, sticks, wires, rocks, and beads in various ways, these people comfortably worked with numbers in a concrete, representational way. If we need to, we can do the same with our fingers.

Many children and adults process information best through their skin and muscles by touching, feeling, and doing rather than by seeing or hearing. These people, called kinesthetic learners, particularly need the concrete connection with numbers that their fingers provide.

Using fingers freely in calculations, students become more confident and faster in their use. Eventually, most students move beyond this use unless they are in a new or stressful situation in which they need grounding. Continued practice with basic math facts helps us compute more quickly and accurately.

I teach students how to count on their fingers. Try it. Hold out your hands, palms up, so that your fingers are separated and not touching anything. Imagine an electrical charge running through your fingers. Feel numbers such as 3, 8, 8 + 3, 11, and so on. The more you practice simple problems like these, the faster you will become. You may find that you don’t even need to move your fingers in order to count. No one else needs to know what you are doing.

I myself, a math teacher, have used my fingers to keep focused as I calculate money in a distracting environment. I have counted on my fingers as a volunteer cashier in a snack booth during a professional football game. I also use my fingers to count rests as I play the piano in a jazz band. Notice how musicians use their feet, hands, or heads to keep track of time as they perform. Would we dare tell them not to? Unfortunately, in math, using fingers to assist calculations has often been forbidden or ridiculed.

Reframe your math work. Change from saying “It is bad to count on my fingers” to saying “Using my fingers (if I need them) to calculate can be quick and helpful. Practice increases speed.”

9. I Should Skip to the Highest Level Math Class

Placing yourself in a math class beyond your current skill level can cause the Mean Math Blues. In order to maintain math skills, you must practice them. When you are not using specific math skills, you forget them. They are not gone forever from your brain, but the connections (called dendrites) that your brain grows to form ideas weaken without use. To reactivate these skills, you need to relearn and practice them. Students who need to extend their math knowledge often find the fastest way is by repeating previous coursework before continuing. Success with math requires a constant match between your current skills and the challenges of the course.
My personal experience is that these skills often return with more clarity and understanding the second time around. Brain research supports my experience, showing that the relearning process actually forms many new connections in the brain as well as reinforces the old ones.

Because math skills depend on facility with prerequisite skills, in order to advance it may be necessary to repeat a math class. There is no shame in forgetting math skills. It is the biological human condition to forget the skills you are not currently using. Brain researchers say, "Use it or lose it." So true with math!

The math placement test at each college gives accurate information about the placement in a math course best suited for each student. Repeating previous courses to relearn skills can be a satisfying experience that gets students up to speed and enables them to succeed as they advance from course to course. Enrolling in the next level without relearning the basics can be very frustrating and can produce anxiety about math. My daughter, now an environmental engineer with B.S. and M.S. degrees, reports that repeating the first two semesters of calculus formed the best possible basis for her continued courses and work in engineering.

Total honesty with yourself regarding your math skills is essential to good performance and understanding. Bluffing yourself into thinking you remember or know more than you do only wastes time in the long run. The more honestly you can admit what you do know and do not know, the lower your level of anxiety will be.

Reframe your math work. Change from saying "I should skip to the highest level math class" to saying "By taking math courses at my skill level, I will complete my math requirements more quickly than if I jump in over my head."

10. My Negative Math Memories Will Never Go Away

Brain researchers have discovered that memories are not set in stone—they are fluid and changeable. You revise your memories all the time. For you to grow beyond any negativity in math, your new math experiences must be different from the old ones.

(Note: If you have very vivid and emotionally charged negative memories of math experiences, you may wish to get some professional assistance from a counselor to separate the negative experience from the math content. Many community colleges and universities provide this service at no cost to students.)

As you read this book and gain a broader perspective, you will know more about the roles both you and your teacher play. You will also know when bad experiences come from your own avoidance behaviors, lack of information, or acting helpless. You will learn when it is valid to say: "Excuse me. I believe this negativity belongs to someone else," or when it is in your best interests to say: "I think I need to act in a different way to achieve success." Chapter 6 will give you suggestions for finding positive encouragement and support for your math work.

To revise negative memories about math, first acknowledge the bad experiences and look at the people involved as well as your behavior. It is likely that any insensitive people involved lacked information or were limited by their own math anxiety. Their learning style might have been different from yours and they could not overcome this difference to communicate with you. As they tried to teach you, they felt responsible for your learning and helpless to communicate at the same time. Feeling both responsible and helpless can cause some people to react with anger.

A teacher, parent, tutor, or fellow student may have said or done some very negative things to you but if you now continue to repeat over and over what was said, you are choosing
to reinforce the negative feelings. This is the point where you can now intervene and take responsibility for change. You can recognize that those people were wrong and replace those negative messages with new messages that are positive for you. As artist/writer Brian Andreas said, “I once had a garden filled with flowers that grew only on dark thoughts, but they need constant attention and one day I decided I had better things to do.”

Reframe your math work. Change from saying “My negative math memories will never go away” to saying “Negative math memories can fade and be replaced in time with current positive experiences that I control and choose.”

This book will help you create new experiences that highlight your abilities to change and to grow. You might be surprised at what releasing the old tapes in your mind can accomplish!

**POSSIBLE SHORT-TERM GOALS TO CHANGE YOUR MATH BELIEFS**

1. Write three ways that you approach math differently now than in the past.
2. Copy the reframes for all the misconceptions you marked true in the quiz.
3. Revisit the T/F quiz weekly to review these misconceptions. Remind yourself that they are false.
4. Ask your teacher for other misconceptions about math.

**ACT FOR SUCCESS | CHAPTER 1**

1. Write three actions for studying math successfully that you have learned from reading the explanations in this chapter. Explain how these actions help math students. (Example: Enroll in the right level of math. This helps math students because their frustration level will be lower in the right level of math, making it easier to learn and to persist.)
2. List any beliefs from the true/false quiz that you marked true. Write down new information that helps you disagree with your old beliefs. Did I convince you to change your mind? If you find a particular negative math thought that you still believe to be true, discuss it with instructors and other students.
3. Ask three math teachers or students what misconceptions about math they think unsuccessful math students believe. Write these misconceptions down and why they are not true. Reframe these misconceptions into more useful words about math study.
4. Begin a journal to chart your progress and track your experiences, thoughts, and brainstorm as you read this book and as you work with math. Purchase a fun notebook or sketchbook to use. Daily write down your thoughts, ideas, goals, feelings, doodles, notes, lists—anything that comes to your mind during the day that might involve you and math or you and learning. Remember: Change is a process. Change takes time. Date your entries so you can see your progress. Your journal—a powerful tool for change—will help you become more conscious of your inner thoughts. Experiment with your journal and see what happens.
Quiz
Answer True or False about your math beliefs.

1. I can’t do math. 1____
2. Math is always hard. 2____
3. Only smart people can do math. 3____
4. Mathematicians always do math problems quickly in their heads. 4____
5. If I don’t understand a problem immediately, I never will. 5____
6. There is only one right way to work a math problem. 6____
7. I am too shy to ask questions. 7____
8. It is bad to count on my fingers. 8____
9. To complete my math requirements quickly,
   I should skip to the highest level math class that I can. 9____
10. My memories of my negative math experiences will never go away. 10____