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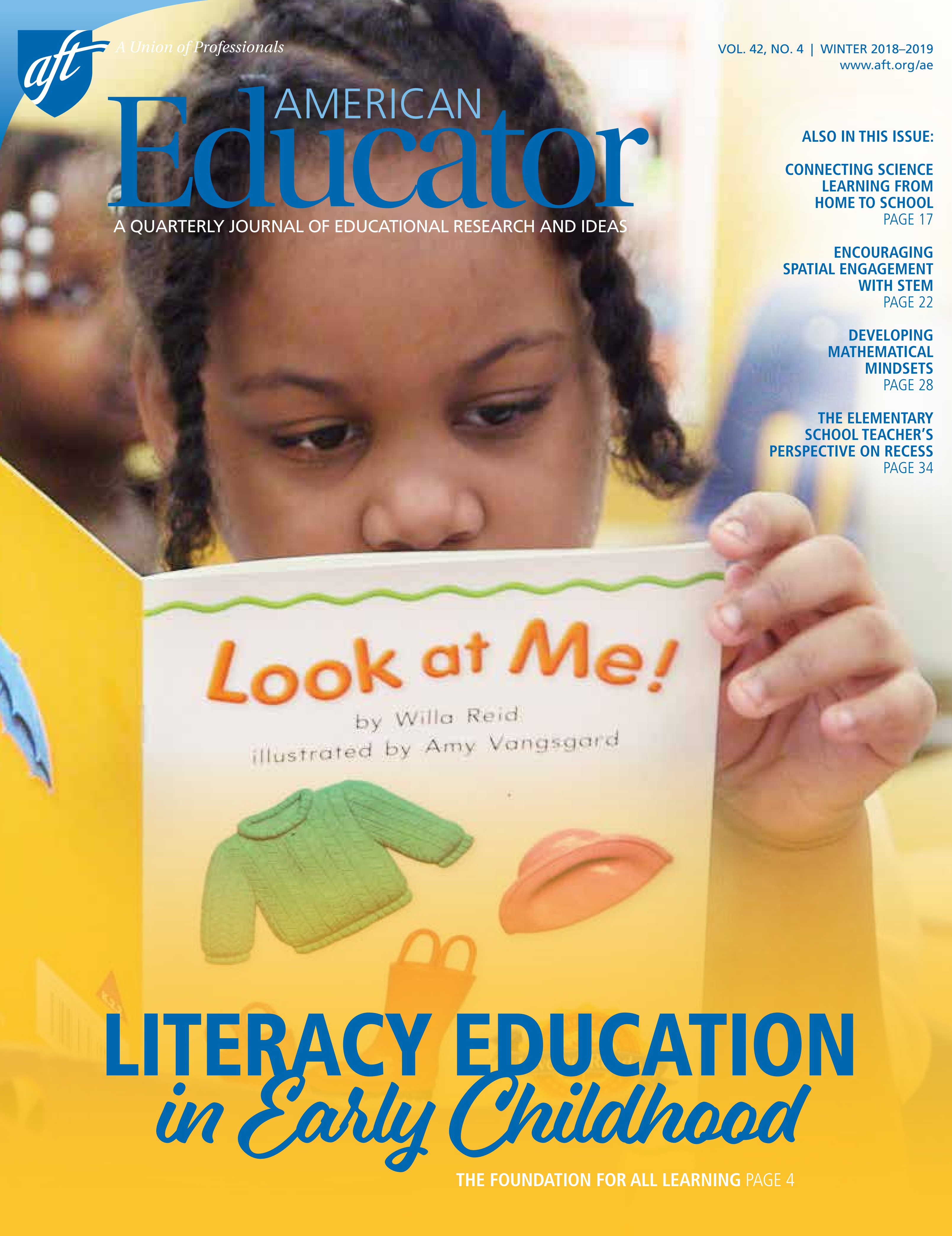

LITERACY EDUCATION *in Early Childhood*

Democracy has to be born anew every generation, and education is its midwife.

–John Dewey

Standing on the Frontlines for Democracy

25 Lessons Learnt on Education and Democracy

To download a poster of these lessons, scan the QR code or visit **http://go.ei-ie.org/25lessonsposterEN**.

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No Time to Lower Our Defenses

RANDI WEINGARTEN, AFT President

Our country's history abounds with moments when Americans had to choose which side they were on: The Revolutionary War. The Civil War. Seneca Falls. The sit-down strikes of the 1930s. Selma. Stonewall. We are in such a moment now.

The Declaration of Independence and the U.S. Constitution frame America's foundational ideals of liberty, equality, justice, and freedom. While we have had dark periods where the words on these documents did not match our country's actions, we have made real strides toward those values. Many of us took democratic rule in the United States for granted—until the last two years.

By any objective, historical measure, President Donald Trump exhibits classic authoritarian behavior: Demagoguery. A war on the truth. Branding journalists and the media as "enemies of the people." Stoking resentment and division. Animating nostalgia for a mythical, idyllic past—supposedly eroded by minorities, immigrants, and political correctness. Sending troops before the midterm elections to "defend" America's southern border against an "invasion" of desperate and exhausted asylum seekers, and pulling back once the election is over. Threatening to punish his political enemies, even seeking to order the Justice Department to prosecute Hillary Clinton and James Comey, and to fire investigators who provide some of the checks and balances in our democratic system.

And while many of these checks and balances are built into our Constitution and government structures, they do not work when the party in power ignores or, worse, undermines them, as Republicans mostly have. No doubt their acquiescence results from the fact that Trump has been giving his backers what they want—huge tax cuts for the wealthy and corporations at the expense of investments in education and infrastructure and of maintaining Social Security and Medicare, undoing generations of environmental and financial regulation, and rushing through the appointments of a slew of conservative judges to federal courts, including to the U.S. Supreme Court. Trump's allies have signaled that it's OK by them to side with foreign strongmen, to lie outrageously, to tear the safety net, and to divide the country the president is sworn to lead.

The midterms pitted fear against problem solving, and this time, problem solving won out.

Trump made the November midterm elections a referendum on himself, using fear and lies in rally after rally to mobilize his base. Meanwhile, Democrats made a different choice, running hopeful campaigns focused on making life better for people—protecting Americans with preexisting health conditions, strengthening public schools, addressing gun violence, taking on student and medical debt and the opioid crisis, raising wages, securing the social safety net, and fixing roads, bridges, and water systems. The midterms pitted fear against problem solving, and this time, problem solving won out.

Despite some heartbreaking gubernatorial and Senate losses, the midterm elections produced a blue wave. But Democratic victories in U.S. House of Representatives, gubernatorial, and statehouse races were not a foregone conclusion. Wall Street was strong, as were employment numbers, although most Americans have not seen the benefits in their wages. And Republican gerrymandering and voter suppression have created scores of congressional districts and statehouse seats designed to give the GOP an impenetrable lock. Two African American gubernatorial candidates in the South, Stacey Abrams and Andrew Gillum, fell short by less than the number of voters who had been purged by state officials, including by Abrams' opponent.

But Americans sent a clear message. They voted for a check and balance on Trump by taking control of the House from the GOP, which has served as a rubber stamp for the president. And they rejected Trump's politics of fear, division, and lies, voting for decency over cruelty, fairness over prejudice, and democracy over demagoguery.

In *On Tyranny: Twenty Lessons from the Twentieth Century*, Yale historian Timothy Snyder takes readers through three times when Europeans confronted authoritarian regimes: the end of World War I, the end of World War II, and the fall of communism. Until recently, most Americans had only been spectators to assaults on democracy. "We might be tempted to think that our democratic heritage automatically protects us from such threats," Snyder writes. "This is a misguided reflex."

I have given this important book to thousands of people with the hope that, once we recognize tyranny for what it is, we the people will act to disrupt it and to protect democracy—at rallies, at town halls, and, ultimately, at the ballot box.

This is no time to sit on the sidelines or lower our defenses. With an increasingly autocratic president and members of his party who refuse to act as a check on his power, we must do all we can to keep the trust and to work with the newly elected Congress and others to help improve people's lives and maintain our democracy and ideals.

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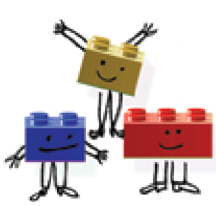
LITERACY



OUR MISSION

The **American Federation of Teachers** is a union of professionals that champions fairness; democracy; economic opportunity; and high-quality public education, healthcare and public services for our students, their families and our communities. We are committed to advancing these principles through community engagement, organizing, collective bargaining and political activism, and especially through the work our members do.

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Americans Vote Our Values

On November 6, the American people sent two very important messages. First, at the federal level, they voted for a check and balance on President Donald Trump. Second, at the state level, they voted for leaders committed to high-quality public education, affordable healthcare, and workers' rights.

In the months leading up to the midterms, AFT members knocked on doors and participated in phone banks, even for many of their own. Our members ran for office in more than 20 states to make sure elected leaders put students first.

Some key highlights include:

- More than 300 AFT members ran for office, and more than 60 percent of them won.
- AFT member Gretchen Whitmer and former AFT member Tim Walz won governor's seats in Michigan and Minnesota.
- When public education was on the ballot, voters overwhelmingly chose to invest in public schools and stand with teachers.

"Our values and aspirations were on the ballot," said AFT President Randi Weingarten, "and in district after district, voters like us turned out in droves and chose hope. We voted for funding for public education, for access to healthcare, for rebuilding infrastructure, and for finding solutions that make life better for *all* Americans."

From top: Michigan Governor-elect Gretchen Whitmer and AFT President Randi Weingarten; Baltimore paraprofessionals and school-related personnel write postcards urging fellow AFT members to vote; AFT Connecticut members with AFT member, 2016 Teacher of the Year, and Representative-elect Jahana Hayes; and Weingarten campaigning in Orange County, Florida, with AFT member and newly elected school board member Johanna Lopez.

AFT MEMBERS SUE LOAN SERVICER NAVIENT

This summer, the AFT conducted a survey to determine the effects of student debt on AFT members who struggle financially. The results were overwhelming:

- **97 percent said student debt has increased stress in their lives.**
- **80 percent have lost sleep over it.**
- **72 percent said it has strained family relationships.**

We've seen the hardship caused by student debt, and we're helping our members take action. Michelle Means, a teacher and mother of two, regularly reaches into her own pocket to provide urgently needed school supplies and snacks for her first-graders. Yet she is staggering under $60,000 in federal student loan debt thanks to misleading information and negligence from her loan servicer, Navient.

Means is one of nine AFT members suing Navient for misdirection, misrepresentation, and neglect. The suit demands Navient stop its abusive practices and seeks compensatory damages for people like Means.

We want to hear from you. We're collecting our members' student debt stories to show Secretary of Education Betsy DeVos that something must change. Visit **go.aft.org/stoploanfraud** to share your student debt story.

WE OWE BILLIONS TO LOW-INCOME STUDENTS

The Alliance to Reclaim Our Schools, a partnership between the AFT and other education and civil rights groups, released a report this fall, *Confronting the Education Debt*, detailing the systemic underfunding of public schools, focusing specifically on black, Latino, and low-income students. According to the report's findings, Congress has failed students from low-income families, students of color, and students with disabilities in particular. The historic underfunding of Title I and IDEA (the Individuals with Disabilities Education Act) has reinforced a separate and unequal education system, leaving a $580 billion funding hole that has shortchanged the futures of our nation's most vulnerable students. Visit **www.reclaimourschools.org** to read the report.

–THE AFT COMMUNICATIONS DEPARTMENT

Reading to Learn from the Start

The Power of Interactive Read-Alouds

By Tanya S. Wright

How many times have you heard someone say: "In kindergarten through third grade, kids learn to read, and then in fourth grade and beyond, kids read to learn"? This phrase is often used to promote the idea that the early years of schooling *should* focus primarily on helping children learn to decode text fluently. Fluent decoding is, of course, critical for independent reading, and we do want children to develop this skill in the early grades of school. However, fluent decoding is necessary but not sufficient for successful reading.[1]

Successful and engaged readers comprehend, learn from, and enjoy what they read. This requires far more than the ability to look at the symbols on the page and say the words that these symbols represent. Readers need background knowledge and vocabulary, they need to know how texts are constructed and how they are used, they need strategies to coach themselves when reading is challenging, and they need to feel motivated to read.

Luckily, children can begin to learn all of this in the early grades of school—by reading! How can children "read to learn" when they are still learning to decode text independently? The answer is that adults read aloud to them. Interactive read-alouds, where adults read text to children and facilitate discussion of the text, are an incredibly effective method for supporting children's literacy learning. In this article, I describe some of the knowledge and skills that children must develop in order to become successful readers, and I share evidence that read-alouds can support students in this learning. In other words, interactive read-alouds have the power to help children read to learn *as* they learn to read.

Tanya S. Wright is an associate professor in the Department of Teacher Education at Michigan State University. A former kindergarten teacher, her research and teaching focus on curriculum and instruction in language and literacy in early childhood and elementary school.

Interactive Read-Alouds

What can children in the early childhood and elementary years learn during interactive read-aloud experiences? It turns out that the answer is a lot. In particular, studies demonstrate that certain ways of reading aloud optimize children's learning. The read-alouds described below share several key features for supporting student learning. First, most effective instructional practices for read-alouds are *interactive*. This means that the teacher and students are actively involved in thinking and talking about the read-aloud text. This *extra-textual* talk (i.e., the talk that happens around the text) facilitates children's literacy development in both early childhood and the elementary grades.[2]

Second, most effective read-aloud techniques are purposeful and planned. This means that the teacher has carefully selected the text and determined how it will be used to support student learning. This includes planning how and when the text will be read, what the teacher will explain or model for the students, and the types of questions, ideas, and words that will be discussed. Third, effective interactive read-alouds can and should occur across the school day, in a broad range of content areas, and not just during language arts.

Despite all the evidence that interactive read-alouds support student learning, studies show they may be neglected during instruction in pre-K and elementary classrooms. In our study of 55 kindergarten classrooms,[3] we observed instruction for more than 600 hours and found that kindergarten teachers spent, on average, only 8.36 minutes engaged in read-alouds of literature and 1.7 minutes on read-alouds of informational text. Note that an average of 1.7 minutes means that most teachers did not read any informational text at all. Even when texts are read aloud, researchers have documented a focus on fiction texts,[4] with limited attention to a broad range of text genres and text structures. Also, the quality of interactive read-alouds may vary greatly across classrooms.[5]

Learning about the World

Interactive read-alouds provide critical opportunities to support children in building knowledge about the world, and this knowledge can in turn support students' comprehension of new texts. The more related knowledge students bring to a text, the better they are at comprehending that text.[6] Importantly, this idea extends beyond fact-based knowledge and includes broader types of knowledge. For example, studies demonstrate that students have stronger comprehension of texts that align with their cultural knowledge.[7]

You can test the relationship between knowledge and comprehension by reading the following paragraphs on a topic that you may know little about:

> It also meant that black holes had a temperature and had entropy. In thermodynamics, entropy is a measure of wasted heat. But it is also a measure of the amount of information—the number of bits—needed to describe what is in a black hole. Curiously, the number of bits is proportional to the black hole's surface area, not its volume, meaning that the amount of information you could stuff into a black hole is limited by its area, not, as one might think, its volume.
>
> That result has become a litmus test for string theory and other pretenders to a theory of quantum gravity. It has also led to speculations that we live in a holographic universe, in which three-dimensional space is some kind of illusion.

This text is from the recent *New York Times* obituary of Stephen Hawking.[8] While you may be able to decode the text quite fluently, even for strong readers it can be difficult to really understand what the text is about unless you have some knowledge of theoretical physics. However, for a reader who knows about black holes or string theory, this passage is easy to comprehend.

So, what might the instructional implications of this finding be? First, and most importantly, we can't wait for children to decode fluently in order to build their knowledge of the world.

We can't wait for children to decode fluently in order to build their knowledge of the world.

The goal should be to build children's knowledge, across a broad range of domains, during the early years of schooling, while they are building their reading fluency. One way to build children's knowledge is by reading aloud to them. While we need knowledge to understand what we read, it is also the case that the more we read, the more we know. In turn, the more we know, the better we become at reading. So, we should start early by reading aloud to young children from a range of texts and genres to build their knowledge of the world.

Studies have shown benefits for students' learning when read-alouds are integrated into content-area instruction. For example, several effective programs have integrated read-alouds into science and social studies instruction.[9] In particular, read-alouds can provide opportunities for children to learn about and discuss ideas aligned with content-area standards that they cannot experience directly in their classrooms. Whether this is a historical event or the opportunity for a child in a midwestern state to learn about the ocean, read-alouds can bring new ideas into the classroom to support content-area learning goals.

Recently, researchers have shown that reading sets of texts that are conceptually or thematically related can be particularly beneficial for building knowledge.[10] The idea is that as knowledge is built over time, students can understand more and more challenging texts. Many adults have had this experience, for example, when taking a class on a new topic or when trying to do research to learn something new. At first, the readings feel incredibly challenging, but over time, the more you read, the clearer the ideas in the texts become. If you read six texts on black holes and cosmology, your understandings of this topic would grow and develop with each text, making it easier and easier to comprehend and learn from the passage you read above. Therefore, teachers should purposefully select sets of related texts with the goal of building children's knowledge across a series of interactive read-aloud experiences.

As discussed above, reading texts that align with students' cultural knowledge may support reading comprehension. Therefore, teachers can build upon the funds of knowledge[11] that students bring to school by including interactive read-alouds with themes and characters from a broad range of cultures and backgrounds. Reading and discussing culturally diverse texts also aligns strongly with recommendations for enacting culturally relevant literacy instruction in early childhood and elementary classrooms.[12]

Children learn and retain more words when teachers provide child-friendly explanations of new vocabulary.

Learning New Vocabulary

Knowing the meaning of words in a text is critical for understanding what we read.[13] While we need vocabulary to comprehend what we read, vocabulary can also be built as readers are exposed to challenging new words in text. Evidence from research studies demonstrates that young children learn vocabulary through interactive read-aloud experiences.[14]

The challenge for our youngest learners, who are not yet able to decode text independently, is that access to the vocabulary of text requires an intermediary—someone to read the text to the child. Unfortunately, if many teachers are not reading aloud regularly to young children, as is indicated by the studies described above, young children may have limited opportunities in school to learn the *academic* vocabulary of texts. Importantly, as children begin to read independently, they continue to benefit from read-alouds. This is because the texts that beginning readers use for practice purposefully limit challenging vocabulary to make the texts easier to decode. Therefore, *while* students are learning to decode fluently, teachers can promote vocabulary development by reading aloud from texts that are *more* challenging than the texts that students can read by themselves.

Children may learn some new vocabulary just from listening to text, but they learn and retain more words when teachers provide child-friendly explanations of new vocabulary.[15] For example, after reading the word *dreadful*, the teacher can stop and say, "When someone feels dreadful, it means she feels awful, she feels very bad." Studies demonstrate that this practice alone can support children's word learning, with estimates that children learn about 22 percent of new vocabulary from this type of brief, one-time explanation.[16]

Interestingly, in this study, two additional explanations of each word's meaning doubled children's retention of new words. Child-friendly explanations are not limited to talk about word meanings, but may include a picture, prop, or action (e.g., using an action to explain the word *crouch*).[17] It can be particularly challenging to come up with child-friendly explanations without preparation. So, this practice is more effective when teachers select words to teach and plan these explanations before the read-aloud. Explaining word meanings before or during read-alouds supports vocabulary development, but it also supports children's comprehension of the text being read.[18]

Another critical feature of effective vocabulary-focused read-alouds is the opportunity for children to engage in *active processing* of new words.[19] Rather than just passive listening, children need opportunities to discuss the meaning of a new word, act out the meaning, think of synonyms and antonyms, and use the

new word in discussion. Typically, this additional practice with words occurs for a small set of important words that the teacher has selected because these are words that children need for future reading (i.e., new or challenging words that occur frequently in text) or for content-area learning.

Providing opportunities for active processing directly after the read-aloud supports students in learning more new vocabulary, but additional practice beyond the initial read-aloud, in other contexts or during a rereading, may be necessary to support retention of new vocabulary.[20] The goal is to create engaging opportunities for children to think about and use new words in meaningful ways.

One way to provide repeated exposure to new vocabulary, and to provide opportunities for students to use new words in discussion, is to read multiple texts on the same topic. Typically, books on the same topic include similar words. When listening to and discussing a set of books about birds, for example, students are likely to encounter words like *nesting*, *migrate*, and *molt* multiple times across the texts. Studies have found that this natural repetition in meaningful contexts benefits word learning.[21] Therefore, the use of text sets may be particularly beneficial because it supports students in building knowledge *and* vocabulary simultaneously.

Learning about Text

Good readers know a lot about text and how text functions. In the early childhood years, children need to learn basic concepts about print—for example, that in English, we read print from left to right across a line of text and from top to bottom on a page. Children begin to learn that the writing in text represents oral language—for example, that one word the reader says aloud is represented by one word on the page (often called *one-to-one correspondence*). Children also need to understand the difference between a letter and a word, and that letters represent particular sounds.

One way that children learn this information is when adults show them how print works during read-alouds. Researchers have tested a method called *print referencing*, in which the teacher holds the text so that it faces the children.[22] The teacher both shows and tells children how text works during the read-aloud. For example, when the teacher runs a finger under the words that are read, children learn about directionality, and when the teacher stops to ask children to notice or point to words, the teacher supports children in developing an understanding of one-to-one correspondence. Studies of print referencing demonstrate that young children make substantial gains in print knowledge when their teachers use this method, compared with children who do not experience this type of interactive read-aloud.[23]

As children learn to become independent readers and writers, they need more sophisticated understandings about the use and function of texts. There is evidence that developing an understanding of the different purposes for text (e.g., to inform, to persuade, to entertain), and the text genres and structures that align with these purposes, supports students both as readers and as writers.[24] Read-alouds provide an important opportunity to expose young children to a range of texts and an opportunity to discuss how authors achieve their purposes for writing. For example, an author who is trying to write an informational text to explain the idea of forces may use a range of text structures to achieve that goal, such as comparing and contrasting pushes and pulls or using cause and effect to show that if you kick a ball, the force will cause it to move. Unfortunately, as discussed above, observational studies demonstrate that read-alouds in the early childhood and elementary grades typically focus primarily on fictional stories, and therefore young children may have few opportunities to develop these understandings across a range of text genres.

Interactive read-alouds that focus on how texts work can also support children as writers. For example, read-aloud texts can be used to help students identify particular features of strong writing.[25] One way to do this is by reading aloud a high-quality exemplar of a particular type of text (sometimes called a *mentor text*) and supporting students in analyzing and discussing features of the text that make it a strong example of writing for that particular purpose. This might include text structures, word choice, use of dialogue, or graphical elements. Students can then use the list of features they have generated as a guide when they engage in their own independent writing.

Learning Literacy Skills and Strategies

Read-alouds also provide the opportunity to teach students a broad range of skills and strategies they will need as they become independent readers. In the early childhood years, young children need to develop phonological awareness (i.e., the ability to distinguish sounds in oral language), letter recognition, and knowledge of letter-sound relationships. (For more on effective literacy instruction in early childhood, see the articles on pages 9 and 12.) These foundational skills can be supported through read-alouds. Children build phonological awareness through interactive read-alouds of books that play with language, such as books that include rhyme or alliteration. Alphabet books promote letter recognition and support students in associating letters with key words that represent particular sounds that letters make. Making these read-alouds interactive by encouraging children's participation ("What pictures do you see that start with the /b/ sound?") can support their development of these early literacy skills.

Young children need to develop phonological awareness, letter recognition, and knowledge of letter-sound relationships.

Teachers can also engage in read-alouds to model reading strategies, intentional mental actions that children can use to coach themselves through reading or writing tasks.[26] Researchers argue that reading strategies are best taught through a gradual release of responsibility framework.[27] The early stages of this framework suggest that teachers model strategy use before students use the strategy with guidance and independently. During interactive read-alouds, teachers can model the use of a broad range of strategies. These may include comprehension strategies (e.g., monitoring, visualizing, or asking questions) or decoding strategies (e.g., saying the sounds in the word or trying a different vowel sound). Beyond just showing children how to use reading strategies, interactive read-alouds enable teachers and children to take time to discuss *why* and *when* a particular reading strategy may be most effective.

Interactive read-alouds provide important opportunities to support students to think deeply about and discuss the meaning of texts.[28] In particular, teachers can use text-based discussion to help students move beyond literal comprehension of a text in order to focus on applying the ideas that were learned. While it is important to make sure that students understand what is happening in the text as it is read, there is growing evidence that young students are capable of higher-order discussion to support deeper comprehension of text.[29] Young children need opportunities to apply ideas, to compare and contrast different parts of a text or multiple texts, to determine the author's purpose and to consider whether the text accomplishes this purpose, and to take a stand on an argument presented in a text. Studies, beginning in the early childhood years, demonstrate that when teachers engage children in more analytic talk during read-alouds, this has long-term benefits for their vocabulary development and text comprehension.[30]

Several groups of researchers have studied methods for supporting discussion during the early childhood and elementary years of school.[31] Included as recommendations in all of these studies is the idea that teachers should promote discussion by asking open-ended questions (e.g., how and why questions) and by supporting children to understand and analyze the *decontextualized* language in texts (i.e., language that is used to convey ideas that are beyond the immediate context). Text-based discussions with younger students may require other scaffolds to prompt conversation, such as providing students with sentence starters that they can use to discuss the text (e.g., "I agree with you because…") or giving students opportunities for small-group or partner discussion before discussing the text as a whole group.

Anyone who has spent time in a classroom has seen the joy on children's faces when it is time for the teacher to read aloud.

Finally, it is important to remember that children love to listen to and participate in interactive read-alouds. I recently visited an early childhood classroom where children had so many favorite books to suggest for read-alouds that the teacher created a "please read" bin where children could place these book requests. Anyone who has spent time in an early childhood or elementary classroom has seen the joy on children's faces when it is time for the teacher to read aloud. In fact, this is such a favorite time of day that researchers have recommended that extra teacher read-aloud time may be an appropriate reward to encourage children's independent reading.[32]

Read-alouds enable children who are not yet reading independently to experience the way reading feels to fluent readers—the pleasure of being swept up in a story, the thrill of learning something new. It is important to maintain this sense that reading is joyful, while also providing opportunities for students to learn, during interactive reading experiences.

One way to maintain this balance is to keep the primary focus on meaning. Sometimes when teachers engage in read-alouds, they focus so much on planned learning goals that the meaning of the text can be lost for children. For example, during a print referencing read-aloud, if the teacher spends too much time pointing out letters and words, the children may not be able to follow the story in the text. Or, if the teacher tries to address too many instructional goals during one interactive read-aloud, the session may go on for too long and the children may lose interest. For example, a teacher may attempt to teach print concepts and five new vocabulary words and a summarizing strategy and then lead a text-based discussion during one read-aloud session. If there are multiple teaching goals, it is most useful to read the text through with a focus on meaning and then revisit the text (or parts of the text) at a later time for additional instructional purposes.

Given all that students learn from participating in interactive read-alouds, a common question from teachers is how much time to dedicate to them. Overall, given the variety of opportunities to learn during read-alouds, it may be most beneficial to read to children multiple times per day for different instructional purposes. But, there is really no clear-cut answer to this question.

In consensus documents written by educational stakeholders in Michigan, where I live, we suggest that read-alouds are an "essential instructional practice" for supporting literacy in pre-K and early elementary school classrooms. By this, we mean that children in *every* classroom should participate in a

high-quality interactive read-aloud *every* day.* Given studies that suggest that read-alouds may not be occurring at all in some classrooms, this goal seems like a critical first place to start. ☐

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First Steps Toward Literacy

What Effective Pre-K Instruction Looks Like

By Susan B. Neuman

The early years are times of wonder for children. Curious about everything, they seek to explore and understand their world. During these early years, they attempt to interpret their world and make meaning through pretend play, drawing, and conversations with those closest to them. Although these first steps toward literacy may not look much like what we consider literacy to be, children are actively trying to use and make sense of reading and writing long before they have mastered the technical skills associated with print.

For young children, reading and writing is literally a mixed medium, chock full of different symbolic activities like singing, dancing, talking, and playing, and this has important ramifications for what literacy instruction should look like. If we take a narrow, somewhat limited view of reading, then we might say that it's all about learning the letter names, letter sounds, and conventions of print. But if we begin to think from a child's point of view, literacy and the ways in which we should teach it include so much more.

What's important to recognize is that children are active constructors of meaning.[1] Adults play a critical role in their lives by engaging their interests, creating challenging but achievable goals, and supporting their efforts to understand through their many questions and unique interpretations. The adults in children's lives are their first literacy teachers, and educator collaboration with families and communities is critical to children's well-being and their school success.

How Literacy Learning Begins

Literacy learning begins early in young children's lives. As children gain facility with different symbol systems, they begin to develop the insight that specific kinds of marks—print—represent meanings. At first, they'll use physical and visual cues, like logos in environmental print, to determine what something says. Many parents will delight in seeing their children recognize common labels in the grocery store, and then see how their children are beginning to make the assumption that print is permanent. Soon after, they will begin to understand that within

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The timetable for when children begin to talk and write varies dramatically.

these signs, there are letters and sounds. Although it may seem as though some children acquire these understandings magically or on their own, studies suggest that they are the beneficiaries of considerable, though playful and informal, adult guidance and instruction.[2]

Nevertheless, there is considerable diversity in children's oral and written language development. Just like walking and crawling, the timetable for when children begin to talk and write varies dramatically. Some children will begin talking as early as 18 months; others, not until much later. Furthermore, children encounter many different resources and types and degrees of support for early reading and writing. Some children may have ready access to a wide range of books, while others may not. Some children will observe their parents writing and reading frequently, others only occasionally. And some children will receive direct instruction, while others much more casual, informal assistance.[3]

What this means is that children come to school with many different experiences and skills. Consequently, no one teaching method or approach is likely to be the most effective for all children. Rather, good teachers bring into play a variety of teaching strategies that can encompass the great diversity of children in our schools. Excellent instruction builds on what children already know and can do, and provides knowledge, skills, and dispositions for lifelong learning.

Strategies for Building Literacy Skills

Children will need to learn the technical skills of reading and writing. Letter knowledge, phonological awareness, and an understanding of speech/sound correspondences are essential for children to learn how to become readers and writers. However, children must also learn how to use these tools to better their thinking and reasoning. Developing oral language comprehension and engaging children in meaningful oral discourse is crucial because it gives meaning to what they are learning.

Shared Reading Experience

One of the most powerful strategies for building these skills in early childhood is the shared reading experience.[4] In listening to stories, children begin to pay attention to print, which reinforces print conventions and concepts in the context of a meaningful experience. (For more on the importance of read-alouds, see the article on page 4 .) But they also hear words outside of their day-to-day discourse, which can help them build vocabulary. The conversational duets that occur around shared book reading can affect children's vocabulary growth and comprehension of stories. Children may talk about the pictures, retell the story, discuss their favorite actions, and request multiple rereadings, which will enhance their understanding. These exchanges help children to bridge what is in the story and their own lives. Providing children with a rich array of information books is likely to enhance their conversations as they try to learn and understand more about their world.

Discovery Areas

Young children also need the opportunity to make choices and to practice what they have learned about print with their peers and on their own. Creating discovery areas for children to explore their understandings, with attractive stories and information books, helps children to integrate play and print. In these engaging discovery areas, children will often pretend to be scientists, veterinarians, or environmentalists, using books to support their understandings. Play is a crucial feature in developing early literacy for young children, because it helps them to interpret their experiences. Play allows young children to assume the roles and activities of more accomplished peers and adults.

Drawing and Writing on Paper

Classrooms that provide children with regular opportunities to express themselves on paper, without feeling too constrained by correct spelling and proper handwriting, also help children understand that writing has real purpose. Teachers can organize situations that both demonstrate the writing process and get children actively involved in it.

Some teachers help children write down their ideas, keeping in mind the balance between children doing it themselves and asking for help. In the beginning, these products likely emphasize pictures, with few attempts at writing letters or words. With encouragement, children begin to label their pictures, tell stories, and attempt to write stories about the pictures they have drawn.

Such novice writing activities send the important message that writing is not just handwriting practice—children are using their own words to compose a message to communicate with others.

Reading and Comprehension

For children to become skilled readers, they will also need to develop a rich conceptual knowledge base and verbal reasoning abilities to understand messages conveyed through print. Successful reading ultimately consists of having a toolkit of procedural skills (e.g., alphabet skills), accompanied by a massive and slowly built-up store of conscious content knowledge.[5] It is the higher-order thinking skills, knowledge, and dispositional capabilities that enable young children to come to understand what they are reading.

Children's earliest experiences become organized or structured into schemas, building blocks of cognition. Schemas provide children with the conceptual apparatus for making sense of the world around them by classifying incoming bits of information into similar groupings. Well-read-to children internalize a form of story grammar, a set of expectations of how stories are told, which enhances their understanding. Knowledge becomes easier to access, producing more knowledge networks. And those with a rich knowledge base find it easier to learn and remember.

Quality indicators of a rich content base for instruction in early childhood programs include a content-rich curriculum in which children have opportunities for sustained and in-depth learning, including play; different levels of guidance to meet the needs of individual children; a masterful orchestration of activity that supports content learning and social-emotional development; and time, materials, and resources that actively build verbal reasoning skills and conceptual knowledge.

In brief, the picture that emerges from research in these first years of children's reading and writing is one that emphasizes wide exposure to print and to developing concepts about it and its forms and functions.[6] Classrooms filled with print, language and literacy play, storybook reading, and writing allow children to experience the joy and power associated with reading and writing while mastering basic concepts about print that research has shown are strong predictors of achievement.

Policy Recommendations for Early Literacy Achievement

Today, the field of early childhood remains a fractured set of programs with little consistency, operating in widely differing contexts with varying levels of funding and resources. Some programs are in public schools, while others are part of community-based organizations or provided in family child care homes.

Policymakers need to integrate funding streams to ensure that the workforce in early childhood is adequately compensated, and that children receive highly qualified teachers and the appropriate resources in all contexts. Specifically, to enhance early literacy, we need:

Professional Development for Early Childhood Educators

A comprehensive, consistent system of early childhood professional preparation and ongoing professional development is badly needed in every state to ensure that staff in early childhood programs and teachers in primary schools receive content-rich, college-level education that informs them about developmental patterns in early literacy learning and about research-based strategies to intensify the content that children are learning during the early childhood years. Ongoing professional development is essential for teachers to stay current with the ever-expanding research base and to continually improve their teaching skills and the learning outcomes for children.

Having small classes increases the likelihood that teachers will be able to accommodate children's diverse abilities.

Smaller Class Sizes

Sufficient resources are needed in early childhood to ensure adequate ratios of qualified teachers to children and to ensure small groups for individualizing instruction. For 4- and 5-year-olds, adult-child ratios should be no more than 1 adult for 8 to 10 children, with a maximum group size of 20. Having small classes increases the likelihood that teachers will be able to accommodate children's diverse abilities, interests, strengths, and needs.

Reading Materials, Especially Books and Digital Media

Sufficient resources are needed to ensure classrooms, schools, and public libraries have a wide range of high-quality children's books, computer software, and multimedia resources at various levels of difficulty and reflecting various cultural and family backgrounds. Studies have found that a minimum of five books per child is necessary to provide even the most basic print-rich environment. Digital media, such as e-books, should also be available to provide alternative, engaging, and enriching literacy experiences.

Resources for Individualized Instruction

Finally, we need policies that promote children's continuous learning progress. When individual children do not make expected progress in literacy development, resources should be available to provide more individualized instruction, focused time, tutoring by trained and qualified tutors, or other individualized intervention strategies. These instructional strategies are used to accelerate children's learning instead of either grade retention or social promotion, neither of which has been proven effective in improving children's achievement.

We cannot underestimate the importance of the early childhood years in children's overall development and literacy learning. What we do in these early years will make a difference in their reading patterns, interests, and lifelong desire to learn. ☐

Endnotes

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Phonics Faux Pas

Avoiding Instructional Missteps in Teaching Letter-Sound Relationships

By Nell K. Duke and Heidi Anne E. Mesmer

The need to explicitly teach letter-sound relationships in U.S. classrooms is settled science.[1] However, too often such instruction is not provided in the most efficient or effective way. These instructional missteps mean that fewer children will develop strong word-reading skills. In addition, ineffective phonics instruction is likely to require more class time and/or later compensatory intervention, taking time away from the growth of other important contributors to literacy development. We have encountered many dozens, if not hundreds, of phonics faux pas. In this article, we focus on seven in early reading instruction that deserve our serious attention.

1. Spending Too Little or Too Much Time on Phonics Instruction

Our field has long had a problem with teachers devoting an inadequate amount of time to phonics instruction. Although some children will pick up word reading with little instructional effort, many require considerable instruction to master the complex task of looking at a series of lines and curves to ascertain the spoken word they represent. In languages in which there is a relatively simple relationship between letters and sounds, such as Finnish and Spanish, by the middle of first grade, children are able to read real words and pseudo-words in the language accurately almost 100 percent of the time.* In languages in which the relationships are somewhat more complex, such as Danish and French, children are about 70 percent accurate by that time point. In English, in which the relationship between letters and sounds is extremely complex, children are about 40 percent accurate at that point.[2] Put another way, English word reading requires a lot more effort to teach and learn than many other languages.

On the other hand, there is such a thing as too much phonics instruction. We have seen prekindergarten and kindergarten classrooms in which the better part of the day is focused on letter-sound instruction (and often in a manner inconsistent with what research would recommend). This is problematic because it leaves insufficient time for many other important areas of development. For example, vocabulary and concept knowledge, which

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*Pseudo-words are words with letter-sound relationships that are plausible in a language but do not actually form a real word.

ILLUSTRATIONS BY LIZA FLORES

are strong predictors of long-term reading and writing success, also need attention. In fact, vocabulary knowledge affects word-reading development. We sometimes cannot even know whether we have read a word accurately unless we already have the word in our vocabulary. Is the word *lemic* pronounced with a short *e*, like lemon, or a long *e*, like *lemur*? Unless you already know this word, you aren't sure. For children trying to learn to read words with low vocabulary knowledge, such uncertainty is common.

Likely the question on your mind is, "How much is enough and not too much?" Unfortunately, research does not offer a decisive answer to this fundamental question. Typically, recommendations range from 30 to 60 minutes per day in grades K–2, with that time including a number of different activities we discuss below.

However, we suggest that the answer also varies by child and should be informed by simple diagnostic assessments. Some children are able to develop letter-sound knowledge more quickly and efficiently than others. This is one reason why differentiated phonics instruction is so well advised. Some instruction is provided to the whole class, but then it is reinforced and gaps are filled in as needed in a small-group context. Research has shown that reading achievement is supported when instruction is differentiated.[3] A number of researchers have developed systems by which assessments determine which letter-sound relationships each child has learned and not yet learned, and a systematic series of lessons are provided accordingly.[4] An important direction for our field is to work toward determining the most time-efficient approaches to ensuring each child in a class meets grade-level expectations in word reading each year.

2. Neglecting the Alphabetic Principle, Concept of Word in Print, and Other Concepts of Print

Imagine going to work for a shipbuilding company. You go to work the first day and are schooled in all the different types of bolts, screws, and nails. You learn their names, the different sizes, and the different types, but you never learn that their purpose is to join pieces of metal and that those pieces of metal are used to build ships! Although this situation is clearly ridiculous, it is actually analogous to what we see in some prekindergarten and kindergarten classrooms. Children are being taught to name letters or even identify the sounds that the letters represent, but they are unclear about *why* they are learning it. Letter-sound knowledge is being learned in a vacuum; the child has no context for how to *use* the information, no "big picture."

To understand the big picture, children must understand the alphabetic principle—how our English system of writing works. The alphabetic principle is simply that visual symbols (letters) represent speech sounds (phonemes). To write the spoken word "dog," you use alphabetic symbols to represent the speech sounds. We can combine and recombine letter symbols to form words. As odd as it may sound, children *can* learn letters and even letter sounds in very rote ways without understanding the alphabetic system. When children do not understand the alphabetic principle, they may do the following:

- Write something but not know how to read it back because they are not using letter sounds.
- Copy words but not be able to read them back.
- Write letters without any match to sounds (e.g., *I went to the store = bmlssmii*).
- Use letters they know to write all words, regardless of sounds.
- Look to the teacher when they can't read a word.
- Say the name of a letter when asked to read a word (e.g., *no = "en"*).

English word reading requires a lot more effort to teach and learn than many other languages.

To understand the big picture, children must understand other concepts of print as well. Concepts of print are the many understandings about how print works, including that print serves specific purposes (e.g., to help us remember or to entertain us); that print is language written down; and that, in English, we read from left to right and from the top of the page to the bottom. All of these and other "mechanics" about how print works are important to learn alongside letters and sounds.

In order to have a true understanding of the purpose and function of letters and letter sounds, children must understand how words are represented in print, or concept of word.[5] This means they know that words are collections of letters that represent a series of speech sounds that collectively represent a unit of meaning. They need to understand that each new word is signified by a space that does not contain any letters. They need to understand that you can see a word as well as say a word.

To understand concept of word in print, children need to watch others reading print and pointing to words.[6] In classrooms, this may be a teacher reading charts or big books to children and pointing to the words as they read. Teachers may also use pointers and sometimes ask children to point to words. In addition to watching others, children need to practice pointing to words themselves. A great way to do this is to allow children to point to words in a memorized line of print, in a dictated story of their own words, or in a simple book with short, repetitive sentences. Although it sounds like a really simple task, it is not. In fact, there are actually stages that occur as children learn

Also vitally important is teaching the sounds associated with the letters.

to point to print. Specifically, they must gain control of multisyllabic words and show understanding that a word like *elephant*, with three syllables, is actually one unified word. When children cannot handle multisyllabic words, they will point to new words for each syllable in a word (e.g., if the text said "kittens cry," the child would point at the word "kittens" for the syllable *kit* and then point at the word "cry" for the syllable *tens*).

Essentially, whenever phonics is taught, there should be a very print-rich environment, with teachers and children interacting with print to acquire the alphabetic principle, concept of word, and other concepts of print. Without these instructional nonnegotiables, letter-sound knowledge will remain inert information.

3. Teaching Letter Names without Letter Sounds

From the alphabet song to children's toys, much of the messaging that young children receive about letters is focused on the names of letters. Although research does suggest the importance of teaching and learning letter names, also vitally important is teaching the sounds associated with the letters. A common faux pas is neglecting instruction in those sounds throughout prekindergarten and sometimes well into kindergarten.

Some people think that teaching letter names is essentially teaching their sounds, but unfortunately that is not the case in English. Some letter names don't have a sound commonly associated with the letter at all. Neither *Hh*, *Ww*, nor *Yy* has its commonly associated sound in its name (e.g., there is no /h/, as in *happy*, in the name of the letter *Hh* ("aych")). Knowing these letters' names definitely does not lead children to know their associated sounds. Some other letters' names contain one of the sounds commonly associated with the name but not the other. For example, *Cc* has one of its common sounds in its name (/s/) but not the other (/k/).

The primary vowels are like this as well. We would have been much better off if they were named by their short sounds (/a/, /e/, /i/, /o/, and /u/, as in *pat*, *pet*, *pit*, *pot*, and *putt*), because those are more common in the words read by beginning readers than their long vowel sounds (the letters' names)—but no such luck. Letter names are also challenging for young readers because they aren't consistent in whether the commonly associated sound is at the beginning or end of the name. For example, in *Mm*/"em," the letter's target sound is at the end of the letter name, but in *Jj*/"jay," the target sound is at the beginning. That means for letter names to help children, they must memorize whether the target sound is at the beginning or end of the name.

The complexities of letter names in English might lead you to think we should not teach letter names at all, but research suggests that teaching letter names is still worthwhile[7]—it just needs to be accompanied by lots of attention to the sound or sounds commonly associated with each letter and by a thorough understanding of the challenges posed by English letter names. A teacher with such knowledge would understand, for example, why a young child might spell the word *daisy* as WAZ. Why? Sometimes children write "W" for the /d/ sound because the letter name for *Ww*—"double-u"—begins with the /d/ sound. The next sound we hear in *daisy* is the letter name for *Aa* (the long *a* sound), and the third and fourth sounds in *daisy* are the name of the letter *Zz* ("zee").

A final point about letter-name knowledge: it is often noted that letter-name knowledge in preschool and kindergarten is a strong predictor of children's later literacy achievement. This is true, but it is not because letter-name knowledge is an even-close-to-sufficient contributor to actual reading or writing. It is helpful, but some children learn to read knowing only letter sounds—no letter names. The predictive power of letter names lies largely in the fact that it is a proxy for other things. Children who know letter names early are more likely to have experienced a substantial emphasis on print literacy in the home and to have attended a strong preschool, for example, which in turn increase the likelihood of higher later reading and writing achievement. *Naming* letters is only one facet of letter knowledge, and probably not even the most important one. It is the *application of letter-sound* knowledge that advances children's reading and spelling.

4. Using Inappropriate Alphabet Key Words

A common tool for teaching the alphabet is alphabet key words, such as *Aa is for apple*, *Bb is for ball*, and so on. The idea is to make alphabet learning easier by creating meaningful associations between the letter and a word that begins with that letter. Unfortunately, too often, alphabet key words are problematic, creating more confusion than clarity for young children. Good alphabet key words need to begin with one of the sounds commonly associated with that letter. For example, *Oo is for octopus* works—the first sound in *octopus* is the short *o* sound. However, *Oo is for orange* does not work. The *o* in *orange* is what we call an *r-controlled vowel*. It does not make its typical short or long vowel sound. Similarly, *Tt is for thumb* does not work because there is no /t/ sound in *thumb*—there is a *th* digraph (two letters representing one sound). Another pitfall to watch out for is an

Systematic phonics instruction with a scope and sequence will produce better outcomes.

alphabet key word that begins with a letter name, which can be really confusing to children. For example, *Ee is for elephant* is confusing because it begins the letter name for *Ll* ("el"), and *Cc is for cake* is problematic because it begins with the letter name for *Kk* ("kay").

Alphabet key words also need to be depicted clearly in a photo or drawing, not easily confused with other items, and they should be words that are known to or can be readily learned by children. We recommend two alphabet key words for the letters *c*, *g*, *a*, *e*, *i*, *o*, and *u*—one for each of their two common sounds. Caution should be exercised in using children's names as key words, as some do not make a sound typically associated with the letter in English (e.g., *Juan*). In these cases, we suggest using the child's name to show the shape and name of the letter but to focus on a different alphabet key word for the sound.

For key words to do their job, children must be able to separate the first sound in the word from the rest of the word (e.g., to separate the /b/ from the /all/ in *ball*). Ideally, children develop this skill, called *initial phoneme segmentation*, during or before the prekindergarten year. However, not all children meet this expectation. Fortunately, you can work on this skill while teaching the alphabet, including alphabet key words. Research strongly suggests that phonemic awareness (conscious awareness of the individual sounds in spoken words—for example, recognizing that *sheep* has three sounds: /sh/, /ee/, and /p/), although an entirely oral skill, is actually best developed with accompanying letters. This initial phoneme segmentation issue is also why you should be judicious about using alphabet key words that begin with blends (two consonant letters pronounced in succession in a syllable, such as *dr* in *drum*); it is especially difficult for young children to separate the initial phoneme in a blend.

5. Lacking a Scope and Sequence

You can teach phonics in many different ways. You can use word or picture cards, magnetic letters, letter tiles, games, or even more traditional methods. However, if you want phonics instruction to be effective, you need to know the *content* (e.g., consonants, short vowels, digraphs) that you are teaching and the *order* in which children typically learn, and thus that you will teach, that content. We call this a *scope* and *sequence*.[8] Across decades, evidence has accumulated to suggest that *systematic* phonics instruction with a scope and sequence will produce better outcomes than instruction that does not follow a scope and sequence.[9]

Historically, a range of less systematic approaches have been popular. Typically, these approaches do not have a clear scope or follow a sequence but instead address letter sounds only as they arise incidentally in interactions with children or are needed to read words within a specific text. So, if a teacher is reading the book *Brown Bear, Brown Bear, What Do You See?*, she will teach the *ee* sound because it is found in the word *see*. The problem with this kind of serendipitous approach *as the driver* of phonics instruction is that information is not presented logically to the child and information gets missed. Of course, children should read connected text as they are learning phonics, and teachers should point out words they are reading that match taught patterns. But the scope and sequence of phonics instruction should not be based primarily on opportune moments in text reading.

Scope and sequence is also important because it helps children to organize information into cognitive categories, or "file folders," that support better cognitive storage and retrieval of information. For example, if one teaches information without a scope and sequence, one might move from teaching the short *a* sound in a consonant-vowel-consonant (CVC) pattern (e.g., *bag*), to teaching the vowel digraph *oa* (e.g., *boat*), to teaching *ch* (e.g., *chip*), to teaching *i_e* (e.g., *bike*). It would be a lot easier to remember these patterns if they were taught in groups: for example, teaching all the short vowel sounds (*a*, *e*, *i*, *o*, and *u*), consonant digraphs that represent unique sounds (*th*, *sh*, *ch*), all the CVC-*e* (silent *e*) patterns (*mate*, *Pete*, *bike*, *note*, *cute*), and then both of the spelling patterns that represent the /oi/ sound (called a *diphthong*; *oy* and *oi*). If instruction follows a scope and sequence, the variations don't seem random but rather work to form a category (e.g., "Oh this *th* is kind of like the *ch*, two letters that make a new consonant sound").

6. Using a Problematic Approach to Teaching Sight Words

Often, even teachers who do devote considerable time to phonics instruction do not apply that instruction to teaching "sight words." Instead, they teach children to memorize sight words visually rather than to decode them. Research suggests that's the wrong approach.[10]

Let's back up and talk about terminology. A sight word actually refers to any word that can be read by sight. *Differentiation* is a sight word for us—we recognize it essentially instantly when we see it. What many teachers call sight words are actually high-frequency words. Because a small number of high-frequency words have less regular patterns (e.g., *was*, *the*), some people call all high-frequency words sight words and think that they must be learned visually and holistically by sight.

In point of fact, letter-sound information amalgamates the word's units into memory better than any other process. When we teach high-frequency words, we need to fully analyze the

Children's reading opportunities should include but not be restricted to decodable texts.

letter-sound relationships within them, whether the word is comprised of expected letter-sound relationships, as in *can* (/k/, /a/, and /n/, just as we would expect); some expected and some unexpected letter-sound relationships, as in *said* (/s/ and /d/ are as expected, /ai/ would normally represent the long *a*, not the short *e*, sound); or entirely unexpected letter-sound relationships, such as *of* (/uv/). Nearly two-thirds of high-frequency words are actually very regular (e.g., *at*, *in*, *it*), but even with those that are not, we need to fully analyze the letter-sound relationships as well as read them accurately many times. We suggest studying each letter's association with each sound, relating the word to other words with the same letter-sound patterns when possible (e.g., *no*, *go*, *so*), and teaching high-frequency words alongside meaningful words (e.g., *like* with *bike*).

7. Missing Essential Elements of Phonics Instruction

We often observe phonics instruction that has some strengths but also some gaps. Effective phonics instruction is multifaceted. You've likely already heard about the need for *explicit instruction.* Explicit instruction is direct, precise, and unambiguous (e.g., telling children what sound the letters *sh* represent together, rather than making the connection indirectly or asking them to figure it out themselves). You probably also realize the need to apply *general learning principles* (e.g., specific feedback). Some other facets that must be present are:

Specific, Applicable Generalizations

Simplistic, broad generalizations or "rules" do not work. For example, if we say that silent *e* signals a long vowel sound *all* the time, then we have a lot of issues. But if the generalization is made more specific, it is more applicable. For example, the silent *e* pattern is consistent more than 75 percent of the time in *a_e*, *i_e*, *o_e*, and *u_e*, but only consistent 16 percent of the time with *e_e*.

Active Construction and Deconstruction of Words

Just explicitly teaching letter-sound relationships is not enough. If it were, we could just tell infants what each letter-sound relationship is and then they could read. Children need opportunities to move letter tiles to build and change words, listen to words and spell them by sound, and so on.

Opportunities for Application

The evidence is clear that young children benefit from opportunities to read text that emphasizes letter-sound relationships they have learned to date.[11] This reinforces the value of their hard work and of using decoding to read words. Children's reading opportunities should not be restricted to decodable texts, or those with only letter sounds they have been taught, but such texts should be a regular part of the reading diet. TextProject.org is a great resource for texts, and information about texts, that support beginning readers to learn to decode, without being as boring or unnatural as some decodable texts are.

Responsiveness

Phonics instruction must be informed by our ongoing observation and assessment of children's phonics knowledge and word-reading skills. We should respond when we notice that a child is confused, is insecure with a particular skill, or has had a major breakthrough. If we are not responsive to our students, some students are likely to be left behind in their word-reading development.

For too long, much discourse around beginning reading instruction has focused on whether to teach phonics. It is time for greater attention to how—and how not—to do so. Universally high-quality phonics instruction—that avoids common missteps—should be our collective focus. ☐

Endnotes

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Increasing Science Literacy in Early Childhood

The Connection between Home and School

By Phil Vahey, Regan Vidiksis, and Alexandra Adair

Julia invited Marco, her friend from preschool, over to make chocolate chip cookies. "Mmmm," says Julia, "chocolate chip cookies are my favorite!" "Mine too," says Marco, "but I've never made them before! This will be fun!"

Julia's parents help the children collect the ingredients and put them on the counter: butter, flour, chocolate chips ("Yay, the best part!" shouts Julia), sugar ("Sugar must be what makes them sweet," says Marco), and all the rest until Julia's dad asks Marco to get two eggs from the refrigerator. "Eggs!" says Marco, "I don't like eggs!" "Well, Marco, we need them, so please take two out." "Do we need them? I really don't like eggs! I think they will ruin the cookies—I don't want to get them."

Julia's dad looks at her mom: What to do? Their favorite recipes all call for two eggs. Besides, this is supposed to be a fun Saturday activity, not a battle of wills with a 4-year-old! "Hmmm," says Julia's mom, "I have an idea. Your teacher's last science newsletter said that in class you tested different ways of making play dough. Do you remember that?" "Yes," says Julia, "that was fun—one turned out soft and one turned out hard!" "Well, let's try two different ways of making chocolate chip cookies!"

Julia's dad breaks into a grin: "What a great idea! We can make one batch with eggs and one without eggs. Something else I read in the newsletter was that it is good to make predictions. Julia, which cookies do you predict will be better?" "Dad, how do I know? I've never done this before. What do you think?" "I have absolutely no idea! Isn't that great! We get to try something new and see what happens! Let me go get some paper and a pen—I want to write down everybody's predictions about how the cookies will turn out."

A few minutes later, Julia's dad has written down everyone's predictions: since Julia can't taste egg in regular cookies, she thinks there will be no difference (now that she thinks of it, maybe parents just sneak eggs into cookies because parents like kids to eat eggs); Marco says the cookies without eggs will (obviously) taste better than the regular cookies; Julia's dad says he thinks eggs make the batter fluffy, so the cookies with eggs will be fluffier; and Julia's mom thinks eggs help to make the cookies soft and moist, so the cookies without eggs will be harder and drier than the cookies with eggs.

Now it's time to make the cookies: "Marco, you measure the chocolate chips." And so begins the process of measuring, mixing, and baking.

There are two things to notice in this fictional account of Julia's home: The first is the scientific thinking that happened (and will happen as the day goes on). A potential showdown with a picky

ILLUSTRATIONS BY CAITLIN ALEXANDER

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eater was turned into an authentic question (what happens when we remove the eggs from a cookie recipe?), a way to investigate the question was proposed (make one batch with eggs, one batch without), predictions were made, and the practices of mathematical thinking and accurate measuring were used to conduct the cookie-making investigation. We can also imagine them discussing other scientific observations once they try the cookies.

The second thing to notice is that making cookie baking more scientific didn't make it any less fun—in fact, it made it more fun. All the traditional aspects of cookie baking are present (including the final step of eating the delicious cookies). But there is also a sense of wonder and anticipation as they await the results of the taste test. On a related note, if you are wondering what the differences between the two batches of cookies are, we don't know—we haven't conducted this experiment, and this reinforces a point made by Julia's dad: adults do not need to know the results of a scientific investigation before conducting it. That's because providing the opportunity for genuine learning to take place, by adults as well as children, is itself a key feature of science.

Parents report feeling unprepared to answer their children's science-related questions.

Turning everyday activities such as baking into scientific activities is more than just fun: it is important for our children's futures. Science investigations provide an opportunity for children to learn about scientific concepts and listen to their peers, family, and community members, and to respond to their questions or ideas. It also provides them with an opportunity to ask and answer their own questions, build persistence, and improve their problem-solving and self-regulation skills, which are essential for academic success.[1]

Additionally, as the world becomes increasingly science- and technology-oriented, all children need to become proficient in science, whatever their chosen field. STEM (science, technology, engineering, and math) education has become a national priority, and even early childhood teachers are expected to increase the quantity and quality of the science experiences they provide, particularly for their traditionally underserved students.

In improving early childhood science experiences, parents can be a powerful ally. As we will discuss in this article, simple changes can make everyday activities more scientific—for instance, asking: "Which objects float in the bathtub and which don't? Why might that be?" Or "Which glass holds more water—the tall, thin one or the short, wide one? How can we tell?" Or "While we are at the zoo today, let's think about some of the things that are similar among all plant eaters and some of the things that are different."

Parents' Attitudes about Science Learning

A recent national study, *What Parents Talk about When They Talk about Learning: A National Survey about Young Children and Science*,* which we published in March 2018, uncovers parents' beliefs and attitudes about science and gives teachers a place to start in making home-school science connections. For the study, we spoke with more than 1,400 parents and caregivers of children ages 3 to 6 across the country with diverse economic situations and educational backgrounds. Key findings include:

Almost all parents are invested in their children's learning, but many feel that science is less important to support at home than literacy and social skills development.

Parents need to know about the increasing importance of science in children's lives and how they can help to develop their children's attitudes toward science, regardless of age. They also need to know that people in different careers and of different ethnicities and cultures engage in scientific practices, and that science isn't about memorizing dry facts but is about communicating ideas, reading both nonfiction and science-based fiction, writing notes and logs and drawing pictures, and investigating a scientific topic to learn more. The national study found that many parents base their ideas on what kinds of learning they should foster at home on their perceptions of teacher expectations, so making those expectations clear could have an impact on parental support of science at home.

Fewer parents feel "very confident" in their ability to support their children's science learning than in other areas.

Parents report not knowing much about science and feeling unprepared to answer their children's science-related questions. Parents should know that science is not about being "correct," but is an active process that includes exploring, observing, offering plausible ideas, and proposing solutions to problems. As in the cookie-baking example above, posing a question and investigating it is a deeply scientific activity. So is taking a nature walk and trying to classify the different types of plants, insects, and animals that you see.

More than half of parents report engaging their children in science-related learning activities daily.

Although they are sometimes unsure about how these activities relate to science, many parents already engage their children in

*To read the full study, visit https://bit.ly/2qxAUMG.

exploring outdoors, in cooking and building activities, in using science-related videos and digital games, and in reading science-related books. This is exciting news for early childhood teachers, who may find it challenging to engage parents in supporting children's school learning. Parents need guidance on making connections to classroom science topics (for example, looking at plant parts). Making these connections explicit can reinforce for parents the need to explore science with their children at home and can also encourage them to do more.

Among the study's other key findings is that 7 out of 10 parents say that knowing what young children need to learn about science, and having ideas for doing science with everyday materials, would help them do a lot more science at home. They just lack ideas for simple activities they can do at home.

And while most parents state that their children use science media (TV shows, videos, games, apps, and websites) at least weekly, and that they, as parents, monitor their children's media use, fewer parents make connections between the science in the media and the science their children do at home and in school.

Later, we offer specific recommendations for early childhood educators to help families increase children's engagement in scientific practices. But first, we discuss what it means to teach science in the early education classroom.

Science in Early Childhood Classrooms

As an early childhood educator, you likely feel pressure to achieve what can sometimes seem impossible, such as finding time to do more science activities in your classroom. Early childhood education standards[2] have a full plate of requirements (including science) that you may have a hard time including in your busy classroom schedule. Contributing to this tension might also be the lingering notion that early childhood settings are not the place for science-based instruction. Additionally, many early childhood educators have had a limited amount of professional development specific to science.[3]

There is no doubt about it—early childhood standards do have a lot of requirements, especially if each area is considered to be something taught independent of the rest of the standards. Fortunately, there are ways to include meaningful science education activities that build on, instead of detract from, activities preschool children do already. And we're sure that many early childhood educators are successfully finding creative ways to do this.

Science allows children to wonder, to make predictions based on that wonderment (while also integrating their past experiences), and to test out and refine those predictions. Examples of what makes an activity "scientific" include things such as questioning which ramp will make a ball roll toward a target faster, or what conditions are best for growing a plant. The important key to this is asking investigable questions and providing rich opportunities for those investigations to occur.

It is also crucial that children be allowed to take the lead. And while they make observations and figure out the best way to record the results, teachers and parents can follow up by asking questions such as "What if ... ?" and "Why do you think that?" For example, "What if we covered the ramps in bubble wrap: Would the balls roll faster or slower? Why do you think that?" Or "What if we changed the slime recipe to have more water: Would it be more or less stretchy? Why do you think that?" Remember that it is not important for anyone (including you, as the teacher) to make correct predictions, to conduct neat and tidy investigations, or to know the "right answer." Instead, the essential component is that the children and adults guiding them embark on the process of investigating together; asking questions, collaborating, sharing tools, revising thinking based on results, and enjoying the journey.

We know the value that parents place on the development of their children's literacy skills, and science activities can provide the foundation for explorations that spill over into early literacy activities. Children benefit from the ability to construct knowledge and develop reading and writing skills through a range of experiences, topics, and purposes, and science activities can provide natural opportunities for practicing these skills.[4] Children can read or look at images that provide factual information about the ocean or weather, and they can document what they see through drawings and writing. These "informational texts" differ from narrative texts that tell a story. Informational texts can be used for posing questions ("What birds can we expect to see in our area?") and for answering students' questions ("Do all insects have six legs? Are spiders insects?").

Science need not be a formal experience in a laboratory.

As early childhood educators know, and as we have tried to make clear, science need not be a formal experience in a laboratory. Our world is made up of the human-made and natural environment, and these contexts provide countless jumping-off points for your students to explore and develop scientific inquiry skills. Armed with a digital camera or a photo-capturing app like Photo Stuff with Ruff (available for free on the PBS Kids app), along with a piece of wood, cardboard, or plastic disguised as a ramp, or a mixture of dirt, leaves, and bugs, educators can continue to support a broad set of learning goals while providing children with engaging and developmentally appropriate science activities that are set within children's everyday experiences and environments.

And perhaps just as importantly, as early childhood teachers, you also have the powerful ability of helping parents engage their children in these activities. Either via a quick conversation at pickup or a short weekly newsletter sent home to parents (either digitally or on paper), something similar to the below exchange can be all the impetus parents need to get started on their own scientific journey with their children:

> We're exploring water in class this week; the children were excited to take turns at the water table, pouring water into different sized and shaped containers, and predicting what familiar objects from around the classroom would sink to the bottom or float to the top. It was something that I enjoyed learning about, too! I didn't always know how the investigations would turn out, but the children and I figured it out and learned together! It's something that you can explore at home, too—for example, at bath time or while in the kitchen washing dishes after dinner.

Ways to Connect Science Learning at School and Home

To bridge the gap between the early childhood classroom and home, educators can find and highlight content areas and activities that are accessible at home, promote and support more science-based discussions at home, and encourage at-home science activities.

Let families know about inexpensive science activities they can do at home.

When connecting science learning at school with experiences at home, we suggest that educators:

1. Choose topics in the classroom that children can explore in school and at home. Moreover, consider phenomena they are likely to see and experience in their daily lives and communities.
2. Provide parents with ideas for activities they can do with their children that don't require special materials or a lot of time. For example, give parents tip sheets with conversation starters and ideas for science activities while walking to school or while at the grocery store. Consider media-based resource suggestions. Send home a newsletter that tells parents about science activities that were done in the classroom and that can be easily duplicated and/or extended at home.
3. Encourage conversations between children and their parents, siblings, and grandparents to explore the science in their communities—for example, send children home with activities that require them to talk with their families about the current science activities they are doing in school.
4. Make a particular effort to connect with families who have less formal education, who may feel particularly insecure about being "wrong," and who may need more resources and encouragement. Let families know about inexpensive science activities they can do at home or in their neighborhood with common everyday items, like using a piece of cardboard to create a ramp or bringing household objects to the bathtub to predict if they will sink or float.

Science Activities and Resources to Consider

Outdoor Exploration and Classification

Many parents need help connecting home activities with the science their children are doing in school, and life science provides a perfect vehicle for making this connection. Children already explore aspects of life science in their class—for example, studying the differences between living and nonliving things—and you can help parents continue that exploration when children are in their home communities. A fun activity to encourage parents to do with their children is to document on a t-chart the different living and nonliving things they see and encounter on their way home from school and/or over the weekend.

This simple activity allows children (and their parents) to understand life science content through the use of science practices, including observing different living and nonliving things, comparing those things, documenting what was found, and sharing and discussing those discoveries with peers and adults. To really help children experience the home-school science connection, this activity can be expanded by creating a larger t-chart in the classroom that includes all the children's findings.

Next, children can sort the different living and nonliving things into other categories. For example, the living things can be sorted into plants, animals, and insects, and the nonliving things can be sorted according to their use or where they came from. To help parents with ideas on additional science activities, you can send students home with a note about a living thing they expressed interest in learning more about, including some suggested resources (e.g., specific books or websites) for families to research and learn from together.

Question Jars

Another way to connect home and school, while reinforcing the idea that adults don't need to have the right answer, is to set up a question jar in your classroom and have children create one for use at home as well. The purpose of the jar is to write down questions that arise during the day or week—for example, "Why is the sky blue?" "Do trees breathe?" "How do fish live underwater?" Parents can write down questions their children ask and add them to the jar at home. Every month or so, you can suggest that parents and children choose one question to research and answer together. You might even want to provide parents with some suggested resources and guidance on how to try and answer the question—for example, helpful websites to consult, like Encyclopedia Britannica (www.britannica.com) or National Geographic (www.nationalgeographic.com). To ensure that the activity engages children and parents in science practices, encourage parents to help their children make predictions before answering the question. Doing so can also serve as a model for other home activities (as seen in the cookie scenario at the beginning of this article).

Literacy and Science

We know that parents already engage their children in literacy activities. Help them connect literacy and science by encouraging parents and children to record their question jar findings using either words or images in a "science journal" or notebook, where they can see all the questions they've answered from their jar throughout the year. To make a clear connection between the classroom and home, children can answer questions from the classroom jar as a classroom activity and include them in the same journal. This science journal can also serve as the basis for encouraging science-related discussions between parents and children: parents can look at the journal entries from school and ask their children to talk about them. Through this exercise, parents can learn that even the teacher doesn't always know the answer, and that that's OK! It also allows parents to see that science is not about technical jargon but is related to things they talk about and do in their everyday lives. Finally, activities such as these help parents understand that science is rooted in and stems from exploration and curiosity, and so by engaging and supporting their children's innate curiosity, they are supporting science learning.

Connect to Classroom Routines

Another way to encourage home discussions and provide simple home activities is to have parents ask their children to perform classroom jobs (e.g., feeding the pet, watering the plants) at home, to encourage making connections to science. For example, some of you may incorporate the weather as part of your daily morning meeting or circle time during class. If you've assigned some of your children the job of "weather reporter" for a given week, they can be sent home with a weather card to fill out with their parents over the weekend. Each card can include prompts that ask the children (with their parents' help) to record the weather (Is it sunny? Is it raining? Is it cloudy?), as well as other weather-related observations (What do you see? What do you hear? What do you feel? What types of clothing are people wearing and why?) and what activities they did over the weekend based on the weather.

Connect to Holidays

Another great way to engage families is to create activities around science-related holidays, such as Earth Day, Arbor Day, and less well-known celebrations, such as International Day of Forests, Solar Appreciation Day, and World Space Week. You can take steps to ensure these activities don't require a lot of setup or materials at home. For instance, on World Planting Day, consider sending children home with a small planting kit. This kit could consist of an envelope with a few seeds in it and some soil, accompanied by a handout with instructions on how to turn a used plastic bottle into a planter and how to help the plant grow by providing it with sunlight and water.

Encourage parents to help their children make predictions before answering the question.

As previously mentioned, an easy way to communicate with families and encourage activities related to these holidays is to send home weekly newsletters. And because some parents, especially those who have less formal education, may be concerned about providing wrong information to their children, the note can end with a link to a short article to help parents learn about the subject. You can say:

> This week, we'll be celebrating World Space Week! Some of the things we'll be discussing in class are the sun, the moon, and the planets. A fun activity you can do at home with your children this month is to observe and then draw the moon once a week. You can also talk about and compare the various shapes of the moon on the different days. Some children might ask tough questions, such as "Why can we only see part of the moon?" or "Why does it seem like the moon is following me?" To learn more about the moon and moon phases, check out this link from National Geographic Kids: https://bit.ly/2PcSKDj.

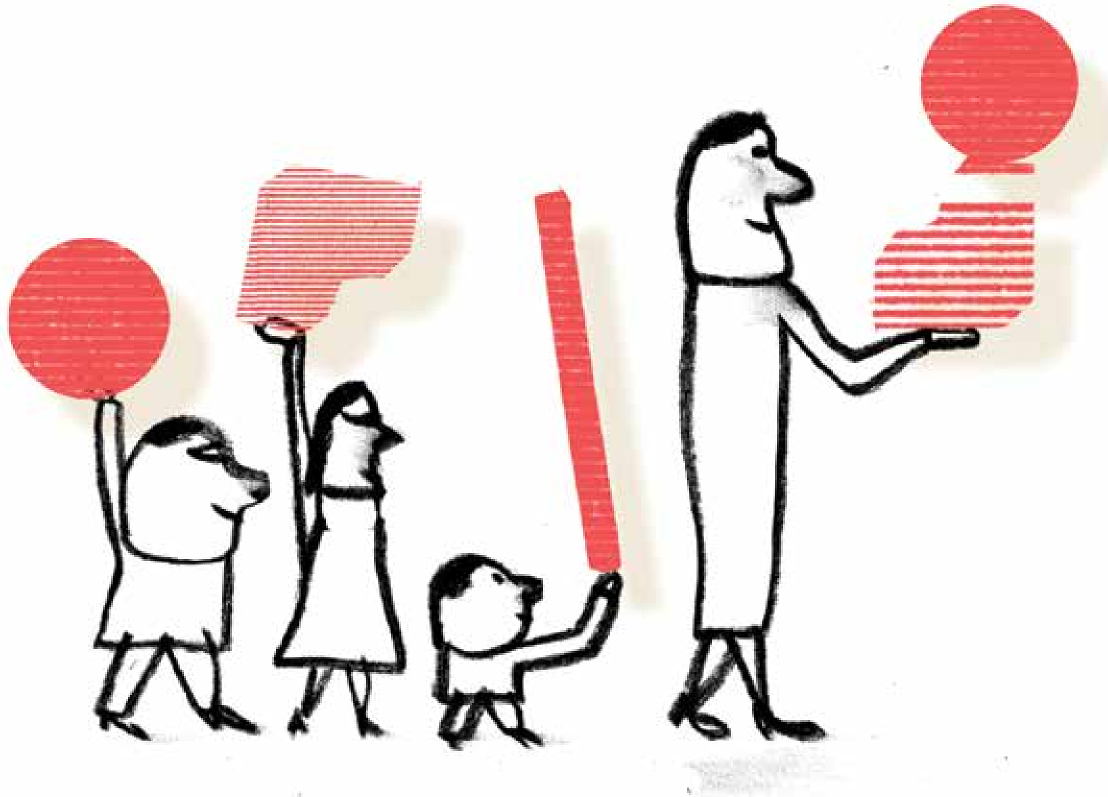
Media-Based Connections

Opportunities to incorporate media into your science teaching abound. Many developmentally- and age-appropriate apps, games, and TV shows address scientific topics and can enhance science experiences for both parents and children. For instance, Early Science with Nico & Nor features a plant journal that can be used in the classroom or at home to track the growth of plants using photographs, a compare and contrast feature, and a graphing feature (available for free in Apple's app store). Also, *Nature Cat*'s "Garden Impossible" episode (available for free on the PBS Kids Video app and website) outlines how to create a planter out of everyday items.

(Continued on page 40)

Spatial Thinking and STEM

How Playing with Blocks Supports Early Math



By Laura Zimmermann, Lindsey Foster, Roberta Michnick Golinkoff, and Kathy Hirsh-Pasek

Remember the last time you assembled a chest of drawers using that black-and-white IKEA diagram? Or the last time you found your way through a new city without your GPS? In these tasks—and many others—you are using spatial skills. These spatial abilities pervade our everyday lives—whether we are walking to the elevator from a doctor's office or deftly rotating our hot coffee cups to place them securely on our kitchen counter. The last 15 years have witnessed a quiet revolution in our understanding of spatial skills,* and we are finding that these all-important STEM (science, technology, engineering, and math) competencies are rooted in spatial knowledge. Where would our understanding of DNA be if James Watson and Francis Crick had not imagined a spatial structure like the double helix? Indeed, your spatial ability in high school is related to whether you become an engineer or a lawyer. Your background in spatial experiences predicts your STEM trajectory.

Spatial skills are the tools we use to visualize and navigate the world around us. Spatial skills allow us to manipulate objects in our environment and in our mind. They allow us to compute and store relations between objects, as when we remember we put our keys under the newspaper. Like gravity, we take these skills for granted, although we use them all the time.

Architecture, engineering, dentistry, and medicine are just a few of the fields in which spatial skills are essential. A mistaken measurement on a bridge could be disastrous for commuters. Dentists and doctors routinely interpret X-rays that not only flip left and right, but also present soft tissues as gray and bone as lighter gray. In biology, our understanding of DNA depends on visualizing the double helix. Members of these professions, among others, rely on a foundation of strong spatial

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*For more on spatial skills, see "Picture This" in the Summer 2010 issue of *American Educator*, available at www.aft.org/sites/default/files/periodicals/Newcombe_1.pdf, and "Seeing Relationships" in the Spring 2013 issue of *American Educator*, available at www.aft.org/periodical/american-educator/spring-2013/seeing-relationships.

ILLUSTRATIONS BY SERGE BLOCH

skills to accurately and successfully perform their work. So, if spatial skills are so important and pervasive, why are they so little discussed?

Spatial Skills and STEM Readiness

Despite important research findings on the impact of early spatial and math learning on later academic success, many schools lack the knowledge, resources, and capacity to focus on STEM and spatial learning in developmentally appropriate ways.

STEM education in the United States presents a multifaceted challenge. One dimension involves a shortage of classroom teachers who are qualified to teach STEM subjects. According to the Department of Education, during the 2017–2018 school year, public schools in 48 states and the District of Columbia reported teacher shortages in math, and 43 states reported shortages in science.[1] This problem may not improve anytime soon, as a study from the University of California, Los Angeles, has found that over the past decade, freshmen's interest in majoring in education has declined.[2]

The National Center for Education Statistics reported in 2014 that attrition rates for students pursuing STEM and non-STEM bachelor's degrees are similar.[3] Interestingly, women leaving STEM majors were more likely to switch majors (32 percent of women switched, versus 26 percent of men), whereas men were more likely to drop out of school (24 percent of men dropped out, versus 14 percent of women). A 2013 survey from the National Science Foundation found that, while unemployment rates for STEM majors are low, in many cases those with undergraduate degrees in STEM fields do not end up employed in their field of study.[4] The exception to this is computer science, where more than half of graduates are employed in their field.

The picture for math is especially concerning. In 2015, the United States ranked 31st out of 35 developed countries on an international mathematics test of 15-year-olds.[5] Only 6 percent scored at or above proficiency level 5, meaning that students can transfer their knowledge to "solve problems that involve visual or spatial reasoning … in unfamiliar contexts." Fully 29 percent scored below level 2, meaning they cannot compare the total distance across two alternative routes or compute the approximate price of an object in a different currency. Such findings create a national imperative for more and better training in the STEM disciplines.

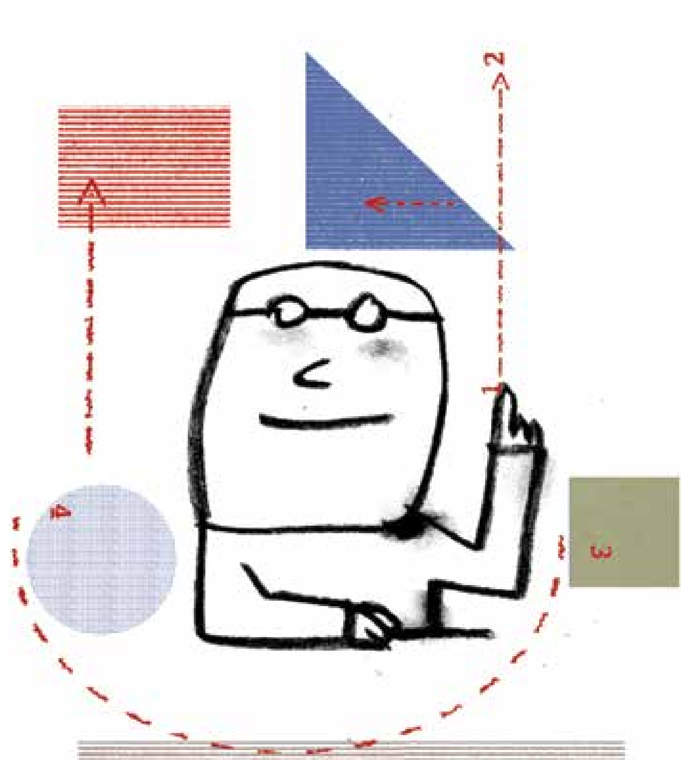
Statistics like these prompt experts to highlight the importance of STEM experiences beginning in early childhood, with the goal of enriching spatial and mathematical learning for all children. In 2017, two independent reports from the Joan Ganz Cooney Center, the University of Chicago, and the Erikson Institute argued that early high-quality STEM experiences have a lasting impact on children's development, consistent with other research findings.[6†] Though neither of these reports explicitly mentioned spatial skills, a 2018 report from the Center for Childhood Creativity, *The Roots of STEM Success: Changing Early Learning Experiences to Build Lifelong Thinking Skills*, includes in-depth information on spatial reasoning—the link to math and engineering—and how it can be developed through dialogue.[7]

The Link between STEM and Spatial Skills

The term STEM was coined in the early 2000s by Judith Ramaley, who served in the directorate at the National Science Foundation.[8] Spatial skills have a strong link with performance in STEM fields, and research has consistently shown that early spatial skills predict later success in these disciplines.

In one study, researchers gave high school students four different spatial tests.[9] They then linked the students' spatial scores to the occupations they had 11 years later. Students who pursued STEM-based careers, such as engineering and computer science, had better spatial skills in high school than those who pursued less STEM-focused careers.

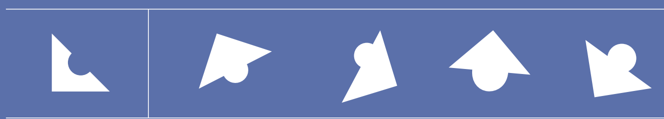
Spatial skills are the tools we use to visualize and navigate the world around us.



†For more on early high-quality STEM experiences, see "Where's Spot?: Finding STEM Opportunities for Young Children in Moments of Dramatic Tension" in the Fall 2017 issue of *American Educator*, available at www.aft.org/ae/fall2017/mcclure_guernsey_ashbrook.

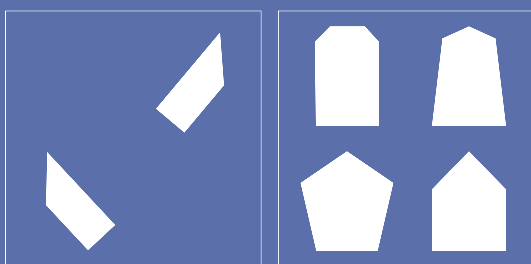
Figure 1: Mental Rotation and Transformation Tasks

A



"Which one of these *(point to four shapes on right)* makes a square with this one *(point to shape on left)*?"

B



"Look at these pieces. Now look at these shapes. If you put the pieces together, they will make one of these shapes. Point to the shape the pieces make."

SOURCE: ELIZABETH A. GUNDERSON ET AL., "THE RELATION BETWEEN SPATIAL SKILL AND EARLY NUMBER KNOWLEDGE: THE ROLE OF THE LINEAR NUMBER LINE," *DEVELOPMENTAL PSYCHOLOGY* 48, NO. 5 (2012): 1233.

STEM accomplishments later in life are facilitated by a mix of intellectually challenging STEM educational opportunities before college. Thus, it is essential to better equip our schools with resources and training so they can provide rich STEM experiences to foster spatial learning and achievement. But this link is not specific to adults, or even high school students. A link between spatial skills and mathematics performance is evident with children as young as preschoolers and elementary school children. In one study, researchers measured the spatial skills of first- and second-grade children at the start of school using a mental transformation test.[10] In one task (see task A in Figure 1 above), children were shown a shape and asked to determine which of the four other shapes, when combined with it, would make a square (the answer: the first shape). In another task (see task B in Figure 1), children were asked what shape on the right would result from combining the two shapes on the left (the answer: the shape on the bottom right).

The researchers then followed these children's improvement in number line calculations throughout the school year. Number lines are inherently spatial, though they are typically considered a tool for mathematical support. Children who had better spatial skills at the beginning of the year improved more on number line calculations throughout the school year. Thus, spatial skills are vital for early mathematical calculations; understanding magnitude rests on understanding the number line.

Interestingly, the spatial learning preschoolers acquire through block and puzzle play relates not only to spatial outcomes but also to mathematical learning. Researchers followed children from ages 3 to 5 to examine a possible link between spacial learning and math.[11] They used a Test of Spatial Assembly, which involves copying an array of shapes with tangram puzzles or copying a LEGO construction by assembling the LEGO blocks. The children were scored based on how well their construction matched the model. They found that the children who did better on the test at age 3 had higher math readiness scores on standardized math assessments at age 5, when most children start kindergarten. These findings are significant because by kindergarten, children's math scores can be predicted through high school.

Supporting Spatial Development

By age 3, individual preschoolers already differ in their spatial skills. So where do these differences start? Are some people born with greater spatial abilities than others? Research with babies finds that as early as 5 months, boys are better than girls at recognizing an object presented as a mirror image.[12] And one study suggests that spatial differences detected at 7 months predict children's spatial abilities at 4 years old.[13] These studies examined "mental rotation"—the ability to mentally manipulate objects to picture them in differing orientations. As adults, we use mental rotation when we imagine how to position our key to unlock the front door, or when we have to match an image that tells us how to insert our credit card in an ATM.

Many children's toys provide opportunities to practice this skill. For example, children's shape sorters involve planning to put a shape into the correct hole, which often requires subsequent physical rotation of the shape. Why is it so easy for adults to fit blocks into shape sorters but so difficult for infants and toddlers? A series of experiments suggests that our ability to manipulate objects flexibly depends on the knowledge that we acquire as young children with objects, actions, and spatial relations.

Apparently, infants can recognize objects that have undergone a rotation.[14] However, recognizing objects from different orientations is just the beginning of spatial knowledge. More complex spatial thinking is fostered through language. For example, the language babies receive from their caregivers during play or daily routines that refers to shapes, sizes, features of shapes, and the orientation of shapes helps them connect spatial thinking about objects with the real world.

Researchers who investigated the key role that spatial language plays in helping children make sense of spatial concepts found that children who hear more spatial language, words like "on," "under," and "far," at 14 months of age tend to produce more spatial language later on and perform better on spatial tasks at 4 years of age.[15] This is because children who have heard greater spatial talk early in life are more likely to produce spatial language, and, in turn, those children who produce more spatial language are likely to perform better on spatial problem-solving tasks.

Rich spatial language can impact children's spatial cognition by focusing their attention to spatial information, and thus facilitate their ability to solve spatial problems. Having the words to explain that the slide is on top of the ladder may help a child better understand not only how to get to the slide, but also how to tell a friend to meet him or her there. Adults' use of spatial language with children while they are building with blocks, working on puzzles, or doing everyday activities appears to provide fuel for spatial knowledge.

Educators can incorporate project-based learning to encourage spatial and mathematical learning in the early years.

Caregivers often use spatial language without even realizing it. Common phrases like "Will you put *on* your socks?" and "Make sure to step *over* the cord" have spatial terms embedded in them. Spatial language also emerges during play, but the quality of these interactions depends on the type of toys caregivers and children use. For example, playing with traditional shape toys results in caregivers using more spatial language and more language overall than when playing with electronic shape toys that bark commands, flash lights, play music, or say unrelated things like "I love you."[16]

Promoting Spatial Learning

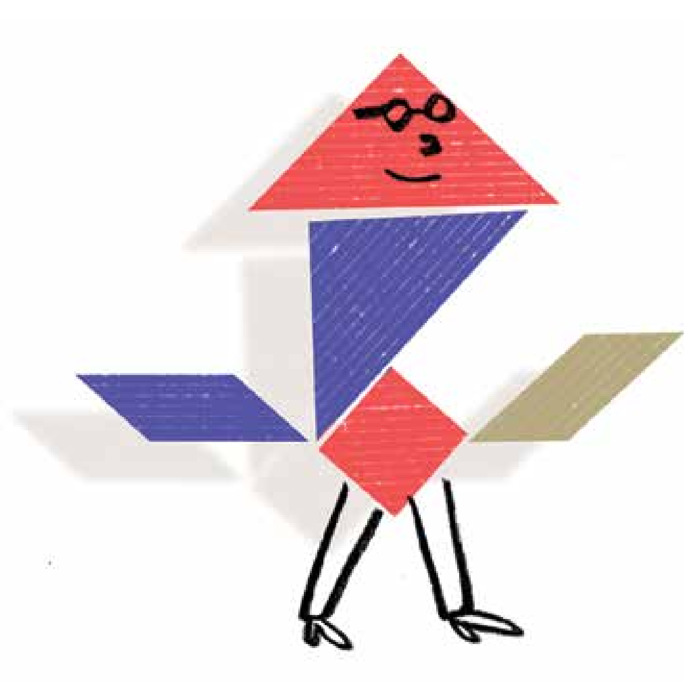
Fortunately, spatial skills are malleable, meaning they can be improved through practice. And there are many ways to promote spatial learning that are quick and inexpensive. How teachers and children engage in spatial play is just as important as the types of activities that are used to promote spatial learning. The science of learning tells us that children benefit from *guided play*. Guided play occurs when an adult provides support to help children achieve a learning goal. Children take the lead, but adults support their exploration through props and by interacting in ways that scaffold interest and learning.

In one study, researchers taught 4-year-olds the properties of geometric forms (for instance, that a triangle is a triangle because it has three corners and three sides).[17] Children were randomly assigned to one of three pedagogical conditions: guided play, didactic instruction, or free play. In the guided play condition, the experimenter and children worked together as detectives to discover "the secrets" of the shapes, or what makes the shapes "real." The experimenter helped the children discover each shape's distinguishing features through questions and encouraging the children to touch or trace the shapes presented on cards.

The didactic instruction condition was similar to the guided play condition in that the children were exposed to the same materials, but these children were asked to watch the experimenter play detective. Thus, the children's engagement differed in that the experimenter acted as the explorer while the children watched and listened. In the free play condition, the children were given the shape cards and a set of construction sticks to play with. The children were then told that Leelu the Ladybug is "a very picky bug who loves shapes, but only real shapes." The children were then asked to look carefully, identify whether each shape was real or fake, and explain why. Then the children were asked to place the real shapes in Leelu's box and the fake shapes in the trash can.

After about 15 minutes of shape training, children's shape knowledge excelled in the guided play condition, compared with those who were just told the secrets (didactic instruction) and those who engaged in free play. Their shape advantage was even maintained after one week. This suggests that a fruitful way of teaching geometric knowledge to young children is through guided play.

To build upon supporting children's learning through guided play, educators can incorporate project-based learning to encourage spatial and mathematical learning in the early years. Project-based learning is a teaching method where students gain knowledge and skills by working to investigate and respond to a complex problem, question, or challenge.



What might spatial project-based learning look like in a preschool classroom?

Play with wooden blocks, tangram shapes, and everyday objects that are found indoors or outdoors can help develop fine motor, language, social, and cognitive skills. But did you know that they also can provide rich opportunities for preschoolers to learn about shapes through spatial talk and guided play? Shape play can be enriched by drawing upon research that finds spatial language can help improve toddlers' and preschoolers' spatial reasoning.

> It is just as important to promote spatial skill development outside of the classroom.

During transition time, present preschoolers with a problem: We need to clean up all the shapes before we can go outside for recess. All the triangles need to go in this basket, and the other shapes need to go in this basket. Ask children to talk about what makes a triangle a triangle, and present them with different variants or nonstandard triangles (e.g., obtuse, scalene, acute). Share the strategy of counting the number of corners, practice it, and then encourage kids to count as they sort. Then ask children if they know another way they can count to figure out the shape (counting the sides). You can even continue the fun outside at recess by asking children to search for different shapes in nature and take pictures or bring them inside to talk about what they found.

Another option is to give students a task with blocks where they need to work together to build a strong structure like a castle or a house. While they are building, ask them about the location of the blocks and encourage their use of spatial prepositions to promote spatial language. Should you put the cube *on top* of the rectangular prism? Which shape did you put *next to* the cylinder? Not only are children learning new spatial prepositions, but they are also getting experience with rotating and manipulating the pieces. To make it even more challenging, have your class try to create a replica of a structure from a detailed image or a series of spatial instructions.

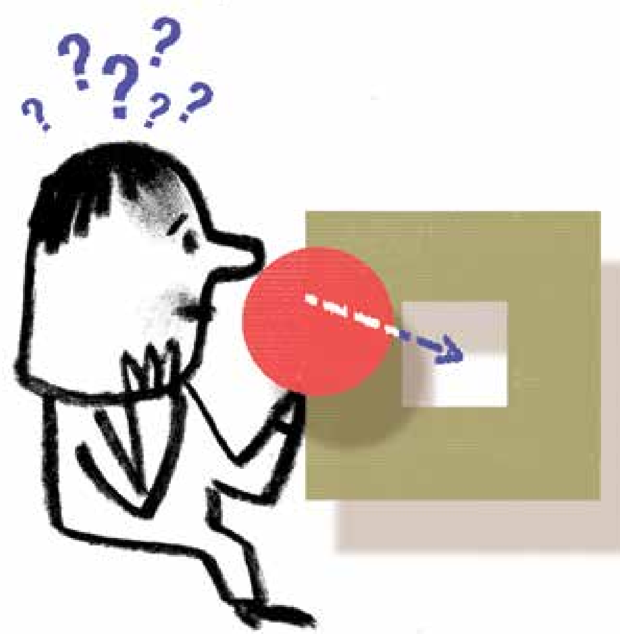
What might spatial project-based learning look like in an elementary school classroom?

At one elementary school we visited, classrooms participate in theme-based education. One year, teachers made up a fictional planet: Orbis, which is in a galaxy on the other side of the sun from Earth. Each classroom became a different country and was tasked with survival problems. Lunaguavia is located near an ocean with ports and has a sunny climate that is ideal for growing produce. Interstasis has rich mineral deposits that can be manufactured into products. Each country needs to make collaborative deals with other countries in order to receive goods.

In this classroom lesson masked as playful problem solving, students are communicating and collaborating to help their countries survive while also learning new content. There are a number of ways to incorporate spatial learning into a classroom scenario such as this. Teachers can introduce a map activity where parts of the map of their country are incomplete and children need to identify the missing landmarks around the classroom and complete the map with stickers that correspond to those landmarks. This is a great opportunity for children to write down or discuss what clues they used or why they chose their locations for the stickers. It incorporates perspective-taking and teaches children about paying attention to spatial cues. Then, once the map is completed, children can work on activities or quests that require calculating the size of a boat or the miles needed to travel. As such, project-based learning becomes an exciting and accessible way of teaching core curriculum.

Informal Learning

As it turns out, a large percentage of children's waking hours (80 percent) is spent outside of school.[18] Therefore, it is just as important to promote spatial skill development outside of the classroom. Fortunately, spatial experiences are all around us, whether in a public space like a park, where children can build a bridge with objects found in nature, or in a children's museum



Cleaning up toys or eating a meal can provide a rich opportunity for children and adults to play, talk, and interact together around spatial ideas.

that teaches STEM skills through hands-on activities using technology such as 3D printers. Informal spaces like libraries and grocery stores can also provide multiple opportunities for engaging in spatial experiences early on.

STEM learning can occur whenever children ask or explore answers to a spatial question or problem. Everyday moments like cleaning up toys or eating a meal can provide a rich opportunity for children and adults to play, talk, and interact together around spatial ideas. Spatial talk can also be promoted through an activity such as I SPY! or a board game such as Chutes and Ladders. Additionally, pointing out shapes in everyday life—rectangular doors, square windows, or circular tables—is an easy way to teach children about shapes and shape properties.

One initiative that is working to transform everyday places into learning opportunities is Learning Landscapes, through which many community projects have been developed, including Parkopolis and Urban Thinkscape in Philadelphia. These projects embed playful learning experiences in public spaces like museums, playgrounds, and bus stops. Recent research has found that these projects are significantly increasing spatial talk between children and their parents or guardians.[19]

Increasing access to a "spatial education" in and out of school can promote both school readiness and long-term performance gains in STEM-related fields. We can continue to draw from a large evidence base about how best to help children develop early spatial skills to lay the foundations for STEM achievement in school and work and better prepare them for the increasingly STEM-centric demands of the world. Now, how do we assemble that dresser? ☐

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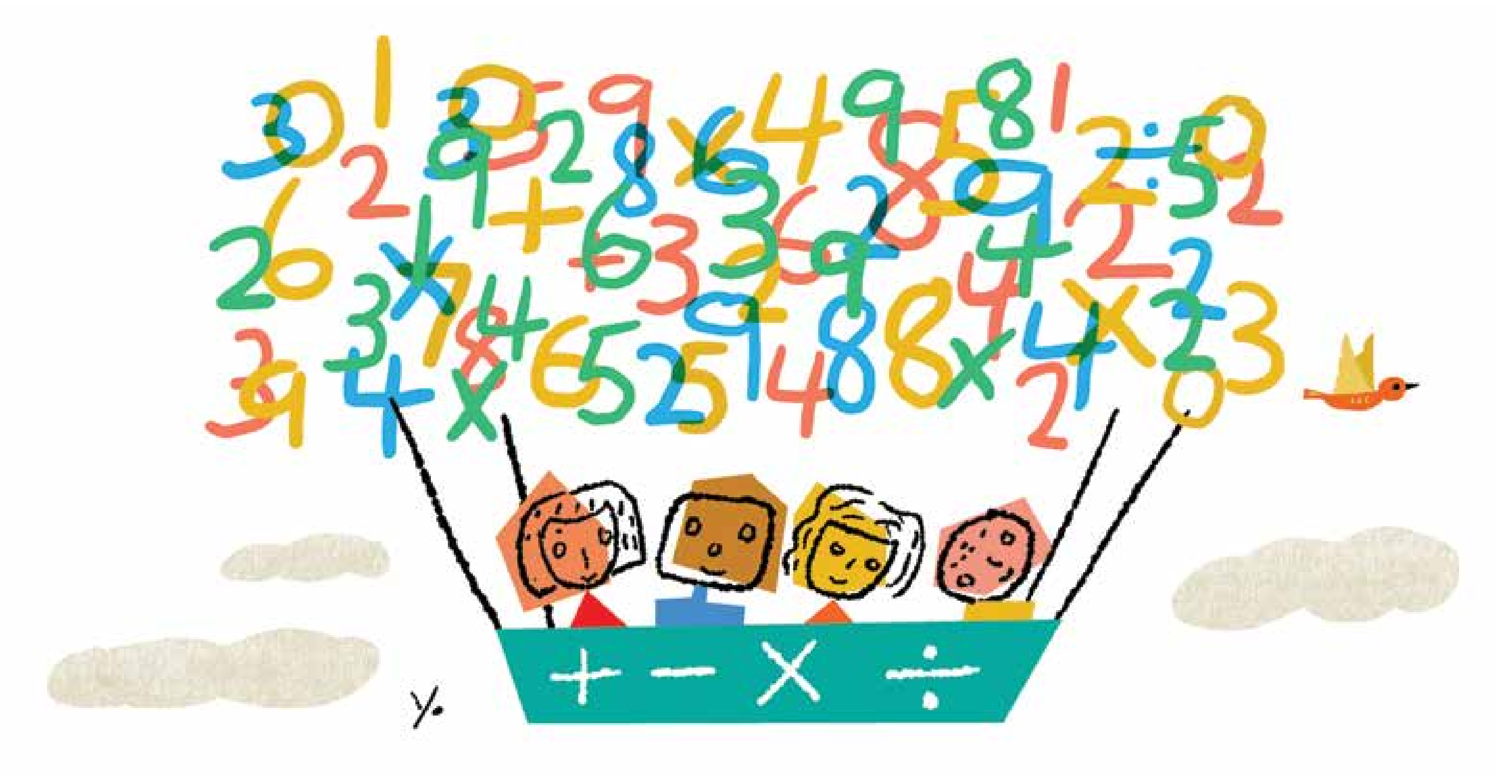
To learn more about the Learning Landscapes initiative, Parkopolis, and Urban Thinkscape, visit www.kathyhirshpasek.com/learning-landscapes.

Developing Mathematical Mindsets

The Need to Interact with Numbers Flexibly and Conceptually



ILLUSTRATIONS BY JAMES YANG

By Jo Boaler

Babies and infants love mathematics. Give babies a set of blocks, and they will build and order them, fascinated by the ways the edges line up. Children will look up at the sky and be delighted by the V formations in which birds fly. Count a set of objects with a young child and then move the objects and count them again, and they will be enchanted by the fact they still have the same number. Ask children to make patterns with colored blocks, and they will work happily making repeating patterns—one of the most mathematical of all acts. Mathematician Keith Devlin has written a range of books showing strong evidence that we are all natural mathematics users and thinkers.[1] We want to see patterns in the world and to understand the rhythms of the universe. But the joy and fascination young children experience with mathematics are quickly replaced by dread and dislike when they start school mathematics and are introduced to a dry set of methods they think they just have to accept and remember.

In Finland, one of the highest-scoring countries in the world on PISA (Program for International Student Assessment) tests, students do not learn formal mathematics methods until they are 7 years old. In the United States, students start much earlier, and by the time they are 7, they have already been introduced to algorithms for adding, subtracting, multiplying, and dividing numbers, and been made to memorize multiplication facts. For many students, their first experience of math is one of confusion, as the methods do not make sense to them. The inquisitiveness of our children's early years fades away and is replaced by a strong belief that math is all about following instructions and rules.

The best and most important start we can give our students is to encourage them to play with numbers and shapes, thinking about what patterns and ideas they can see. In her autobiography, Sarah Flannery, who won Europe's Young Scientist of the Year Award in 1999 for inventing a new mathematical algorithm, talks about the way she developed her mathematical thinking from working on puzzles at home with her dad, and how these puzzles were more important to her than all of her years of math class.[2]

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Successful math users have an approach to math as well as mathematical understanding that sets them apart from less successful users. They approach math with the desire to understand it and to think about it, and with the confidence that they can make sense of it. Successful math users search for patterns and relationships and think about connections. They approach math with a *mathematical mindset*, knowing that math is a subject of growth and that their role is to learn and think about new ideas. We need to instill this mathematical mindset in students from their first experiences of math.

Research has shown definitively the importance of a growth mindset—the belief that intelligence grows and that the more you learn, the more mathematical pathways you develop. But to erase math failure, we need students to have growth beliefs about themselves and accompany them with growth beliefs about the nature of mathematics and their role in relation to it. Children need to see math as a conceptual, growth subject that they should think about and make sense of.

When students see math as a series of short questions, they cannot see the role for their own inner growth and learning. They think that math is a fixed set of methods that either they get or they don't. But when students see math as a broad landscape of unexplored puzzles in which they can wander around, asking questions and thinking about relationships, they understand that their role is thinking, sense making, and growing. When students see mathematics as a set of ideas and relationships, and their role as one of thinking about the ideas and making sense of them, they have a mathematical mindset.

So how do we develop mathematical mindsets in students so that they are willing to approach math with sense making and intuition? Before they start school, the task is straightforward. It means asking children to play with puzzles, shapes, and numbers and think about their relationships.

But in the early years of school, we live in a system whereby students are required, from an early age, to learn many formal mathematical methods, such as those used to add, subtract, divide, and multiply numbers. This is the time when students stray from mathematical mindsets and develop fixed, procedural mindsets. This is the time when it is most critical that teachers and parents introduce mathematics as a flexible conceptual subject that is all about thinking and sense making. The domain of early number work gives us the perfect example of the two mindsets that can develop in students, one that is negative and leads to failure and one that is positive and leads to success.

Number Sense

In an important research study, two British researchers worked with students, ages 7 to 13, who had been nominated by their teachers as being either low, middle, or high achieving.[3] All of the students were given number problems, such as adding or subtracting two numbers. The researchers found an important difference between the low- and high-achieving students. The high-achieving students solved the questions by using what is known as number sense—they interacted with the numbers flexibly and conceptually. The low-achieving students used no number sense and seemed to believe that their role was to recall and use a standard method, even when this was difficult to do.

For example, when students were given a problem such as 21—6, the high-achieving students made the problem easier by changing it to 20—5, but the low-achieving students counted backward, starting at 21 and counting down, which is difficult to do and prone to error. After extensive study of the different strategies that the students used, the researchers concluded that the difference between the high- and low-achieving students was not that the low-achieving students knew less mathematics, but that they were interacting with mathematics differently. Instead of approaching numbers with flexibility and number sense, they seemed to cling to formal procedures they had learned, using them very precisely, not abandoning them even when it made sense to do so. The low achievers did not *know less*, they just did not use numbers flexibly—probably because they had been set on the wrong pathway, from an early age, of trying to memorize methods and number facts instead of interacting with numbers flexibly.[4]

The researchers pointed out something else important—the mathematics the low achievers were using was a harder mathematics. It is much easier to subtract 5 from 20 than to start at 21

The best start we can give students is to encourage them to play with numbers and shapes.

and count down 6 numbers. Unfortunately for low achievers, they are often identified as struggling with math and therefore given more drill and practice—cementing their beliefs that math success means memorizing methods, not understanding and making sense of situations. They are sent down a damaging pathway that makes them cling to formal procedures, and as a result, they often face a lifetime of difficulty with mathematics.

A mathematical mindset reflects an active approach to mathematics knowledge, in which students see their role as understanding and sense making. Number sense reflects a deep understanding of mathematics, but it comes about through a mathematical mindset that is focused on making sense of numbers and quantities. It is useful to think about the ways number sense is developed in students, not only because number sense is the foundation for all higher-level mathematics[5] but also because number sense and mathematical mindsets develop together, and learning about ways to develop one helps the development of the other.

Mathematics is a conceptual domain, not a list of facts and methods to be remembered.

Mathematics is a conceptual domain. It is not, as many people think, a list of facts and methods to be remembered. When students learn to count, they remember order and names for numbers, but they also develop the *concept* of number; that is, the idea of a number. In the early stages of learning to add numbers, students learn a method called "counting on." Counting on is used when you have two sets of numbers—for example, 15 plus 4—and you learn to count the first set (counting to 15), then continue counting (16, 17, 18, 19). When students learn the method of counting on, they develop the concept of "sum." This is not a method of addition; it is a conceptual idea.

In the next stage of their mathematics work, students may learn to add groups of numbers, such as three groups of 4, and as they learn to add groups, they develop the concept of a product. Again, this is not a method (of multiplication); it is a conceptual idea. The ideas of a number, a sum, and a product are concepts in mathematics that students need to think deeply about. Students should learn methods, such as adding and multiplying, not as ends in themselves but as part of a conceptual understanding of numbers, sums, and products and how they relate to each other.

We know that when we learn mathematics, we engage in a brain process called "compression." When you learn a new area of mathematics that you know nothing about, it takes up a large space in your brain, as you need to think hard about how it works and how the ideas relate to other ideas. But the mathematics you have learned before and know well, such as addition, takes up a small, compact space in your brain. You can use it easily without thinking about it. The process of compression happens because the brain is a highly complex organ with many things to control, and it can focus on only a few uncompressed ideas at any one time. Ideas that are known well are compressed and filed away. William Thurston, a top mathematician who won the Fields Medal, describes compression like this:

> Mathematics is amazingly compressible: you may struggle a long time, step by step, to work through the same process or idea from several approaches. But once you really understand it and have the mental perspective to see it as a whole, there is often a tremendous mental compression. You can file it away, recall it quickly and completely when you need it, and use it as just one step in some other mental process. The insight that goes with this compression is one of the real joys of mathematics.[6]

Many students do not describe mathematics as a "real joy"—in part because they are not engaging in compression. Notably, the brain can only compress concepts; it cannot compress rules and methods. Therefore, students who do not engage in conceptual thinking, and instead approach mathematics as a list of rules to remember, are not engaging in the critical process of compression, so their brain is unable to organize and file away ideas; instead, it struggles to hold onto long lists of methods and rules. This is why it is so important to help students approach mathematics conceptually at all times. Approaching mathematics conceptually is the essence of what I describe as a mathematical mindset.

What about Math Facts?

Many people believe that it is not possible to think conceptually about mathematics all the time because there are lots of math facts (such as 8 x 4 = 32) that have to be memorized. There are some math facts that are good to remember, but students can learn math facts and commit them to memory through conceptual engagement with math. Unfortunately, some teachers and parents think that because some areas of mathematics are factual, such as number facts, they need to be

learned through mindless practice and speed drills. It is this approach to early learning about numbers that causes damage to students, makes them think that being successful at math is about recalling facts at speed, and pushes them onto a procedural pathway that works against their development of a mathematical mindset.

Math facts by themselves are a small part of mathematics, and they are best learned through the use of numbers in different ways and situations. Unfortunately, many classrooms focus on math facts in isolation, giving students the impression that math facts are the essence of mathematics, and, even worse, that mastering the fast recall of math facts is what it means to be a strong mathematics student. Both of these ideas are wrong, and it is critical that we remove them from classrooms, as they play a key role in creating math-anxious and disaffected students.

I grew up in a progressive era in England, when primary schools focused on the "whole child," and I was not presented with tables of addition, subtraction, or multiplication facts to memorize in school. I have never committed math facts to memory, although I can quickly produce any math fact, as I have number sense and I have learned good ways to think about number combinations. My lack of memorization has never held me back at any time or place in my life, even though I am a mathematics professor, because I have number sense, which is much more important for students to learn and includes the learning of math facts along with a deep understanding of numbers and the ways they relate to each other.

For about one-third of students, the onset of timed testing is the beginning of math anxiety.[7]* Cognitive scientist Sian Beilock and her colleagues have studied people's brains through MRI imaging and found that math facts are held in the working memory section of the brain. But when students are stressed, such as when they are answering math questions under time pressure, the working memory is compromised, and students cannot access the math facts they know.[8] As students realize they cannot perform well on timed tests, they start to develop anxiety, and their mathematical confidence erodes. The blocking of the working memory and associated anxiety is particularly common among higher-achieving students and girls. Conservative estimates suggest that at least a third of students experience extreme stress related to timed tests, and these are not students from any particular achievement group or economic background. When we put students through this anxiety-provoking experience, we lose students from mathematics.

Math anxiety has now been recorded in students as young as 5.

Math anxiety has now been recorded in students as young as 5, and timed tests are a major cause of this debilitating, often lifelong condition. In my classes at Stanford University, I encounter many undergraduates who have been math traumatized, even though they are among the highest-achieving students in the country. When I ask them what led to their math aversion, many talk about timed tests in second or third grade as a major turning point when they decided that math was not for them. Some of the students, especially women, talk about the need to understand deeply (a very worthwhile goal) and being made to feel that deep understanding was not valued or offered when timed tests became a part of math class. They may have been doing other, more valuable work in their mathematics classes, focusing on sense making and understanding, but timed tests evoke such strong emotions that students can come to believe that being fast with math facts is the essence of mathematics. This is extremely unfortunate.

We see the outcome of the misguided school emphasis on memorization and testing in the numbers of students dropping

*For more on math anxiety, see "Have Math Anxiety?: Here's How to Not Pass It Down to Your Kid," available at https://bit.ly/2p93q6T.

out of mathematics and in the math crisis we currently face. When my own daughter started times table memorization and testing at age 5, she started to come home and cry about math. This is not the emotion we want students to associate with mathematics, but as long as we keep putting students under pressure to recall facts at speed, we will not erase the widespread anxiety and dislike of mathematics that pervades our schools.[9]

So what do we do to help students learn math facts if we do not use timed tests? The very best way to encourage the learning of facts and the development of a mathematical mindset is to offer conceptual mathematical activities that help students learn and understand numbers and number facts. Brain researchers studied students learning math facts in two ways. One approach was through strategies; for example, learning 17 x 8 by working out 17 x 10 (170) and subtracting 17 x 2 (34). The other approach was through the memorization of facts (17 x 8 = 136). They found that the two approaches (strategies and memorization) involve two distinct pathways in the brain and that both pathways are perfectly good for lifelong use. Importantly, though, the study also found that those who learned through strategies achieved "superior performance" over those who memorized; they solved test questions at the same speed and showed better transfer to new problems. The brain researchers concluded that automaticity should be reached through the understanding of numerical relations, achieved through thinking about number strategies.[10]

The most powerful learning occurs when we use different pathways in the brain.

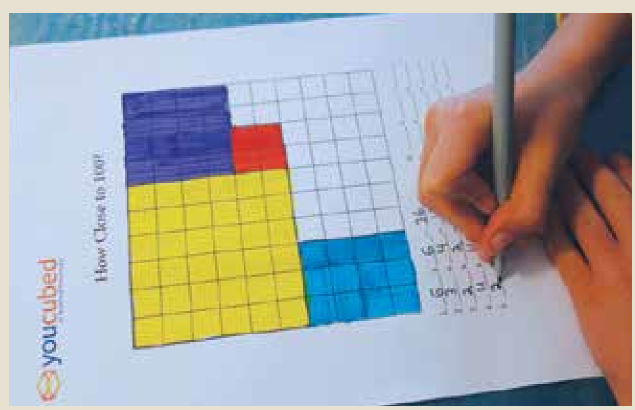
In another important study, researchers found that the most powerful learning occurs when we use different pathways in the brain.[11] The left side of the brain handles factual and technical information; the right side handles visual and spatial information. Researchers found that mathematics learning and performance are optimized when the two sides of the brain are communicating.[12] Researchers also found that when students were working on arithmetic problems, such as subtraction, the highest achievers were those who exhibited the strongest connections between the two sides of the brain. The implications of this finding are extremely important for mathematics learning, as they tell us that learning the formal abstract mathematics that makes up a lot of the school curriculum is enhanced when students are using visual and intuitive mathematical thinking.

In "Fluency without Fear," a paper published by Youcubed, the research group I lead, we included this evidence and activities that teachers and parents can use to enable the important brain connections. One of the math games we included in the paper became hugely popular after it was released and was tweeted around the world.

The game is called "How Close to 100?" Each student plays with his or her own game sheet, which is a blank 100-square grid (see Figure 1 below). To begin, the first player rolls two dice, and the numbers that come up are the numbers the student uses to make a rectangular array anywhere on the grid. The goal is to be the first person to fill the 10 x 10 grid. The students also fill in number sentences after each roll. The game ends when one player fills up his or her grid. (To watch a short video of students playing the game, visit www.youcubed.org/resources/different-experiences-with-math-facts.) In this game, the students are learning number facts, such as 4 x 6, but they are also doing something much more important. They are thinking about the meaning of the number facts and what 4 x 6 represents, visually and spatially.

Another game that encourages the same powerful brain connections takes the idea of math cards, which are often used in damaging ways, such as drill and speed "flash cards," and uses them very differently. Our math cards depict numbers in various ways. For example, 9 and 4 can be shown with an area model, sets of objects such as dominoes, and a number sentence (see Figure 2 on page 33). The aim of the game is to match cards with the same total, shown through different representa-

Figure 1: How Close to 100?



For free math resources, visit www.youcubed.org, a website run by Jo Boaler and a Stanford-based research group.

tions, with no time pressure. Teachers lay all the cards down on a table and ask students to take turns picking them. They pick as many as they can with the same total, shown through any representation, and then explain how they know that the different cards are equivalent.

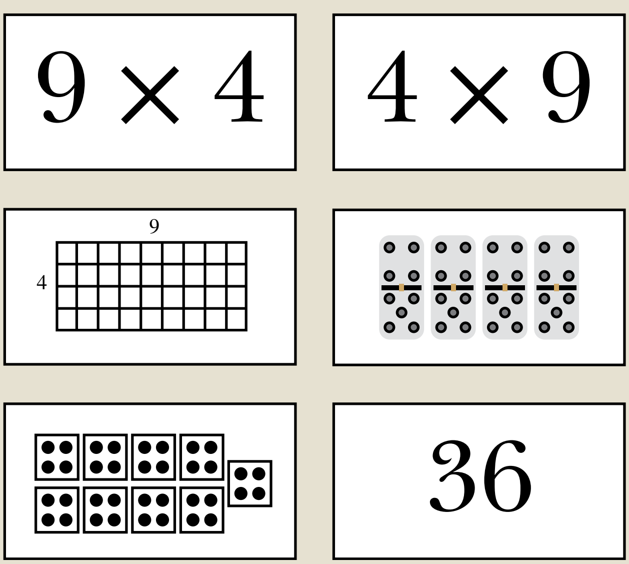
This activity again focuses on understanding multiplication, visually and spatially, encouraging brain connections at the same time as rehearsing math facts. The game can also be played with the cards face-down as a memory game to add an extra challenge.*

These activities teach number sense and a mathematical mindset and encourage communication between brain pathways. The antithesis of this approach is a focus on rote memorization and speed. The more we emphasize memorization to students, the less willing they become to think about numbers and their relations and to use and develop number sense.[13] Some students are not as good at memorizing math facts as others. That is something to be celebrated; it is part of the wonderful diversity of life and people. Imagine how awful it would be if teachers gave tests of math facts and everyone answered them in the same way and at the same speed, as though they were all robots.

In a recent brain study, scientists examined students' brains as they were taught to memorize math facts. They saw that some students memorized them much more easily than others. This will come as no surprise to readers, and many of us would probably assume that those who memorized better were higher-achieving or "more intelligent" students. But the researchers found that the students who memorized more easily were not higher achieving; they did not have what the researchers described as more "math ability," nor did they have higher IQ scores.[14] The only differences the researchers found were in a brain region called the hippocampus, the area of the brain responsible for memorized facts. The hippocampus, like other brain regions, is not fixed and can grow at any time,[15] but it will always be the case that some students are faster or slower when memorizing, and this *has nothing to do with mathematics potential*.

*A full set of math cards and other free resources are available at https://bit.ly/2ix6eXA.

Figure 2: Math Cards



SOURCE: *MATHEMATICAL MINDSETS*, PAGE 41. REPRINTED WITH PERMISSION OF JOSSEY-BASS/WILEY.

In order to learn to be a good English student and to read and understand novels and poetry, students need to have memorized the meanings of many words. But no English student would say or think that learning English is about the fast memorization and recall of words. This is because we learn words by using them in many different situations—talking, reading, and writing. English teachers do not give students hundreds of words to memorize and then test them under timed conditions.

All subjects require the memorization of some facts, but mathematics is the only subject in which students are given frequent timed tests from a young age. Why do we treat mathematics in this way? We have the research evidence that shows students can learn math facts much more powerfully with engaging activities; now is the time to use this evidence and liberate students from mathematics fear. ☐

Endnotes

1. See, for example, Keith Devlin, *The Math Instinct: Why You're a Mathematical Genius (along with Lobsters, Birds, Cats, and Dogs)* (New York: Basic Books, 2006).

2. Sarah Flannery and David Flannery, *In Code: A Mathematical Journey* (New York: Workman Publishing, 2002).

3. Eddie M. Gray and David O. Tall, "Duality, Ambiguity, and Flexibility: A 'Proceptual' View of Simple Arithmetic," *Journal for Research in Mathematics Education* 25, no. 2 (1994): 116–140.

4. Jo Boaler, *What's Math Got to Do with It?: How Teachers and Parents Can Transform Mathematics Learning and Inspire Success* (New York: Penguin Books, 2015).

5. David Feikes and Keith Schwingendorf, "The Importance of Compression in Children's

(Continued on page 40)

Ready for Recess?

The Elementary School Teacher's Perspective

BY CATHERINE L. RAMSTETTER AND DALE BORMAN FINK

Simeon is a third-grader in Mr. Mitchell's elementary school classroom. His winning smile and outgoing personality have gained him plenty of friends. But he's also a master at distracting his peers during independent work. This particular day, he repeatedly reaches into Daniel's space, taps his fingers, and makes the sound of a drumroll. Mr. Mitchell cajoles him, cautions him, and finally calls him to the side of the room to speak to him privately. The only effect seems to be that Simeon turns his intrusive sounds and motions toward Kayla instead of Daniel. Finally, Mr. Mitchell announces in front of the whole class, "Simeon, you either get to work right now and stay focused, or you will stay in and do your work while the other children are at recess!"

Will the threat of losing recess be enough to motivate Simeon to become productive? How many times will the threat work before Mr. Mitchell has to carry it out and show Simeon and his classmates he is serious? Once he does, will Simeon become more studious—or will he become one of those children who frequently lose out on recess?

The question Mr. Mitchell must ultimately answer is this: Is recess a reward to be earned only by the children who are on task and who comply with academic and behavioral expectations? Or is recess an important part of every child's school day, offering benefits—to physical health, social development, and sense of autonomy—that are too important to be taken away?

We know that Mr. Mitchell is not alone in his predicament. In a 2010 Gallup survey, 77 percent of principals or other building administrators said that some or all of their teachers used withholding of recess as punishment.[1] Based on our qualitative studies of classroom teachers in elementary schools in Illinois, Massachusetts, Ohio, and Texas, we have witnessed the uncertainty of teachers who use this strategy. Even among educators who do withhold recess, many worry that the strategy is at best a weak and imprecise disciplinary tool that could backfire. At a loss for other ways to improve student motivation and behavior, many teachers seem to have arrived at the same conclusion as Tamar, a thoughtful third-grader we interviewed: "I'll say it is a good consequence, since a lot of kids like recess."

The purpose of this article is to promote a deeper, more complex understanding of the challenge that "recess time" poses to elementary school educators and to thereby understand the practices in which they are currently engaging. Because teachers

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are expected to shepherd students through a vast array of learning standards while remaining sensitive to their social, physical, and emotional well-being, decisions about who gets to participate in recess are made under great pressure. Also, teachers often correctly perceive that only limited resources are available to help them.

After sharing what we have learned about teachers' perspectives, we will briefly discuss two examples of school initiatives that support teachers in managing classrooms while ensuring that recess remains part of every child's day. It is our hope that by reading this article, educational leaders working on this issue will see the necessity of engaging classroom teachers in the big-picture discussions about recess and related health and wellness policies.

The Benefits of Recess and Why Teachers Sometimes Withhold It

With the support of selected elementary school principals, we distributed a survey in three school districts in Massachusetts (March 2014) and two in Ohio (February 2017). We interviewed a small sample of teachers in those two states as well as a sample of teachers in Illinois and Texas. The survey included questions asking for quantitative responses (e.g., "How many children have you held out of recess at least once during the current academic year?") and others calling for qualitative responses (e.g., "Check off from the following menu all the reasons you held children from recess"). Respondents also had a number of opportunities to expand on their answers with open-ended comments.

The data we present here show teachers' attitudes toward recess and their practices relating to withholding it as a disciplinary tool. While these results can add an important dimension to the dialogue about recess, they should be taken as suggestive, not definitive. Participation of teachers in such a survey could only take place in schools where superintendents and principals chose to cooperate with our inquiry; we do not make claims about the randomness or representative nature of our sample.

When asked about the ways recess benefits their students, 100 percent of respondents said recess was beneficial and selected at least one benefit from providing recess; not one checked the box indicating their belief that recess offers "minimal or no benefits." The two types of benefits most teachers agreed with overwhelmingly were, "Promotes health and wellness (e.g., fresh air, physical exercise)" and "Promotes social development (e.g., learning to interact with peers)." More than 96 percent of teachers checked off each of these options, as shown in Figure 1 on page 36. A majority of respondents (77 percent) also felt that recess "Promotes students' autonomy or self-direction," while 42 percent checked off the box that recess "Provides learning experiences related to the general curriculum." Eighteen percent wrote in an additional benefit, such as promoting self-confidence, creativity, and problem-solving abilities, besides the menu of four choices we offered.

One second-grade teacher we interviewed, in expanding on her ideas about the benefits of recess, also provided a critique of her district's reasons for having reduced recess:

> Our school district has limited young children to one 25-minute recess per day in an attempt to pretend that more learning is taking place. Our second-graders are forced to endure a three-and-a-half-hour morning with no break. This, in my opinion, is counter to better learning. A short outdoor break would bring the students back refreshed, and then more actual learning would take place. Even adult retail workers get more breaks than our 7- and 8-year-olds.

Despite the unanimous response that recess offers important benefits to students, two-thirds (68 percent) of our respondents had withheld all or part of a recess period from at least one student during that school year—individually, and not as part of a classwide loss of recess. (Classwide loss of recess was something we did not explore in our work, as we wanted to learn about the withholding of recess from individual students as a disciplinary strategy.)

The biggest proportion of these teachers (two-thirds of the two-thirds who used this form of discipline) had withheld recess because a "Student's words or actions violated behavioral expectations." As shown in Figure 2 on page 36, smaller proportions had denied recess for other reasons: 56 percent for not getting work done during class, and 22 percent for failing to complete and turn in homework. Twenty-six percent of respondents volunteered another reason for withholding recess, such as students engaging in unsafe behavior at recess, not following recess rules, not completing class work, and needing academic intervention.

Even educators who withhold recess worry that the strategy is a weak and imprecise disciplinary tool that could backfire.

When asked whether teachers think taking away recess is "working" to accomplish the intended outcome (i.e., improved behavior or improved academic attention/work completion), the answers were mixed. Teachers pointed to examples of students they felt had corrected their behavior or improved their classroom productivity after experiencing the loss of recess—or even just a portion of recess—as little as one time. However, most teachers seemed to feel that in denying a student recess as often as four times a month, the sanction was probably not having the desired effect.

100 percent of respondents said recess was beneficial.

The Need to Include Teachers

Substantial numbers of elementary school teachers are withholding from recess the very children they tell us "need it the most." Nearly all of these teachers wish they had other ways to motivate their students, as they clearly do not question the intrinsic value of recess time. Teachers expressed a need for support in developing alternatives to withholding recess. That begins with engaging teachers in a school's development of consistent academic/behavioral expectations, consequences, and strategies.

Connecting recess with these whole-school initiatives requires teachers to be included in preparation and adoption. As those closest to students and parents, teachers must be part of the process of embracing common practices and explicit language to ensure recess will not be withheld for academic or punitive reasons. As a result, teachers will not feel "on their own" or "at a loss," because the culture of the school supports them.

Schools would be well advised to consider the American Academy of Pediatrics' policy on recess, which states that "cognitive processing and academic performance depend on regular breaks from concentrated classroom work, [which] applies equally to adolescents and to younger children. To be effective, the frequency and duration of breaks should be sufficient to allow the student to mentally decompress."[2] Thus, while each school must examine resources and schedules within the context of its environment, it is possible to build in more than one recess, combined with lunch, to provide frequent, regular breaks.

Figure 1: Teacher Survey Responses about Benefits of Recess

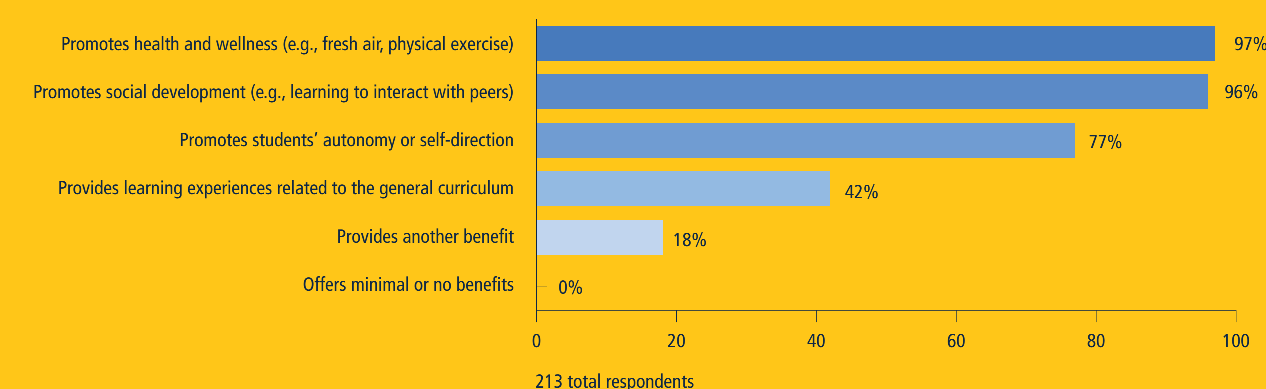
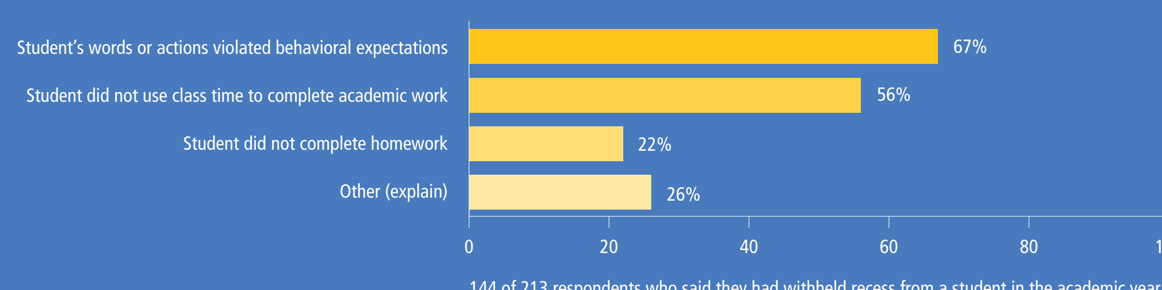


Figure 2: Reasons Teachers Withheld Recess from Individual Students



The benefits of outside play are such that recess ought to be held outside.[3] Since this is their personal time, children ought to be able to choose their recess activity—which may or may not involve moderate to vigorous physical activity. Certainly, recess is an opportunity to promote activity and a healthy lifestyle for children, but it is "particularly unstructured recess [that] provides the creative, social, and emotional benefits of play."[4] Extending the concept that regular breaks augment cognitive processing, and that teaching is a cognitive endeavor, when teachers supervise/monitor recess (without directing activities), teachers also take a break from classroom instruction, even if they are on duty as monitors. We suggest that recess not be used as a way for teachers to engage in much-needed planning time. For planning time to be truly productive, it ought not to be squeezed into breaks, such as 15-minute increments for recess.

Examples of teacher-involved, schoolwide initiatives that support educators in managing classrooms without withholding recess are found in the Positive Behavioral Interventions and Supports (PBIS) program (www.pbis.org/school) and the Let's Inspire Innovation 'N Kids (LiiNK) Project (www.liinkproject.tcu.edu).* In PBIS, the school leadership team, which includes teachers, examines data about discipline, culture, and practices, and decides where change is needed. The team chooses behavioral expectations, frames them with positive language, and creates strategies to support children's development of these behaviors.

In LiiNK schools, there is also a schoolwide adoption of consistent, positive language to communicate behavioral expectations. LiiNK embeds recess four times a day, coupled with a character education curriculum. The character education component teaches and reinforces the noncognitive skills—such as empathy, respect, and self-control—that are critical to the behavioral expectations for a nurturing learning environment.

The value of recess as part of successful schooling is such that it ought to be considered part of every child's learning and development. When done well, recess offers children a chance to interact with peers to practice and develop healthy, lifelong social-emotional skills, such as communicating, negotiating, and sharing.

While recess offers children a break from the structured and teacher-directed portions of the school day, it can also be a useful observation time for teachers. The social dynamics and choices students make moving about autonomously may lead to insights about how to work with certain children. They may even find that fresh air and loud, squealing voices is invigorating. Both teachers and students return to the classroom refreshed and ready for learning.

Recess ought to be considered part of every child's learning and development.

Just as teachers should be invited to contribute to curriculum, textbook, and scheduling decisions, it is imperative that they also be included in initiatives and decisions related to recess. At the school district level, recess is most often one component of the district's wellness policy. Many such policies offer general guidelines but do not translate directly into the classroom; a general statement supporting the right of recess for every child does not offer Mr. Mitchell any concrete support for dealing with Simeon.

Engaging more teachers in crafting those policies will tend to make them more specific and applicable at the classroom level. The more we involve teachers, the more we are likely to identify specific steps that will turn a vision of a healthier school climate into a recipe that works in the classroom, thus ensuring that every child's recess is protected regardless of classroom behavior, and that teachers have supportive leaders, peers, and strategies to carry out such an important policy. ☐

*For more on promising programs that support recess, see "Time to Play" in the Spring 2017 issue of *American Educator*, available at www.aft.org/ae/spring2017/ramstetter_and_murray.

Endnotes

1. Robert Wood Johnson Foundation, "The State of Play: Gallup Survey of Principals on School Recess" (February 2010).

2. American Academy of Pediatrics, "Policy Statement: The Crucial Role of Recess in School," *Pediatrics* 131, no. 1 (2013): 186.

3. Deborah J. Rhea, Alexander P. Rivchun, and Jacqueline Pennings, "The Liink Project: Implementation of a Recess and Character Development Pilot Study with Grades K & 1 Children," *Texas Association for Health, Physical Education, Recreation & Dance Journal* 84, no. 2 (Summer 2016): 14–17, 35; and Michael Yogman et al., "The Power of Play: A Pediatric Role in Enhancing Development in Young Children," *Pediatrics* 142, no. 3 (2018): 3.

4. American Academy of Pediatrics, "Policy Statement," 186.

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Page 37: iStock/tepic.

Modeling Collaboration for Our Children

Although we teach different subjects and grade levels, as educators we all want the same things for our children. We want them to be happy, healthy, and successful. And we want them to be kind and productive members of society.

Research and practical experience have shown us time and time again that the most powerful way to teach the characteristics and behaviors we want to see in children is to *model* them. For those of us who want to do better for our young people, we can make collaboration a habitual part of our workday in our schools.

Harness the Greater Community

If you and your fellow educators face challenges such as bullying, chronic absenteeism, a lack of access to books and supplies, or even a rise in anxiety and other mental health issues among your staff and students, Share My Lesson can help. Teachers and principals cannot and should not solve these problems alone. Check out our collection of resources tailored to paraprofessionals and school-related personnel and share them with your school's support staff members, who help to make schools safe and welcoming places every day.

Community collaboration is the key message in three of our blogs: "Attendance Awareness: How to Defeat an Overlooked Barrier to Equity," "Beyond the School Fundraisers: Finding Meaningful Opportunities for Family and Community Engagement," and "Power in Community and Conversation: One Year after Charlottesville." No matter what your school may be facing, working together shows young people how we can join forces to solve complex problems.

Shine a Light on Well-Being

With anxiety, depression, and other mental health concerns on the rise, educators can respond by reaching out to experienced professionals to help bring well-being back into focus. For more on this topic, check out the new resources in our "Promoting Children's Well-Being" and "Mental Health Awareness" collections.

We have also recently pulled resources together that focus on teacher well-being. If we are not OK, how can we expect our students to be? Be sure to peruse our "Educator Wellness and New Teachers Webinars" collection as well as our blog on maintaining work-life balance.

Additionally, an uptick of conversations on punitive discipline practices, such as out-of-school suspension, has encouraged us to create a collection on restorative practices, which can help schools move toward more effective and equitable ways to foster positive school culture and behavior. For practical solutions to common behavioral challenges, check out these three recent Share My Lesson blogs: "Four Ways to Foster Emotional Intelligence," "Knee-to-Knee Conflict Resolution: Success Starts with Support for Teachers," and "Conformity, Identity, and Rebellion: A Thematic Approach to SEL."

Explicitly Teach Our Values

In response to unwanted behaviors, school climate researcher Sameer Hinduja suggests that we tell our students, "We don't act that way because we are Seahawks" (or Mustangs, or whatever your school mascot may be). His research demonstrates the incredible correlation between school culture and academic success.

Students cannot learn when they feel threatened, invisible, or disrespected. One of our new partners, Ashoka, offers several resources to teach empathy and other social skills. Another partner, the Middle School Kindness Challenge, offers a way to infuse research-based social-emotional learning into the rituals of school life.

It may feel cliché to say, "Be the change you wish to see in the world." But if we want to change the national conversation, we must start with showing our young people how to work together. It is essential not just for their health and development but for our own.

Let us know what lesson plans or tools are missing from the list below and how we can continue to support you by emailing us at content@sharemylesson.com.

–THE SHARE MY LESSON TEAM


ISTOCK/ASISEEIT

Recommended Resources

Paraprofessionals and School-Related Personnel
http://go.aft.org/ae418sml1

Attendance Awareness
http://go.aft.org/ae418sml2

Beyond the School Fundraisers
http://go.aft.org/ae418sml3

Power in Community and Conversation
http://go.aft.org/ae418sml4

Promoting Children's Well-Being
http://go.aft.org/ae418sml5

Mental Health Awareness
http://go.aft.org/ae418sml6

Educator Wellness and New Teachers Webinars
http://go.aft.org/ae418sml7

Be Proactive: Maintain Your Work-Life Balance
http://go.aft.org/ae418sml8

Restorative Practices
http://go.aft.org/ae418sml9

Four Ways to Foster Emotional Intelligence
http://go.aft.org/ae418sml10

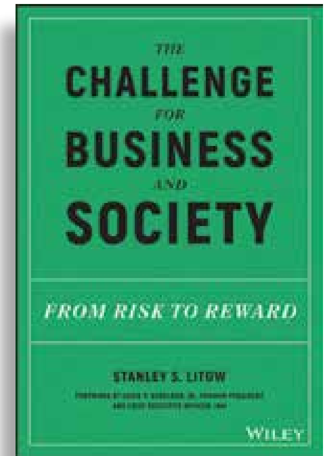
Knee-to-Knee Conflict Resolution
http://go.aft.org/ae418sml11

Conformity, Identity, and Rebellion: A Thematic Approach to SEL
http://go.aft.org/ae418sml12

Ashoka
http://go.aft.org/ae418sml13

Middle School Kindness Challenge
http://go.aft.org/ae418sml14

THE CHALLENGE FOR BUSINESS AND SOCIETY: FROM RISK TO REWARD



For those frustrated by the undue influence of big business on public education, Stanley S. Litow offers a simple message: it doesn't have to be this way. Corporations can strategically partner with schools to support both the public good and their bottom line. In his book *The Challenge for Business and Society: From Risk to Reward* (Wiley), the former IBM executive devotes several pages to what he learned leading that company's effort to contribute to high school education reform in New York City.

As the head of IBM's corporate citizenship programs and the IBM Foundation, Litow oversaw the creation of P-TECH (Pathways in Technology Early College High School). The school, which opened in 2011, was established in Brooklyn thanks to a partnership between IBM, the City University of New York, and the New York City Department of Education. The United Federation of Teachers and the American Federation of Teachers also played a pivotal role in its creation.

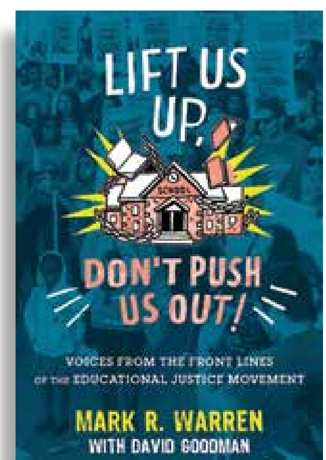
The school is home to a six-year program that prepares students, most of whom come from low-income families, for careers in information technology by enabling them to take college courses for free as soon as they are ready. Students also participate in paid internships with IBM and work closely with company mentors. Those who earn their associate's degree are guaranteed a job interview with the multinational corporation. P-TECH also prepares students to pursue bachelor's degrees at a four-year university, if they choose to do so.

Since its inception, the school has set student attendance and achievement records and has inspired the creation of similar schools in Chicago; Newburgh, New York; and Norwalk, Connecticut. What sets this college-to-career effort apart is "a comprehensive academic program that engages educators along with strong private-sector engagement and support," Litow writes.

But P-TECH is not the only innovation that IBM has pioneered with educator input. In 2017, the company launched Teacher Advisor with Watson. The free resource provides teachers access to high-quality lesson plans and instructional videos; its purpose was to serve as a teacher's very own personal coach. Early on, IBM executives realized that Watson "would need to be nonjudgmental," Litow writes. "Nor would it be used to evaluate teacher performance."

For educators, such words from a corporate executive are reassuring and telling. They mark a stark departure from past business-inspired education reforms, notorious for their obsession with test scores and accountability.

LIFT US UP, DON'T PUSH US OUT!: VOICES FROM THE FRONT LINES OF THE EDUCATIONAL JUSTICE MOVEMENT



In Boston, Chicago, and Los Angeles, and in other cities small, big, and somewhere in between, grass-roots organizations, community groups, and teachers unions are banding together to empower low-income communities of color. They are finding common ground over issues such as community schools, affordable housing, immigrants' rights, and safe and welcoming schools.

Lift Us Up, Don't Push Us Out!: Voices from the Front Lines of the Educational Justice Movement (Beacon Press) tells their story. Edited by Mark R. Warren, a professor of public policy and public affairs at the University of Massachusetts Boston, with David Goodman, an independent journalist, the book is a compelling collection of essays from activists, scholars, and organizers nationwide. Authors share how they have engaged parents and students in a range of actions, including disrupting the school-to-prison pipeline, supporting LGBTQ youth, and fighting back against the mass closing of neighborhood public schools.

This last issue strikes at the very heart of educational justice in Chicago Public Schools. In fact, two chapters of *Lift Us Up* focus on that district alone. Born and raised on Chicago's South Side, Jitu Brown, the national director for the Journey for Justice Alliance, tells how, in 2015, a group of committed parents led a 34-day hunger strike to save Walter Dyett High School. After building alliances with organizations such as the American Federation of Teachers, the Alliance to Reclaim Our Schools, and the Advancement Project, the strike made national news. Ultimately, the district agreed to keep the school open. Today, it serves the neighborhood, and Brown writes that "nearly all freshmen are on track to graduate."

Building on this chapter is one written by Brandon Johnson, an organizer for the Chicago Teachers Union (CTU) and a former middle school teacher. Johnson shares how CTU transformed "from a traditional 'wages and hours' union to a social justice union working with families and communities of color for racial equity and justice." He also recounts the union's 2012 strike, led by then president Karen Lewis. The strike succeeded in stopping merit pay, protecting benefits and retirement security, and pushing the expansion of student access to art, music, and physical education.

But "the larger success," as Johnson describes it, "was to bring community and labor together to fight for public schools and the rights of workers." It's the kind of success that *Lift Us Up* can hopefully inspire elsewhere.

Reading to Learn

(Continued from page 8)

Educational Review 84 (2014): 74–84; Kristan A. Morrison, Holly H. Robbins, and Dana Gregory Rose, "Operationalizing Culturally Relevant Pedagogy: A Synthesis of Classroom-Based Research," *Equity & Excellence in Education* 41 (2008): 433–452; and Mariana Souto-Manning, *Multicultural Teaching in the Early Childhood Classroom: Strategies, Tools, and Approaches, Preschool–2nd Grade* (New York: Teachers College Press, 2013).

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Increasing Science Literacy

(Continued from page 21)

If you are already incorporating media into your classroom in beneficial ways, you can help parents do the same at home. One of the many benefits of media is its accessibility. Most families today have access to media via their smartphones, tablets, and computers. If you are using certain content in your classroom that's also accessible at home, let parents know about it and how to get it. With so many media-based resources available, parents may really appreciate this guidance to support and extend their children's learning.

By working together, early childhood educators and parents can foster a love of science—and a love of learning—in their children. After all, both sets of adults have significant roles to play in creating a world in which children understand that inquiring about the natural world and investigating their surroundings is not only a commonplace experience but a respected and rewarding one too. ☐

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