Handwriting in early childhood

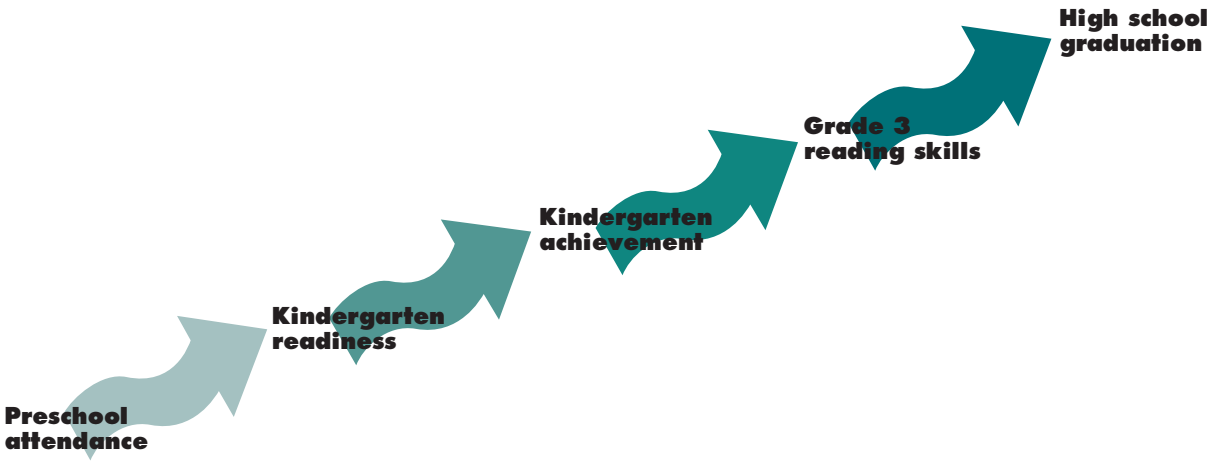
A strategy for school success

The latest research in handwriting for preschool children

Zaner-Bloser

The Importance of School Readiness

In late 2014, President Barack Obama announced a $1 billion investment in early childhood education in the United States, calling it "one of the best investments we can make" (PBS, 2014). The benefits of preschool and early learning programs for children have been well documented over the last several decades: early care and education programs positively affect children's cognitive and social development, both in terms of immediate gains and lasting benefits for educational achievement. Children from disadvantaged backgrounds particularly benefit from high quality preschool programs that focus on kindergarten readiness (Barnett, 2008).



Quality preschool programs focus on kindergarten readiness because readiness is the primary predictor of kindergarten success. Children who enter school with foundational skills such as proficiency in early reading are more likely to enjoy ongoing academic success, to attain higher levels of education, and to secure employment as young adults (Child Trends Data Bank, 2015). According to the Annie E. Casey Foundation, preschool that focuses on language, social, emotional, and cognitive development may eliminate the achievement gaps by ages 5 and 8 between low-income and middle-income children (Annie E. Casey Foundation, 2013). The National Research Council concluded that "academic success, as defined by high school graduation, can be predicted with reasonable accuracy by knowing someone's reading skill at the end of third grade. A person who is not at least a moderately skilled reader by that time is unlikely to graduate from high school" (National Research Council, 1998).

Literacy and language development are key foundations of readiness, and research over the last three decades also suggests that **handwriting is a key component of literacy in preschool and early childhood.** Forming letters and words by hand is a complex skill: it requires a child to coordinate letter formation, letter knowledge, and fine motor skills. Research shows significant links between children's early attempts at writing and their developing knowledge about how books and printed materials work and how words on a page can create meaning (Zhang, Hur, Diamond, & Powell, 2015)—that is, emerging reading skills. Learning to write letters and form words are powerful first steps toward academic success.

How can handwriting instruction promote school readiness?

Young children learn the alphabet, the basis for literacy

One cornerstone of high quality preschool is a focus on literacy development, and a strong predictor of later reading skills is alphabet knowledge (Piasta & Wagner, 2010). The National Association for the Education of Young Children (NAEYC) recognizes development of the alphabetic principle as a goal for the preschool years, and the latest revision of the Head Start Early Learning Outcomes Framework suggests that by age 5 children should be able to name more than 15 uppercase and 18 lowercase letters, know their sounds, and write their first names, along with using invented spelling and letter-like forms to communicate in writing using print-appropriate conventions (NAEYC, 1998; Administration for Children and Families, 2015). Children as young as age 3 demonstrate language-specific approaches to writing, and children's writing knowledge and writing-related skills increase and become more stable during preschool ages (Puranik & Lonigan, 2011).

> If we want to create circumstances for the most success in life, we must start in early childhood.
>
> —Wackerle-Hollman, 2015

Preschool-age children start scribbling letter-like forms as early as age two, and these scribbles develop all the features of writing such as directionality and linearity as a child develops (Dinehart, 2015; Feder & Majnemer, 2007; Puranik & Lonigan, 2011)—their "writing" begins to look different from their drawings. In addition, a child's ability to copy designs at an early age is associated with reading development (Cameron et al., 2012). Researchers find that even very young children can recognize the loops and connectors of cursive writing before they can write script themselves (Bonneton-Botté, De La Haye, Marec-Breton, & Bara, 2012).

Handwriting instruction can start as early as preschool and prekindergarten with the right approach. Even at the preschool level, teachers can encourage literacy skills by leading students through letter formation activities, including writing their own name and practicing writing other simple words and letters (Puranik, Lonigan, & Kim, 2011). In early learning settings, rigorous attention to the detail of individual letters is less important than the letter forming process itself: new research has shown that variability in children's letter formation is actually a crucial part of their learning to identify and form letters (James & Englehardt, 2012). In fact, writing by hand is essential for brain development in the preschool and preliterate years.

Handwriting helps develop the brain for literacy

Writing by hand engages the brain in learning and especially activates the "reading circuits" of the brain. Using the results of modern brain imaging techniques, research suggests that writing by hand plays a substantial role in the visual recognition and learning of letters, a foundation for both reading and writing. Through studies using functional Magnetic Resonance Imaging (fMRI) to probe how the brain processes stimuli in real time, researchers have demonstrated that

- There is a distinct system in the human brain that is recruited during reading that is also recruited during writing.
- The reading network develops as a function of handwriting (printing) experience.
- Handwriting (printing), and not keyboarding, leads to adult-like neural processing in the visual system of the preschool child.

Findings like these suggest that self-generated action, in the form of printing letters by hand, is a crucial component in setting up brain systems for reading acquisition.

One exploration found that children who practiced printing letters by hand had far greater brain activity than did children who just looked at the letters, traced them using standard typeset manuscript, or found them on a keyboard (James & Englehardt, 2012). The children were shown a letter and then asked to draw, trace, or type it. Although each group learned the letters, the children who wrote them by hand had greater activity in the area of the brain, the left fusiform gyrus, long known to be involved in reading and letter processing as well as engaging the motor skills area of the brain. Only the experience of printing letters by hand—what the researchers call "free form printing"—results in this complex network activity of brain regions used in visual processing and physical movement (James & Englehardt, 2012).

> The motor experience of manually creating letterforms helps children discriminate the essential properties of each letter, which leads to more accurate representations bolstering both skilled letter recognition and later reading fluency.
>
> —Gimenez et. al (2014)

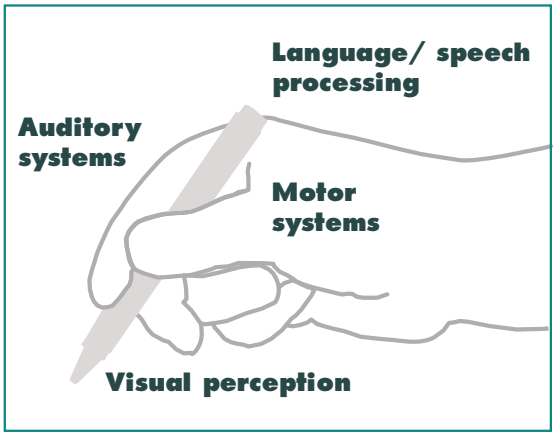
Writing by hand seems, based on this emerging empirical evidence from neuroscience, to play a large role in the visual recognition and learning of letters (James & Atwood, 2009; James, Wong, & Jobard, 2010; Longcamp et al., 2008; Gimenez et al., 2014). Other recent research also suggests this is universal: the engagement of these systems in the brain through handwriting is also cross-cultural and independent of the letterforms of a particular language. In one

> Early experiences determine whether a child's developing brain architecture provides a strong or weak foundation for all future learning, behavior, and health.
>
> —Center on the Developing Child, Harvard (2007)

study, for example, brain imaging of French language writers and Chinese language writers showed remarkable similarities when they wrote in their languages despite their alphabets' different graphical forms (Nakamura et al., 2012). Regardless of language, writing by hand activates two regions of the brain: an orthographic decoding system (visual perception) and a kinesthetic gesture system (linking visual and motor).

More recent research also suggests that learning to write and to pronounce the elementary sounds of language also promote complex mapping between the visual and auditory systems, linking visual representations of letters not only to motor paths for handwriting but also speech production. Researchers posit that literacy training sets up important links between the visual and the auditory systems in the brain that support later reading. Authors in one study provide evidence of direct links between children's handwriting quality and the functional efficiency of the area of the brain involved in phonological decoding (called the inferior frontal gyrus; see Golestanirad, Das, Schweizer, & Graham, 2015) during the early stages of literacy development; they found that higher handwriting quality correlated with higher gray matter volume (that is, the density of brain cells) in this region (Gimenez et al., 2014). Higher gray matter volume in a brain region typically signals higher ability and skills in the activities governed by that region as well as more efficient neural processing.

In one recent meta-analysis of the literature that examines brain activity during handwriting, the authors concluded that no fewer than a dozen distinct areas of the brain are involved in written language production (Planton, Jucla, Roux, & Demonet, 2013). The authors compiled data from 19 recent studies about the specific coordinates in the brain activated by different writing tasks; they used those locations to create a map of the "handwriting brain." These studies, too, crossed cultural and linguistic barriers to lay evidence for a universal cognitive network activated by writing by hand. Clearly, learning to write by hand develops the complex brain systems that support literacy and learning.



Printing by hand develops fine motor skills, a predictor of kindergarten success

Researchers have known for decades that early fine motor skills—paper and pencil tasks such as writing by hand as well as manipulating small objects—are intimately connected to later cognitive skills. One explanation may be that infants and toddlers continually adapt their movements to their growing bodies and their increasing neural development. Studies show that the motor tasks associated with early development are complex: early childhood is wrought with trial and error, reward-based feedback loops that build what researchers call "learning to learn" neural connections in the brain (Adolph, 2005). These learning pathways, forged by fine motor skills in general, set the stage for school readiness.

> Poor fine motor skills can make cognitive learning and performance more difficult because of the simultaneous need for fine motor skills in cognitive activities.
>
> —'...'Grissmer et al., 2010

Fine motor skills are the strongest predictor of special education referral and the second strongest predictor of kindergarten retention (Cameron et al., 2012; Roth, McCaul, & Barnes, 1993). Children in preschools spend about 37% of their day engaged in fine motor skill activities, and only about 10% of that time is spent with paper and pencil—but kindergartners spend nearly half their day engaged in fine motor activities and nearly half that time on paper and pencil tasks (Marr, Cermak, Cohn, & Henderson, 2003). Introducing more fine motor and writing experiences can help preschoolers make the leap to kindergarten successfully.

> When copying letters and words, children need not only control the fine movements and force of the fingers and hand, but attend to the relevant stimulus, keep in working memory the target to be copied, coordinate visual and manual movements, and integrate this perceptual and motor information with linguistic rules about orthographic structure.
>
> —Maldarelli, Kahrs, Hunt, & Lockman, 2015

Current research in fine motor skills development suggests a strong link between fine motor skills in general and kindergarten success. Children with stronger fine motor skills do better not only in literacy tasks such as letter writing but also in kindergarten math (Luo, Jose, Huntsinger, & Pigott, 2007; Son & Meisels, 2006); in addition, these skills are associated with ongoing reading and mathematics achievement as late as fifth grade (Dinehart & Manfra, 2013; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Murrah, 2010). In one study, researchers analyzed three different longitudinal international studies of children's school experiences to determine the relationship between fine motor skills and school readiness (Grissmer et al., 2010).

After controlling for children's initial reading and math test scores, they found that children with more advanced fine motor skills at school entry had higher achievement in both reading and mathematics in fifth grade. One theory is that higher motor skills are evidence of automaticity: children do not have to "think through" each movement of their hands and eyes and therefore have greater processing capacity available to learn letter and number shapes, for instance (Cameron et al., 2012).

Preschool instruction in handwriting is developmentally appropriate

Instruction in handwriting in preschool supports the new Head Start Early Learning Outcomes Framework Ages Birth to Five (2015), which are designed to promote school readiness. The recently revised framework identifies five overarching domains: Approaches to Learning; Social and Emotional Development; Language and Literacy; Cognition (at the preschool level, this specifies math and scientific reasoning); and Perceptual, Motor, and Physical Development (Administration for Children and Families, 2015). Research shows that handwriting instruction and practice in preschool not only supports language and literacy but also motor development. In addition, the complex brain mapping created during early handwriting experiences underlies the Approaches to Learning domain, which includes emotional and behavioral self-regulation (including working memory and attention; Gerde, 2014).

Handwriting instruction supports all Head Start learning domains for school readiness

Approaches to Learning	Social and Emotional Development	Language and Literacy	Cognition (Reasoning)	Perceptual, Motor, and Physical Development
In writing by hand, children develop and practice self-regulation strategies. Handwriting supports executive function by engaging a child's attention and developing her ability to focus (Cameron et al., 2012).	At the preschool level, stories created with invented spelling and pictures can be shared and processed in a writing workshop (King, 2012). Collaborative writing also supports cooperation and social learning.	Writing by hand teaches letter formation, letter recognition, knowledge of print, and sound-letter correspondences (Puranik et al., 2011; Puranik & AlOtaiba, 2012).	The National Math + Science Initiative recommends training in handwriting to improve learning (Honeycutt, 2013). Writing can help develop a child's logical ability, preparing her for math and science reasoning (Willis, 2011).	Writing by hand engages children in fine motor skills tasks, developing their ability to think about, plan, and form letters and simple words. Motor difficulties can be identified and addressed even before formal schooling.

Handwriting instruction in preschool additionally takes advantage of an important developmental period for fine motor skills. In one study, a group of 276 children regularly received visual-motor tests, and results confirmed that scores increased significantly for each child during each eight-month period between the ages of 2.8 and 6.5 years, suggesting that this age range may be a period of especially strong growth in skills (Memisevic & Hadzic, 2013).

According to literacy researchers, kindergarten-age students should be able to name and copy lowercase letters as well as to write their own name (Berninger, 2015; also see Common Core State Standards for kindergarten foundational skills, http://www.corestandards.org/ELA-Literacy/RF/K/). The difference between the time that kindergarten children spend in writing tasks versus the time preschool children do suggests that developing this skill may be key for kindergarten readiness. Getting preschool-age children ready for kindergarten means immersing them in more writing experiences and providing explicit handwriting instruction to foster the automaticity in producing letters that will free up their internal resources for more complex composing skills (Dinehart, 2015).

Because most of the writing that young children encounter in books and electronic media is in manuscript format, research shows that starting with traditional manuscript writing makes the most sense for early childhood (Kuhl & Dewitz, 2013; Puranik & Lonigan, 2011). Traditional manuscript letters mimic what young children see in the environments around them, particularly on signs and in school books. Children also see digital devices with manuscript letters on their keyboards. In more than one study, kindergartners who received handwriting instruction in nontraditional "joined" or "slanted" styles were more likely to make letter-recognition mistakes when reading traditional vertical print (Kuhl & Dewitz, 2013; Graham, 2013). Prior to kindergarten, children have been exposed to manuscript writing all around them and may have already begun to mimic what they see. Introducing the idea of different strokes and their sequence in producing letterforms is developmentally appropriate for preschool (Stevenson & Just, 2014).

Handwriting difficulties can signal other developmental issues

Finally, early difficulties in handwriting can signal other developmental issues (Dinehart, 2015); diagnosing these as early as possible means any intervention has a greater possibility of success. Given the unique coordination of different systems of the brain needed to produce handwriting, slow or untidy handwriting can be a marker for several issues, including developmental coordination disorder (DCD; Scordella et al., 2015). Children with DCD pause longer when writing and write larger letters and, as a result, produce less written text (Prunty, Barnett, Wilmut, & Plumb, 2013, 2014). DCD affects both fine motor and gross motor movements and is also often associated with learning and

language difficulties as well as attention deficit hyperactivity disorder (ADHD; Kaiser, Shoemaker, Albaret, & Geuze, 2015; Brossard-Racine, Majnemer, Shevell, Snider, & Belanger, 2011). Difficulty with handwriting in children with DCD is a major predictor of more general learning difficulties later on in adolescence and adulthood (Bo et al., 2014).

> [W]riting difficulties…can serve as an early indicator of more global cognitive concerns in young children.
>
> —Dinehart, 2015

Motor difficulties, language difficulties, and emotional-behavioral problems often occur together (Dinehart, 2015); one recent study identified concurrent lower language abilities and more emotional-behavioral problems in preschool children who also had movement difficulties. These children showed decreased listening and expressive capabilities in language as well as a higher frequency of withdrawal behaviors (King-Dowling, Missiuna, Rodriguez, Greenway, & Cairney, 2015). Research also shows the connection between motor impairment in general and behavioral or emotional struggles in prekindergarten children that can last through their school years (King-Dowling et al., 2015). Instruction in handwriting can provide preschool teachers a way to mark developmental milestones across the rapid age-related changes in motor skills and social-emotional behaviors in the preschool years as well as to help support children's language and cognitive development.

Handwriting instruction supports school readiness

Explicit handwriting instruction in the preschool years, using developmentally appropriate classroom practices, can provide strong foundational skills to prepare young children to enter kindergarten. Thoughtful researchers have advocated a refocused attention on handwriting in the school curriculum given the emphasis in the Common Core State Standards on high-quality written texts. Improving fine motor writing skills and handwriting readiness in preschool children may be a key to improving academic skills in the long term (Dinehart, 2015); this investment in time and resources can prove invaluable for creating success in school and beyond.

> [E]ven though handwriting transcription fluency is considered a low-level skill, it appears to be nonetheless consistently related to and an accurate predictor of the amount and quality of the texts students produce—of students' creativity of thought, organization, coherence of ideas, comprehensiveness of topical coverage, and clarity of expression.
>
> —Reutzel, 2015

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The latest research in handwriting instruction at the preschool level

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