

Preschool
Curriculum:
What's In It
for Children
and Teachers



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Preschool Curriculum: What's In It for Children and Teachers



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Advances in cognitive science make it clear that very young children are capable of much more academically than was previously imagined.

1. INTRODUCTION

Much of the research on young children's learning investigates cognitive development in language, mathematics, and science. Because these appear to be "privileged domains"—that is, domains in which children have a natural proclivity to learn, experiment, and explore—they allow for nurturing and extending the boundaries of the learning in which children are already actively engaged....

What should be learned in the preschool curriculum? In addressing this question, [we]... focused largely on reading, mathematics, and science because a rich research base has provided insights in these domains suggesting that more can be learned in the preschool years than was previously understood.

Eager to Learn: Educating Our Preschoolers
NATIONAL RESEARCH COUNCIL

IT HAS BEEN WELL ESTABLISHED that early childhood is a crucial time for children's cognitive development.² Less understood is that very young children are ready—and excited—to develop skill and understanding in language and literacy, mathematics, and science. Indeed, pre-kindergarten (pre-K) learning experiences in these domains can help to build the skills, knowledge, and attitudes that prepare young children for future academic success.

In the early childhood years, children are eager to understand more about the world. Young children actively strive to build knowledge and to develop language to communicate about what they learn. They develop theories about how the world works; they learn to solve problems; and they ask questions in a constant quest for information. And, when provided with supportive and stimulating environments, they eagerly engage in language learning, literacy practices, math play, and science exploration.³

The knowledge that children gain in early childhood is crucially important for their futures, with a quality pre-K experience helping to lay the foundation for the kinds of skills, knowledge, and behaviors that children will be expected to master during school. This is particularly true for children growing up in poverty—many of whom lag far behind their middle-class peers in key academic areas by the time they enter kindergarten.⁴ Indeed, the reading, math, and attention skills that children bring to school have been found to be a strong predictor of their later academic success.⁵ Without intervention, these early disparities tend to be sustained or even widen over time. (This is because most students learn at fairly equal rates when they are in school and wealthier students are likely to have more opportunities for out-of-school learning.⁶) To close or significantly nar-

row these achievement gaps, policymakers must either figure out how to drastically increase the rate of learning for poor schoolchildren to surpass that which is typical for any student, or—more practically—figure out how to help prevent this gap from opening in the first place. High-quality pre-kindergarten programs are one promising avenue for reaching this goal.⁷

Why this Publication?

Many states have implemented or are moving toward voluntary universal pre-K, including 38 states that now have state-financed preschool programs for 3- and 4-year-olds.⁸ These policies are in part motivated by the needs of working families and in part by compelling research suggesting that strong pre-K programs can help to ameliorate academic discrepancies at the start of elementary school.

A recent survey, for example, found that 43 states and the District of Columbia have adopted early learning standards aligned with state academic standards for the elementary grades, with several more in the process of developing them.⁹ These documents are of varying levels of quality, including some that are academically vacuous and some that appear to require the inappropriate "pushing down" of elementary school experiences into the pre-K

years.¹⁰ Advances in cognitive science make it clear that very young children are capable of much more academically than was previously imagined. It is also clear that high-quality, age-appropriate, academically rich pre-K experiences are often unavailable to poor and minority children—the very children who are likely to gain the most benefit from them.¹¹

What does high-quality pre-K look like? There is now a wealth of research—from fields as diverse as education, cognitive psychology, neuroscience, and sociology—to suggest what a quality preschool education should be. According to the research literature, quality indicators include easy to measure “structural” factors—such as child-to-teacher ratios and teachers’ education levels.¹² In terms of cognitive growth, however, “process” factors—the daily human interactions and activities that have the potential to enhance children’s cognitive, physical, and social-emotional development—appear to be more central. Of particular importance is the quality of instruction, which appears to have a vital, lasting effect on building children’s cognitive and social skills through the elementary school years.¹³

In terms of *what* is taught, we know that children in pre-K classrooms that spend time on the key academic content areas, such as literacy, language, and mathematics, have an academic advantage as they enter early elementary school.¹⁴ The field has also benefited from several impressive research reviews that offer important guidance—from the National Research Council, the National Institute for Early Education Research, the National Association for the Education of Young Children, and content area groups, such as the International Reading Association, the Center for the Improvement of Early Reading Achievement, and the National Council of Teachers of Mathematics, among others. As a source of concrete advice for the improvement of practice, however, much that has been written seems either too academic or too narrowly focused to be of practical use to pre-K educators. Thus, we have endeavored to produce an accessible overview of research findings on young children’s cognitive development, including a discussion of the implications for the improvement of preschool curricula.¹⁵

The central thesis of this work is that the effectiveness of today’s preschool programs could be significantly improved

if they were aligned with what we now know about how children learn in the academic disciplines of language, literacy, mathematics, and science. This is not to say that we believe that these subjects should be the exclusive focus of a quality pre-K curriculum. History and the social sciences, music, arts and crafts, movement, and foreign languages—all have a place in a rich, well-rounded curriculum. The featured subjects, however, appear to be “privileged domains”—that is, areas in which children may be predisposed to learn. As such, there is a wealth of research about these subjects to help guide the improvement of pre-K curricula.

Much is also known about effective methods for teaching this content to very young children. Not surprisingly, these approaches differ substantially from the teaching methods commonly used with older children. In pre-K, children should be taught foundational knowledge through developmentally appropriate instructional techniques, such as read alouds, discussions, songs, games, projects, and other active learning opportunities.¹⁶

Both free play and “structured” play (where teachers purposefully design play experiences to support specific learning goals) are particularly important for this age group.¹⁷ During play, children learn by exploring and manipulating materials; they learn to imagine themselves in new situations, role play, take turns, and set and follow rules; they practice oral language as they communicate with peers; and they remember, incorporate, and rehearse new knowledge and skills.

The four chapters that follow address the “privileged” content areas—oral language and pre-literacy (split into two chapters), mathematics, and science—including background information drawn from the research literature. Each indicates appropriate accomplishments for pre-K children; effective instructional practices; key components of a strong curriculum; suggestions for working with English language learners; and additional resources for the content area addressed. We hope that they offer useful guidance to practitioners and policymakers as they strive to improve preschool quality, generally, and the quality of the preschool experiences offered to poor children, in particular.

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2. ORAL LANGUAGE

The most important aspect to evaluate in childcare settings for very young children is the amount of talk actually going on, moment by moment, between children and their caregivers.

Meaningful Differences¹
BETTY HART AND TODD RISLEY



ORAL LANGUAGE IS ARGUABLY the most crucial area of academic focus during the pre-kindergarten years. Oral language is the primary means by which children gain knowledge about the world, and it is the vital foundation for children's literacy development.

By the time children arrive in kindergarten, most will know an average of 3000 to 5000 words.² They will also speak in grammatically complex sentences made up of three or more words. This language skill develops over the first five years of life through interactions with parents and teachers who model spoken language. Toddlers first use language to label objects and communicate basic needs, but their knowledge of vocabulary and grammar also grows rapidly during early childhood. Listening and speaking are the primary ways that pre-K children learn new concepts and ideas, and express their thoughts, observations, and feelings.

In pre-K, children must develop as listeners and speakers. **Receptive** (listening) language grows as children are exposed to completely new words or to words they already know that are used in new and different ways. Pre-K children can learn some word meanings after only one or two exposures if the word is paired with a concrete object, an action, or a brief explanation. This type of word learning, called **fast-mapping**, explains young children's rapid acquisition of vocabulary when they are in language-rich environments.³ Children gain a more nuanced understanding of vocabulary with each exposure. They may need to hear a new word several times before fully incorporating it into their receptive vocabulary, and probably many times more before using it in their **expressive** (speaking) language.

Two key areas of oral language that should be addressed in pre-K are **vocabulary** and **phonological awareness**. Both

relate to children's literacy development. Phonological awareness is the ability to hear and manipulate sounds in language. This understanding that the stream of oral language can be broken into smaller units of sound—words, syllables, individual sounds (phonemes)—enables children to map sounds onto letters when they begin formal instruction in reading.⁴

Vocabulary size in pre-K can predict children's ability to comprehend texts throughout elementary school and into middle school.⁵ This is because children generally learn words in relation to the specific meanings—objects, concepts, relationships, actions, emotions—they are meant to convey. Children will not understand the words they encounter in text or the meaning conveyed by them unless these words are already part of their receptive vocabularies. As a result, children with large vocabularies and a relatively broad range of knowledge are in a better position to comprehend, learn from, and enjoy the books they read, contributing to successful learning experiences.

By the time children arrive in pre-K, there are vast differences in their oral language skills. One study found that by age 3, children who grew up in poverty had been exposed to half as many words as their middle-class peers. This vocabulary gap remained five years later when the children were 9 years old.⁶ Limited oral language puts children growing up in poverty at a disadvantage when learning to read and comprehend texts. The relationship between pre-K oral language and children's literacy development, as well as the social class differences in oral

Oral Language Accomplishments for Pre-K⁷

Listening

- Understand and follow one- and two-step oral directions.
- Pay attention to sounds in language (e.g., recognize rhymes, hear alliteration, clap syllables).
- Listen for a variety of purposes (e.g., for enjoyment, to gain and share information, to perform a task, to learn what happened in a story, to converse with an adult or peer).
- Enjoy listening to and discussing storybooks; demonstrate comprehension by asking questions and making comments.
- Understand the overall sequence of events in stories.

Speaking

- Speak in complete sentences made up of three or more words.
- Speak clearly enough to be understood by unfamiliar adults and use appropriate levels of volume, tone, and inflection.
- Participate in extended conversations and use appropriate conversational techniques (e.g., taking turns speaking, listening actively, contributing ideas).
- Use new vocabulary and grammatical construction appropriately in his/her own speech.
- Use spoken language to communicate thoughts, feelings, and needs; to describe experiences and observations; to express opinions and ideas.
- Tell stories.
- Repeat or act out familiar stories, songs, rhymes, and finger and counting games (fingerplays) in play activities.

language that are already visible at the beginning of pre-K, make it imperative for pre-K teachers to emphasize instruction in oral language in their classrooms.

Which Instructional Practices Support Children's Language Learning?

A Language-Rich Classroom

Language learning builds on itself. When children are exposed to adults who talk with them regularly about a broad variety of subjects, they become better at speaking and comprehending. Children gain the words they need to represent and communicate their growing knowledge about the world, and they apply what they know to learning even more new words and concepts.

The quantity and quality of these language interactions with adults and other children matter for children's oral language development. Unfortunately, talk is often lacking in pre-K classrooms. A recent study found that children spent almost 60 percent of their time in pre-K not in conversation at all.⁸ These conditions are severely detrimental for children's language and literacy development—especially for those children who are unlikely to be exposed to a language-rich learning environment outside of school. Teachers should make every effort to ensure that children are engaging in meaningful conversations and language use throughout the day.

To create a language-rich classroom, pre-K teachers should:⁹

- Engage children in extended conversations.
- Encourage children to tell and retell stories and describe events.
- Discuss a wide range of topics.
- Model use of new and unusual words.
- Discuss word meanings.
- Ask open-ended questions.
- Give explicit guidance on vocabulary, syntax, and pronunciation.
- Challenge children to justify their thinking.
- Focus on the expression of ideas.

Shared Reading of Challenging Books

Reading aloud to children is one of the best ways to facilitate oral language and vocabulary development. Children need to be exposed to a broad selection of texts, but they also need to experience repeated readings of books so that they have multiple opportunities to learn new language. Thematic units, where several books on the same topic or theme are read aloud over time, can also help deepen and broaden children's understanding of new words and concepts—allowing them to “get” the ideas and vocabulary in slightly different contexts.

Books expose children to several types of language that are foundational for academic success:

Decontextualized language—language that must be especially precise because the reader does not have the advantage of being in the same physical location as the author.

Sophisticated vocabulary and new concepts—interesting new words and ideas. Informational or nonfiction picture books are often underutilized in pre-K classrooms, but they are very useful for introducing interesting new information, ideas, and language to children.

Book language—language that is specific to written text, including phrases such as *happily every after* or *said the boy* that are not used in everyday speech. Children need a firm grasp of this language in order to comprehend storybooks.

Dialogic Reading

An important part of shared reading is discussion surrounding books, because language interactions facilitate children's oral language development. One well-researched technique for encouraging children's comprehension and expressive language during read-alouds is Dialogic Reading.¹⁰ Teachers use the acronym CROWD to remember five types of prompts that engage children in conversations about books:

Completion questions to focus children on the structure of language used in the book (i.e., "*Brown Bear, Brown Bear, What do you see? I see a red bird looking at ____.*"¹¹).

Recall questions to check children's understanding of the content of the story.

Open-ended questions to engage children in extended talk about the book.

W questions—who, what, when, where, why—to teach vocabulary.

Distancing or bridging prompts to help children relate ideas in the book to life experiences beyond the story.

Phonological Awareness Activities

Children develop phonological awareness as they learn new vocabulary and differentiate between words that sound similar, such as *cat* and *cot*.¹² In addition to introducing new vocabulary, pre-K teachers should provide intentional instruction in phonological awareness activities by reading books to children that focus on rhyming and

High-Quality Preschool

High-quality preschool programs can boost language and literacy skills and, ultimately, reading achievement. But quality is essential, and many preschools fall short in promoting language and literacy.

In a high-quality preschool, the teacher should provide a good model of verbal language throughout the day. For example, when a child points a finger and says "Dat," the teacher has a number of good choices. She could expand for him and say, "You want the red ball?" or she could say, gently, "Tell me what you want," or "Tell me what you want in words." Some teachers say, "Use your words," but accept the closest approximation that they think the child can produce. She should also have informal conversations with each child every day, encouraging them to use language by asking open-ended questions, such as why, how, and what-if.

Preschools should help children to learn, think, and talk about new domains of knowledge. They do this by providing opportunities for children to use language in a variety of ways, by ensuring lots of interesting conversations in which children are involved, by offering opportunity to play with language in ways that support phonological awareness and by incorporating meaningful uses of literacy into everyday activities. Children who have a wide body of background knowledge and life experiences are more likely to succeed in reading. They are more likely to relate to stories, recognize words in them, and to understand events described in books.

Starting Out Right: A Guide to Promoting Children's Reading Success (1999).

National Research Council, M. Susan Burns, Peg Griffin, and Catherine E. Snow (Editors). Washington, D.C.: National Academies Press.

alliteration, singing songs, chanting nursery rhymes, and using musical instruments to clap out words and syllables.

Types of phonological awareness for pre-K children include:

Rhyming—the ability to notice that two or more words have endings that sound the same (also called *rimes* or *word families*).

Alliteration—the ability to notice that two or more words begin with the same sound (also called *onsets*).

Sentence segmenting—the ability to sense individual words in the stream of spoken language.

Syllable blending and segmenting—the ability to hear the separate syllables in a word, and to put syllables together orally to make a word or break a word into separate syllables.

When engaging in phonological awareness activities, teachers should be aware that dialect differences may have an impact on children's perception of the phonology of language.

High-Quality Oral Language Curricula

An oral language curriculum can support teaching and learning in the Pre-K classroom. The following aspects are particularly important in high-quality oral language curricula:

Integrated Language Learning

Children learn language when it is presented in meaningful contexts. Researchers suggest that teachers should engage children in oral language learning through knowledge-building units of study in math, science, literacy, social studies, and the arts.¹³ A strong curriculum teaches vocabulary during studies of interesting content. This strategy provides repeated exposure to new words and teaches children the words they need to represent the new ideas and concepts that they are learning.

Explicit Instruction

Curricula should actively address oral language. It is not enough to provide children with incidental exposure to words. Instead, the curriculum should include opportunities for active language instruction, including challenging read

alouds as well as daily discussions of books, new concepts, and new vocabulary. The curriculum should also include phonological awareness books, games, and songs.

Opportunities for Play

One way that children practice oral language is through their play. A strong curriculum provides time and opportunities for free and structured play. Children are introduced to new vocabulary for a particular theme or topic during shared book-reading and discussions, but they practice new words as they engage in active play. For example, pre-K children learning about wild animals will use sophisticated words such as *ferocious* and *jungle* as they play with plastic animals in the classroom or as they pretend to be wild animals on the playground.

Conclusion

Oral language is the foundation for children's learning, and the pre-K years are a crucial time for language development. Vocabulary and phonological awareness are particularly important areas to address because they directly relate to learn-

English Language Learners

The transition to a pre-K classroom where English is the primary language can be challenging for English Language Learners (ELLs) and their teachers. Unfortunately, the research in this area is not as definitive as that for the oral language development of native English speakers, but there is enough to suggest what good practice might be. For example, research suggests that teachers should encourage parents to continue to speak with and read stories to children in their first language at home. Continued growth in the first language seems to facilitate children's understanding about the way language works and may help to speed acquisition of new concepts and vocabulary.¹⁴ Children with strong first language skills apply this knowledge to learning English.

ELLs go through several stages of language development when they attend a pre-K where English is the primary language. One way these have been categorized is:¹⁵

Home language use—Children continue to use their home language because they have not yet realized that others do not speak their language.

Nonverbal period in the new language—Children learn by watching and listening to the English speakers

in the classroom. They may use nonverbal communication such as pointing, miming, crying, or whimpering.

Telegraphic and formulaic language—Children begin to name objects and people or use a few key phrases that they have memorized to deal with many social situations.

Productive use of new language—Children begin to combine phrases they have learned and names of objects to make new sentences. Children will make lots of mistakes at this age as they experiment with communicating in English.

Children move through these stages at different rates. At all stages, pre-K teachers should interact with children as much as possible. Teachers support children's learning of English when they:¹⁶

- Demonstrate using multimedia—videos, pictures, concrete objects.
- Use gestures and body language.
- Speak slowly and enunciate clearly, without speaking more loudly than normal.
- Repeat information, and review and rephrase if the child does not understand.
- Anticipate words that will be difficult and provide explanations.
- Encourage peer interactions through play and small group activities.
- Are encouraging and patient.

ing to read. Pre-K teachers can promote oral language skills by creating a language-rich environment, reading aloud, discussing books, and engaging in phonological awareness games and activities. A strong curriculum should integrate language learning into knowledge-building activities.

Suggested Reading

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Useful websites:

<http://ies.ed.gov/ncee/wwc/>—What Works Clearinghouse: Provides information on which instructional techniques and curricula are effective.

<http://nieer.org/standards/>—National Institute for Early Education Research State Standards Database: Lists language and literacy content standards by state.

<http://www.aft.org/earlychildhood/>—American Federation of Teachers Early Childhood Educators Page: Provides links to information and resources of use to early childhood educators and child care providers.

<http://www.colorincolorado.org/>—Colorín Colorado: An online service which provides information, activities, advice and resources for educators and families of Spanish-speaking English language learners.

<http://www.naeyc.org/>—National Association for the Education of Young Children: Provides journal, magazine and position statements related to early childhood education.

<http://www.reading.org/>—International Reading Association: Provides magazines, journals and links related to language and literacy.

¹ Hart, B. and Risley, T. *Meaningful Differences*. Baltimore: Paul H. Brookes Publishing, 1998 (preface to 2002 edition quoted here).

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3. LITERACY

Literacy learning begins early in life and is ongoing. It does not wait for kindergarten or first grade. Starting from infancy, the informal and playful things that adults do to promote children's language and literacy really count.

"Literacies in Early Childhood:
The Interface of Policy, Research, and Practice"¹
DOROTHY S. STRICKLAND



THE PRE-K YEARS are an important time for children's literacy growth. Children who are engaged in meaningful, knowledge-building experiences with print gain the foundational skills for becoming skilled readers and writers.

Literacy development begins at birth and is encouraged through children's participation with adults in literacy activities. Early experiences have lasting effects as children develop the attitudes, knowledge and skills that prepare them to become readers and writers.² Most importantly, children should develop the belief that reading and writing are useful and enjoyable. Pre-K children demonstrate this positive attitude when they ask adults to reread favorite books and when they imitate adult reading and writing behaviors.

In addition to motivation, children need a solid oral language foundation and an understanding of the alphabetic code (including phonological awareness and alphabet knowledge), as well as print awareness. Children must develop a rich vocabulary and a variety of background knowledge to

help them comprehend books.³ They must learn how to hear and manipulate the sounds in oral language (phonological awareness) and to name and recognize letters of the alphabet. Eventually, children must put it all together by matching sounds with letters of the alphabet. Also, children should gain an understanding of the conventions of print, such as how to turn pages and which direction to read.

There are vast differences in children's early literacy experiences. Children who grow up in poverty have fewer experiences with print in their homes, as well as fewer available print resources in their neighborhoods.⁴ One estimate suggests that children from typical middle-class families experience 1,000 hours of book-reading before entering first grade, while children from low-income families may only experience 25 hours.⁵

Literacy Accomplishments for Pre-K⁶

- Enjoy listening to and discussing storybooks.
- Develop new background knowledge and vocabulary.
- Understand that print carries a message.
- Engage in reading and writing attempts.
- Hear and manipulate sounds in language (recognize rhymes, alliteration, syllables, and individual phonemes).
- Identify letters of the alphabet and make letter-sound matches.
- Identify labels and signs in the environment and know some familiar words in print, such as own first name.
- Use known letters or approximations of letters to represent written language.
- Use knowledge of letters to write or copy familiar words, such as his/her own name.

Clearly, children arrive at pre-K with a range of background literacy experiences, but effective teachers can provide rich language and literacy instruction for all children. Pre-K teachers must provide intentional instruction in key areas of early childhood literacy. When early literacy experiences are integrated with engaging opportunities to discover new information about the world, all children develop towards becoming readers and writers.

Children learn about literacy as they make use of reading and writing to further their investigation of interesting new concepts and information. Rather than a set of isolated skills, teachers should integrate literacy instruction into all subject areas in the pre-K classroom, including math, science, social studies, and the arts.⁷ In this way, children gain foundational knowledge, vocabulary, and print skills to prepare them to read and comprehend text. For example, in a classroom where children are learning about insects, teachers can:

- Read informational books and storybooks about insects to develop background knowledge and relevant vocabulary, as well as comprehension and book-use skills.
- Engage children in songs and chants about insects to develop phonological awareness while reinforcing content knowledge.
- Encourage children to draw and “write” about insects that they find outdoors or that they investigate in the science center. As children attempt to write, they practice their letter/sound knowledge and develop an understanding of the connection between oral language and print.

Embedding literacy learning within knowledge-building activities is engaging for pre-K children, and it teaches that reading and writing are meaningful and purposeful activities.

The Alphabetic Principle—Connecting Phonemic Awareness and Letter Knowledge

In order to learn to read, children must understand that there is a relationship between the sounds in oral language and the letters of the alphabet. This fundamental understanding of the connection between sounds and letters is called the **alphabetic principle**. Children who arrive at kindergarten knowing letter names and sound-letter matches are on their way to learning to decode (sound out) and spell words.⁸

Pre-K teachers can help children gain an understanding of the alphabetic principle through **phonological awareness**

songs and games as well as alphabet activities. Phonological awareness activities include rhyming, singing, and chanting to help children hear the sounds in oral language, with the ultimate goal of helping children to develop **phonemic awareness**, the ability to hear individual phonemes (the smallest sounds in language that can be represented by letters). Children learn to hear phonemes when teachers say words

slowly, stretching out the word, so that children learn to isolate each sound.

In conjunction with developing phonemic awareness, teachers can help children learn about the alphabet by providing opportunities to practice recognizing, naming, and producing letters. Teachers can systematically introduce children to the letters of the alphabet and their sounds. In addition, pre-K children can learn about letters through a variety of multi-sensory activities including play with alphabet manipulatives (e.g., puzzles and magnetic letters) and the opportunity

to form letters and write their names using a variety of materials (e.g., with play dough, fingerpaint, stencils, letter stamps). Teachers can help children to make connections between sounds and letters by reading alphabet books and, most importantly, by modeling and encouraging developmental writing and phonetic (invented) spelling.

Developmental Writing

Developmental writing engages children in actively making the connection between print and oral language. Children who understand that writing is used to communicate ideas and information are interested in attempting to write. At first, children draw pictures to express their ideas on paper, but as they learn the differences between print and illustrations, their writing attempts look more like symbols. As children learn to write their own names, they develop an understanding that writing is made up of letters of the alphabet, and they begin to incorporate letters into their writing attempts. Over time, children learn to use letters to represent specific sounds in words (e.g., writing *home* as *h* or *hm*). This phonetic (invented) spelling encourages children to connect their phonemic awareness (ability to hear sounds in words) and their alphabet knowledge.

Teachers encourage children’s developmental writing when they:

- Write and read back children’s dictated words, pointing to each word as it is read aloud.
- Model phonetic (invented) spelling during shared writ-

Phonological awareness: The understanding that the stream of oral language can be broken into smaller units of sound—words, syllables, individual sounds (phonemes).

Phonemic awareness: The understanding that words can be broken into sounds (phonemes). Phonemic awareness is the type of phonological awareness that is most related to reading and writing.

Alphabetic principle: The understanding that there is a systematic relationship between letters and sounds. For example, the word *cat* has three sounds and is written with three corresponding letters.

ing experiences (e.g., morning message or a thank-you note). Teachers say the word slowly, exaggerating key sounds and then match letters to each sound.

- Create a writing center with a variety of papers and writing tools, and include writing materials in play areas throughout the classroom.
- Encourage children to draw a picture and then to write words about their picture. The picture helps children focus on what to write.
- Accept and encourage all writing attempts.
- Ask children to “read” their story when they are finished. Write children’s words on the bottom or back of the page and read the story back to the child to reinforce the connection between oral and written language.

Formal handwriting practice and a focus on correct spelling are not useful instructional techniques for pre-K children.

Shared Reading

Reading aloud to children, also called shared reading, is an important way for children to learn about literacy. Shared reading shows children that print carries a message, and repeated readings of familiar books help children to learn that this message is consistent and unchanging over time. Children learn that reading is valuable and enjoyable as they listen to and discuss books. Teachers must schedule times to read to children individually and in small groups, as young children are better at focusing and engaging in discussion in

these smaller situations.

Exposure to a variety of books also enables children to develop their vocabulary and background knowledge, which helps them to comprehend more and more complex books. Teachers should purposefully expose children to challenging books that contain engaging subject matter and sophisticated vocabulary. Reading a variety of books on a similar topic helps to deepen children’s understanding by reinforcing new vocabulary words and key concepts.

Children gain specific knowledge from different genres of books. Teachers should tailor instruction to the type of book being read.

Children also learn about print by watching adults model its use. As teachers read aloud, they can help children to understand how text works by intentionally demonstrating concepts of print. These demonstrations work best when teachers read from a big book or lap book with simple print that is large enough for children to see. The book is faced toward the children so that they can observe the print as the teacher reads and “thinks aloud” to explain how print works.

Children should learn:

- How to hold a book correctly.
- Where to find the title and author of a book.
- Where to begin reading.
- How to turn pages correctly.
- Directionality (a line of text is read from left to right, then down to the left of the line below).

Type of Book	Instructional Strategy
Storybooks	<ul style="list-style-type: none"> ■ Explain new and sophisticated vocabulary. ■ Engage children in discussions about narrative structure (e.g., characters, setting, conflict or problem, resolution). ■ Help children to see connections between their own lives and characters in the book. ■ Ask children to make predictions about what will happen next based on illustrations and storyline. ■ Encourage children to retell the story.
Information Books	<ul style="list-style-type: none"> ■ Introduce and explain new vocabulary related to the topic. ■ Discuss new concepts and ideas. ■ Model “looking up” the answer to children’s questions.
Alphabet Books	<ul style="list-style-type: none"> ■ Encourage children to name the next letter. ■ Make connections between letters and sounds. ■ Discuss words and pictures that start with a particular letter/sound.
Rhyming Books	<ul style="list-style-type: none"> ■ Read rapidly so children hear the pattern. ■ Encourage children to listen for rhyming sounds. ■ Pause and let children fill in the rhyming word.

- The different purposes of text and illustrations.
- The visual difference between a single letter, word, and a sentence.
- That there are spaces between words.
- One-to-one correspondence (each word said aloud is represented by one printed word on the page).

A Print-Rich Environment

When classroom environments include appropriate literacy materials organized in an accessible manner, children engage in many literacy behaviors and use complex language.⁹ Children learn that print appears in different forms (e.g., books, letters, labels) and that print is used for a variety of purposes (e.g., to inform, to tell a story). They become able to identify the familiar labels and signs in their classroom environment. The experience of being surrounded by print leads children to understand that print carries meaning and that it is practically useful. In print-rich classrooms, children demonstrate this understanding by attempting to read and write during their play. These “pretend” efforts should be encouraged, as they demonstrate children’s interest in and engagement with print.

A literacy-rich environment includes:¹⁰

- A dedicated reading area or library with books stored in an orderly and inviting way.
- Books in a variety of genres and formats (e.g., fiction, non-fiction, alphabet books, big books).
- Books related to curriculum themes or topics that children are studying.
- A dedicated writing area that includes a variety of papers and writing tools.
- Books and writing materials throughout the classroom (e.g., science books in the science area, paper and crayons in the dramatic play area).
- The alphabet displayed and visible at children’s eye view, with children having access to alphabet toys and manipulatives (e.g., alphabet puzzles, magnetic letters).
- Functional signs that are visible around the classroom (e.g., the class schedule, labels for toy storage, names on cubbies).

- Children’s drawing and writing attempts displayed around the room as well as products from group writing experiences (e.g., charts, homemade books).

High-Quality Literacy Curricula

A useful curriculum should support literacy teaching and learning in the Pre-K classroom. In addition to the curriculum features mentioned in the previous chapter (see *Oral Language*), the following aspects are particularly important in high-quality literacy curricula.

An Integrated Curriculum

In the pre-K years, literacy instruction should be integrated into knowledge-building experiences.¹¹ Children of this age learn best when their literacy experiences are tied to interesting and engaging study of topics in math, science, social studies, and the arts. Curricula should provide opportunities to learn about print while children are engaged in learning new concepts and information.

Developmentally Appropriate Literacy Practices

Curricula that focus on drilling children in isolated skills are not suitable or effective for pre-K children—but curricula that sideline literacy experiences until elementary school are also inappropriate, because they limit children’s opportunities to develop key foundational understandings.

Instead, developmentally appropriate curricula build on children’s prior learning to provide meaningful, engaging, and knowledge-building experiences with print.¹² That is, a useful curriculum will help teachers structure children’s learning of the alphabet, the conventions of print, a broad vocabulary, and all of the other elements addressed in these pages in an age-appropriate fashion.

Scope and Sequence

A scope and sequence provides teachers with information about which areas are covered and in what order instruction should occur. Instruction should build from the simple to the more challenging over the school year (e.g., phonological awareness activities may start with rhyme, then move to

English Language Learners

Small or whole group opportunities to sing, chant or “read” along as an adult reads a familiar book can be particularly helpful for English Language Learners. These situations are fun-filled and non-threatening, as ELL children can choose to practice English language as part of the group. Rereading big books or rhyming books until children have memorized the words helps ELL students to become active participants in classroom literacy experiences.

Children learn best in welcoming and accepting environments. Teachers should ensure that the classroom library contains books that positively reflect all children’s identity, home language, and culture, and that shared reading experiences regularly make use of these books.

syllables, then move to phonemes) with many opportunities for practice and review.

Ongoing Informal Assessment

An effective literacy curriculum provides a means for teachers to monitor and document children's progress over time. Assessment should be linked to instruction, enabling teachers to respond to children's needs and to identify children who might need additional instruction. Assessment also enables teachers to keep parents informed and involved. Ongoing assessments may include note-taking, portfolios of children's work, and checklists or other observation activities.

Conclusion

Children should develop a wealth of knowledge about reading and writing during pre-K. Pre-K teachers promote children's literacy development by embedding reading and writing in content-rich learning experiences. Teachers should make connections between phonemic awareness and alphabet knowledge, encourage children's developmental writing, engage in shared reading, demonstrate concepts of print, and provide opportunities for play in a print-rich classroom. The goal is to create engaging experiences which focus on using literacy to communicate and create meaning as children learn about their world.

Suggested Reading

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Schickedanz, J. A., and Casbergue, R. M. *Writing in Preschool: Learning to Orchestrate Meaning and Marks*. Newark, DE: International Reading Association, 2004.

Strickland, D. S., and Schickedanz, J. A. *Learning About Print in Preschool: Working with Letters, Words, and Beginning Links with Phonemic Awareness*. Newark, DE: International Reading Association, 2004

Useful websites:

<http://ies.ed.gov/ncee/wwc/>—What Works Clearinghouse: Provides information on which instructional techniques and curricula are effective.

<http://nieer.org/standards/>—National Institute for Early Education Research State Standards Database: Lists language and literacy content standards by state.

<http://www.aft.org/earlychildhood/>—American Federation of Teachers Early Childhood Educators Page: Provides links to information and resources of use to early childhood educators and child care providers.

<http://www.colorincolorado.org/>—Colorín Colorado: An online service which provides information, activities, advice and resources for educators and families of Spanish-speaking English language learners.

<http://www.reading.org/>—International Reading Association: Provides magazines, journals and links related to literacy.

<http://www.readingrockets.org/>—Reading Rockets: Provides book lists, information and articles related to reading.

<http://www.rif.org/>—Reading is Fundamental: Provides book lists, lesson suggestions and articles related to reading.

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- ¹⁰ Smith, M., Dickinson, D., Sangeorge, A., and Anastasopoulos, L. *Early Language and Literacy Classroom Observation*. Baltimore, MD: Brookes, 2002.
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- ¹² Neuman, S. B., Copple, C. and Bredekamp, S.

4. MATHEMATICS

Research on the responsiveness of infants to change in number has suggested that humans are “predisposed” to learn simple mathematics, just as they are predisposed to learn language.... These early concepts and skills include the recognition of shape and size and eventually pattern, the ability to count verbally (first forward and later backward), the recognition of numerals, and the ability to identify quantity from a very general level (more and less) to a specific level requiring the mastery of one-to-one correspondence (e.g., knowing which group has four and which has five).

*Eager to Learn: Educating Our Preschoolers*¹
NATIONAL RESEARCH COUNCIL



IN PRE-K, CHILDREN MUST DEVELOP essential skills, concepts, and thought processes that serve as the foundation for future mathematics learning and school achievement.

Educators once wondered whether mathematics instruction was appropriate for pre-K children, but an abundance of research shows that children engage in spontaneous mathematics play and demonstrate intuitive understandings about mathematics well before pre-K.² Children gain these understandings through observation and experimentation during their everyday experiences. In pre-K, teachers help children to build on these general understandings and their natural interest in mathematics. In particular, children benefit from solving problems that advance their mathematical thinking and from opportunities to learn mathematics vocabulary and communicate mathematical ideas.

In pre-K, children should advance in their knowledge in five major areas of mathematics: number and operation, algebra, geometry, measurement, and data analysis and collection.³ When teachers purposefully structure opportunities for mathematics experiences in these areas, children learn new concepts and skills and also develop core thought processes that are needed for mathematics, including problem-solving, reasoning, representing, communicating, and connecting math ideas.⁴

Children’s mathematics achievement at the start of kindergarten is a strong predictor of their academic success.⁵ However, in mathematics, as with other core content areas, children who grow up in poverty lag behind their middle-class peers in developing key knowledge and skills.⁶ Also, children from the United States demonstrate weaker mathematics achievement than children in other parts of the world, and this discrepancy may already be evident as early as kindergarten.⁷

Which Instructional Practices Support Children’s Mathematics Development?

Problem-Solving

Pre-K mathematics is much more than rote memorization of counting words or names of shapes. Children of this age are capable of engaging in thoughtful mathematics reasoning and problem-solving. One way to move beyond rote mathematics is to provide children with a variety of engaging, hands-on opportunities to broaden their understanding of math concepts. For example, rather than simply telling children that a shape is a triangle, teachers can ask children to examine several different types of triangles to determine how they are the same. Or, ask children to make as many different triangles as they can with a geoboard and rubber bands. Instead of always lining objects up when they are counted, teachers can ask children to “figure out” how to count objects that can not be moved. Or, in a collection of multicolored counters, teachers might ask children to try counting only the blue ones. Children should be encouraged to talk about their work and to discuss what they have learned. Rather than memorizing what to do (e.g., line up objects, point to each one, say the counting word), children stretch their mathematical thinking when they are asked to participate in these interesting and appropriately challenging mathematics activities. Through active problem-solving using concrete objects, children develop a deep understanding of mathematical concepts.

Mathematics Accomplishments for Pre-K⁸

Number/Operations

- Count to 10 in the context of play or activities.
- Demonstrate understanding of one-to-one correspondence (each object in a set is counted only once).
- Develop increasing ability to combine, separate, and name “how many” concrete objects.
- Use the names for numbers and associate number words (including “zero”) with collections or sets of objects counted.

Patterns/Algebra

- Sort and classify objects.
- Predict what comes next when patterns are extended.
- Recognize, duplicate, and extend simple patterns.

Geometry

- Recognize shapes.
- Describe how shapes are alike and different.
- Match and sort shapes.
- Use words that identify where things are in space (near, far).
- Use positional words to describe the location of objects (inside, underneath).

Measurement

- Experience, compare, and use language related to time.
- Use terms to compare the attributes of objects (longer, shorter, heavier).
- Order a set of objects according to size, weight, and length.
- Use tools to measure objects.

Data Analysis/Collection

- Collect, organize, and describe data.
- Use terms to compare attributes of objects (bigger, smaller, lighter).
- Order a set of objects according to size, weight, or length.
- Solve problems that involve collecting and analyzing data.

Mathematics Vocabulary

Pre-K children have intuitive understandings about mathematics, but they have difficulty articulating this knowledge because they lack mathematics vocabulary. Pre-K children may use an imprecise word such as “big” to explain that an object is long, tall, or heavy because they do not know these more descriptive words. Children may also have general understandings of mathematics terms without knowledge of their specific use in mathematics. When a young child asks for “the bigger half” of a sandwich, it is clear that the child does not yet know the precise mathematical meaning of the word *half* (two equal parts of a whole). Communicating is considered one of the fundamental processes of mathematics, but it is impossible to do without knowledge of appropriate and sophisticated mathematics language.⁹ Young children are able to learn correct mathematics terminology, and teachers help by purposefully introducing new words. Beyond counting words, pre-K teachers should introduce the following types of mathematics vocabulary:

- Names of two-dimensional and three-dimensional shapes—e.g., circle, pyramid, cube, hexagon.
- Language to describe shapes—e.g., sides, lines, angles, round.
- Terms to compare quantity—e.g., more than, less than, equal.
- Terms to compare length and weight—e.g., longer, longest, heavier, heaviest.
- Language related to time—e.g., earlier, later, morning, night, today, tomorrow.
- Words that identify where things are in space—e.g., near, far.
- Positional words to describe the location of objects—e.g., inside, underneath, next to.

Teachers should intentionally teach and explain mathematics vocabulary and should review words often. Teachers can encourage children to practice this language by asking open-ended questions that allow children to describe their mathematics play.

Play with Mathematics Manipulatives

Mathematics **manipulatives** are concrete objects that are easily handled, such as beads, puzzles, and blocks that children can work with in ways that help them understand and explore mathematics concepts. For example, sorting buttons encourages children to focus on mathematical attributes including the size and shape of each button as well as the number of holes in each button. Pre-K children need opportunities to use these materials in guided mathematics activities and in free play.

Children are more likely to choose to use mathematics manipulatives during free play when these objects are familiar. Teachers should highlight materials, model ways that they can be used, and structure problem-solving activities that help children to learn to use the manipulatives. Math materials should be stored in an organized and accessible manner within children's reach. Children need long blocks of time to experiment with these materials. The chart below provides a list of mathematics manipulatives with suggestions for their use:

Curriculum Integration

Pre-K teachers should schedule times dedicated specifically to mathematics, but mathematics can also be integrated into many everyday activities as well as content area learning in the

pre-K classroom. When a child counts out the correct number of snacks for the children at her table or the teacher announces that free play will be over in “five minutes,” children learn the everyday uses of mathematics.

One way to integrate mathematics and literacy is to use read alouds to introduce or review mathematical concepts and vocabulary. Children's mathematics knowledge is deepened when teachers actively connect concepts from books to hands-on mathematics activities so that children can apply and practice what they have learned. The list on page 18 highlights selected exemplary texts for teaching key mathematics concepts.

Counting, measuring, and graphing can be integrated into almost any social studies or science study. If children are learning about parts of the body, the teacher can help them to count “how many” of each part people have. This topic also provides the opportunity to introduce the concept of “symmetry.” A study of pets provides the opportunity to create a graph displaying the number and type of pets owned by children in the classroom. Making the most of curriculum integration and everyday math opportunities requires thoughtful planning, but this type of instruction deepens children's understanding of the practical applications of mathematics.

Toys and manipulatives

- Magnetic numbers (numeral recognition).
- Counters—teddy bear counters, bean counters, bug counters, buttons, shells (one-to-one correspondence, sorting and categorization, creating and extending patterns, more, less, combining).
- Unifix Cubes (one-to-one correspondence, more, less, combining, non-standard measure, creating and extending patterns, three-dimensional graphing, sorting).
- Math games—Uno (recognizing numerals), dominoes (counting and matching), board games that use dice (counting), playing cards (counting, matching, pairing).
- Geoboards and rubber bands (shapes).
- Foam shapes (shape recognition).
- Attribute shapes (sorting and categorization).
- Puzzles (shapes, special relationships, problem-solving).
- Wooden building blocks (three-dimensional shapes, problem-solving, spacial relationships).
- Building toys—Legos, Lincoln Logs, Tinkertoys, Bristle Blocks (problem solving, spacial relationships).
- Pattern blocks (shape recognition, combining shapes, creating and extending patterns).
- Beads, lace, pattern cards (creating and extending patterns).
- Math links — Link'n Learn Links (nonstandard measurement — length, can also be used as counters).
- Measuring cups, measuring spoons, ruler, yardstick, tape measure (standard measurement).
- Balance (measurement, weight).

High-Quality Mathematics Curricula

A mathematics curriculum can support teaching and learning in the pre-K classroom. In addition to the curriculum features mentioned in the previous chapters, the following aspects are particularly important in high quality mathematics curricula.

Scope and Sequence

An effective mathematics curriculum provides a set of organized activities that are presented in a systematic manner. Children need opportunities for in-depth thinking about key mathematical concepts in a sequence that is compatible with research on children's development of mathematical ideas.¹¹ Content should align with standards for pre-K and later grades and should focus on "big ideas" or key concepts in mathematics.¹²

Opportunities for Practice

Pre-K children need time and regular opportunities for mathematics play. Play enables children to practice using mathematical ideas that they know and to explore using mathematics materials in new ways. Children need ample time to engage in free play, as well as opportunities to engage in play activities that have been purposefully structured to focus children's attention on specific concepts and skills.

English Language Learners

Mathematics is deeply rooted in language and communication. English Language Learners (ELLs) may struggle with mathematics tasks because they do not understand the teacher's explanation of the activity. ELL children may not be able to ask for help or feel comfortable asking for help, which can lead to disengaged or frustrated behavior. Pre-K teachers should be aware that these difficulties are likely to occur, and should actively work to engage ELLs in mathematics activities. Pre-K teachers help ELLs to learn mathematics when they:

- Actively teach mathematics vocabulary. Review words often.
- Provide concrete examples when possible.
- Provide repeated demonstrations. Make sure to show, as well as tell, what to do.
- Facilitate hands-on mathematics activities in small groups so that ELLs feel more comfortable participating.
- If possible, find a bilingual volunteer or aide who can provide ELLs with assistance, explanations, and translations in the child's first language during planned mathematics activities.
- Encourage and praise children for their participation.

Selected Read-Aloud Texts for Teaching Mathematics¹⁰

- *Ten Black Dots* by Donald Crews (Harper & Row, 1968)—counting.
- *Five Creatures* by Emily Jenkins (Douglas & McIntyre, 2001)—sorting and categorization.
- *What Comes in 2's, 3's, & 4's* by Suzanne Aker (Simon & Schuster, 1990)—concept of number.
- *The Legend of Spookley the Square Pumpkin* by Joe Troiana (Greenwillow, 2003)—shapes.
- *Inch by Inch* by Leo Lionni (HarperCollins, 1995)—measurement.

Ongoing Informal Assessment

A strong curriculum provides tools and techniques for ongoing progress-monitoring with the goal of informing the teaching of mathematics. Appropriate methods of informal assessment include regular observation of children as they perform mathematics tasks, and interview techniques where teachers ask children questions that probe their thinking.

Opportunities to Individualize Instruction

There is a wide range in the time it takes for pre-K children to grasp mathematical concepts. A strong curriculum includes opportunities and techniques for teachers to assess children's mathematical understandings in order to plan or adapt instruction. The curriculum should provide teaching strategies that meet the needs of the full range of learners and in particular the needs of children who are struggling to make progress.

Conclusion

In pre-K, children should develop new mathematics knowledge and skills in five key areas: number, patterns, geometry, measurement, and data analysis. Pre-K teachers promote children's mathematics learning when they provide problem-solving opportunities; teach mathematics vocabulary; provide opportunities for structured and free play with mathematics manipulatives; and when they integrate mathematics into everyday experiences and content area studies. A high-quality mathematics curriculum can help teachers to structure and plan appropriate mathematics experiences. The goal is to guide children through a series of engaging mathematics activities that strengthen their knowledge of key concepts and build mathematics thinking processes.

Suggested Reading

Clements, D. H., Sarama, J., and DiBiase, A. M., eds. *Engaging Young Children in Mathematics: Standards for Early Childhood Mathematics Education*. Mahwah, NJ: Lawrence Erlbaum, 2004.

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Neuman, S. B., Roskos, K., Wright, T. S., and Lenhart, L. *Nurturing Knowledge: Building a Foundation for School Success by Linking Early Literacy to Math, Science, Art, and Social Studies*. New York: Scholastic, 2007.

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Schwartz, S. *Teaching young children mathematics*. Greenwood Publishing: Westport, CT, 2005

Taylor-Cox, J. "Algebra in the early years?: Yes!" *Young Children*, 58, 2003: 14-21.

Useful Websites:

<http://ies.ed.gov/ncee/wwc/>—What Works Clearinghouse: Provides information on which instructional techniques and curricula are effective.

<http://nieer.org/standards/>—National Institute for Early Education Research State Standards Database: Lists mathematics content standards by state.

<http://www.goenc.com/>—goENC: Provides articles, lesson ideas and curriculum resources for teaching math and science. Requires paid subscription.

<http://www.naeyc.org/>—National Association for the Education of Young Children: Provides journal, magazine, and position statements related to early childhood education.

<http://www.nctm.org>—National Council of Teachers of Mathematics: Provides content standards and focal points for math instruction.

¹ National Research Council. Bowman, B.T., Donovan, M.S., and Burns, M.S., eds. *Eager to Learn: Educating Our Preschoolers*. Washington, D.C.: National Academies Press, 2001.

² Clements, D. H., Sarama, J., and DiBiase, A. M. eds. *Engaging Young Children in Mathematics: Standards for Early Childhood Mathematics Education*. Lawrence Erlbaum: Mahwah, NJ, 2004.

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⁶ Arnold, D. H., and Doctoroff, G. L. "The Early Education of Socioeconomically Disadvantaged Children." *Annual Review of Psychology*, 54, 2003: 517-545.

⁷ Stevenson, H., Lee, S. S., and Stigler, J. "The Mathematics Achievement of Chinese, Japanese, and American Children." *Science*, 56, 1986: 693-699.

⁸ National Council of Teachers of Mathematics, 2000; National Council of Teachers of Mathematics, 2006.

⁹ National Association for the Education of Young Children/National Council of Teachers of Mathematics, 2002.

¹⁰ Neuman, S. B., Roskos, K., Wright, T. S., and Lenhart, L. *Nurturing Knowledge: Building a Foundation for School Success by Linking Early Literacy to Math, Science, Art, and Social Studies*. New York: Scholastic, 2007.

¹¹ National Association for the Education of Young Children/National Council of Teachers of Mathematics, 2002.

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5. SCIENCE

The past 20 to 30 years of research have shown that children come to school with a great capacity for learning in general and learning science in particular. Even preschool children have a rich set of ideas, conceptual frameworks, and reasoning skills. They bring to school rudimentary “theories,” rules of thumb, and general principles that help them separate the world into different domains and organize their expectations about how things ought to behave. Their understanding of the world helps them explain phenomena and solve problems. They are able to engage in surprisingly sophisticated scientific thinking in the early grades and can appreciate deep points about the nature of science.

Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms¹

NATIONAL RESEARCH COUNCIL



IN PRE-K, CHILDREN BEGIN TO LEARN the practices of scientific inquiry as well as foundational knowledge in science. Together these skills and concepts lay the groundwork for children’s learning in this key content area.

Pre-K children are ready and eager to learn science. Young children are naturally curious about the world, and they regularly ask “why” and “how” questions that logically lead to scientific inquiry. Pre-K science capitalizes on this desire to discover new ideas as children participate in free exploration and guided activities using science tools and materials.

In pre-K, children should grow in both their ability to participate in the cycle of scientific inquiry and in their knowledge of science concepts. Through active participation, children learn the steps that scientists use to investigate and problem-solve. They pose an interesting question, plan and predict, experiment and/or observe to test ideas, record findings, and communicate about what has been learned. As children participate in this process, they gain new knowledge in key areas of science including physical science, life science, and earth science. These activities also build background knowledge and vocabulary that are essential for future science learning as well as for reading comprehension in the elementary years.²

Children gain a firm grasp on new knowledge, skills, and vocabulary when teachers facilitate a variety of experiences that relate to the same broad science concept.³ In-depth science studies that integrate oral language, literacy, and mathematics provide meaningful and coherent learning

experiences for young children. Teachers simultaneously reinforce important understandings in all of these essential content areas.

In a world where science and technology are integral to daily life, it is essential that children are introduced to scientific reasoning and concept knowledge in the pre-K years, thus developing the foundations for science literacy and for future academic success.

Which Instructional Practices Support Children’s Science Development?

Scientific Inquiry

Scientific inquiry builds on children’s natural desire to discover new knowledge about their surroundings. The goal is to actively engage children in the process that scientists use to answer questions about the world. Teachers guide children as they determine an interesting science question and suggest possible methods to find an answer or explanation. Children then participate in observing and experimenting to determine an answer to their question. As children participate in inquiry and investigations, they gain in-depth knowledge of science content. While children’s preconceptions about the world can be resistant to change, active participation in hands-on science experiences is more likely to

Science Accomplishments for Pre-K⁴

Physical Science

- Describe the properties of objects and materials (e.g. color, size, shape, taste, smell). Explore how things move and change.
- Show increased understanding of changes in materials and cause-effect relationships.
- Use their senses and tools to gather information, investigate materials, and observe relationships.
- Observe and discuss common properties, differences, and comparisons among objects and materials.

Life Science

- Identify features of plants and animals that help them live in different habitats.
- Show an understanding that plants and animals need water and food.
- Know that living things go through life cycles (e.g., growth, change).
- Name some human body parts and know their function.
- Recognize the difference between living organisms and non-living objects.
- Recognize that people have unique features, but are alike in many ways.
- Know that people need food, exercise, and rest to stay healthy.

Earth Science

- Recognize that some events in nature have a repeating pattern (e.g., seasons of the year).
- Know different types of weather and that weather changes over seasons.
- Show respect for the environment.
- Know vocabulary to describe major features of the sky (e.g. clouds, moon) and earth (e.g., mountain, river).
- Know that materials can be reused or recycled.

Scientific Inquiry

- Show interest in investigating phenomena.
- Use the senses to make observations.
- Begin to systematically compile, classify, and order collected information.
- Make predictions based on previous experience and background knowledge.
- Participate in simple investigations to test observations, discuss and draw conclusions, and make generalizations.
- Use tools to gather information (e.g., magnifying lens, eyedropper, camera).
- Develop explanations for observations.
- Name, record, and share information with others either orally or in written form (i.e., uses pictures and developmental writing).

advance their ideas than simply being told new information.⁵

For example, in a pre-K classroom where children are learning about plants, one question could be, *What do plants need to grow?* A child may suggest that plants need light to grow, or the class may read a book that provides this information. To investigate whether this answer is accurate, the teacher can guide children through a simple experiment. Children might place one plant to grow on a windowsill and one plant in the closet. As children predict what will happen, observe, gather and record information, and discuss and track the progress of their plants, they learn both scientific content (what plants need to grow) as well as the practices of scientific inquiry.

While some questions are impossible to investigate through experiments in the pre-K classroom, the overar-

ching goal is to engage pre-K children in building their scientific knowledge while actively using the methodologies of this discipline.

Process of Scientific Inquiry⁶

- Exhibit curiosity, define questions from current knowledge.
- Propose preliminary explanations or hypotheses.
- Plan and conduct simple investigations.
- Gather evidence from observation.
- Explain based on evidence.
- Consider other explanations.
- Communicate explanation.

Careful observation is an important aspect of scientific inquiry, and teachers should provide a variety of opportunities for children to develop this skill. To answer the

question, *How do trees change in different seasons?*, a pre-K class might observe, photograph, and compare a tree in the playground in fall, winter, and spring. This project teaches children the skill of scientific observation as they gain new knowledge about plants and seasons. Children should learn that scientists use all of their senses to gather information. They should also be exposed to science tools that can aid in the observation process (e.g., magnifying glasses). Recording observations and communicating about what has been discovered are essential to this process.

Science Vocabulary

Children need words to name and discuss the new ideas that they gain through science activities. Pre-K children are capable of learning the correct terminology for the concepts that they explore, and it is important for young children to learn to use the language of science. This includes the vocabulary for scientific inquiry (e.g., *What do you **predict** will happen in our **experiment**?*).

Teachers promote learning of science vocabulary by actively modeling word use and explaining the meaning of new words during large-group, small-group, and one-on-one conversations about science. Children should be encouraged to talk about their science explorations and investigations. Children's vocabulary development is encouraged during in-depth studies of key science concepts because they have repeated exposure to new words in a variety of contexts. Shared reading and discussion of informational science books is another way to introduce and reinforce science vocabulary.

Science vocabulary for pre-K children:

- Words for scientific inquiry (e.g., predict, observe, experiment).
- Words for science activity (e.g., mix, measure, compare).
- Names of science tools (e.g., magnifying glass, balance, dropper).
- Words for careful observation (e.g., smell, see, feel).
- Words to describe properties of objects (e.g., rough, shiny, round).

In addition, teachers should introduce relevant vocabulary as children learn about a specific science topic.

Science Materials⁷

For investigating

Magnifying glasses
Binoculars
Mirrors
Flashlights
Magnets

For measuring

Balance
Rulers
Tape measures
Stop watch
Kitchen timer
Yard stick
Hour glass

For containing and collecting

Cups, trays, jars, bottles
Boxes, egg cartons
Paper bags
Pouches, nets

For recording

Camera
Notebooks, pads, writing tools
Chart paper, graph paper
Tape, scissors, glue

Science Area

An engaging science area encourages children to play and explore using science materials. Dedicating an area of the classroom specifically to science demonstrates the importance of this content area and encourages children to investigate science materials during their free play.

Teachers should change the science area regularly so that children have new materials to discover. This area should be used to further investigations that are taking place in the classroom, and should include tools, books, and other relevant materials to the topic of study. If the class is studying the lifecycle of butterflies, the science area may include books about caterpillars and butterflies, real larvae or a chrysalis for children to examine, paper for children to draw what they observe, a large scale model or picture cards of the stages of the life cycle, and appropriate science tools (e.g., magnifying glass) to aid in children's investigation.

Free play with science materials helps children to generate new questions and to practice using the ideas that they have learned. During guided exploration, the teacher helps to scaffold children's learning by purposefully structuring science activities that advance children's knowledge, skills, and vocabulary.

Beyond the science area, teachers can include science materials throughout the classroom and outdoor areas. The block area, the sand and water tables, the dramatic play area, the classroom library, and even the playground are all places where children can engage in science exploration.

Curriculum Integration

Many literacy and mathematics ideas can be taught and reinforced as children participate in science investigations. In fact, some researchers suggest that literacy and mathematics skills are more meaningful to children when they are taught as part of integrated units of study rather than as isolated skills.⁸ Project-based learning is captivating to children, and this method provides opportunities to integrate subject areas while sustaining and deepening children's science inquiry.

There are fundamental mathematics concepts and skills that are necessary to perform most science investigations. These include counting and determining "how many," comparing, classifying, and measuring. Teachers should pur-

posefully facilitate children's use of mathematics during science activities.

Literacy skills are also integral to scientific inquiry. Teachers read aloud to provide background knowledge, encourage children to use developmental writing to draw and record their observations, and engage children in conversations using science vocabulary.

Science investigations provide an opportunity to bring informational texts into daily use in the pre-K classroom. Research demonstrates that shared reading and discussion of information books has many benefits for pre-K children, but this genre is often underutilized in early childhood classrooms.⁹ Reading books about content supports background knowledge and vocabulary development, and teaches children that books are a useful place to obtain and communicate information. When reading informative, nonfiction books, teachers should:

- Point out features that are particular to this type of text, such as labeled pictures and diagrams.
- Demonstrate reading to “look up” an answer to a specific question rather than always reading the book from beginning to end.
- Explain new vocabulary and concepts in simple language that children can understand.
- Engage in repeated readings of the same book to reinforce new ideas and vocabulary.

High-Quality Science Curricula

A science curriculum can support teaching and learning in the pre-K classroom. In addition to the curriculum fea-

English Language Learners

The vocabulary of science can present a huge difficulty for English Language Learners (ELLs) because there are content-specific terms for students to learn that may not be used in everyday speech.

In addition to teaching vocabulary words during science investigations and shared book reading, pre-K teachers can help ELLs by using picture cards to introduce and reinforce key vocabulary words that are relevant to the topic that the class is investigating. While picture cards are especially useful to ELLs, all children in the class will enjoy participating in picture card games that reinforce vocabulary that is related to the science topic.

Picture cards can be placed on a wall in the whole-group meeting area, and children in the class can take turns pointing while the group calls out the word for each picture. Picture cards can also be copied and stapled into small books for children to keep so that ELLs can practice their new English words by “reading” the pictures at home and at school.

tures mentioned in the previous chapters, the following aspects are particularly important in high-quality science curricula.

Scope and Sequence

A scope and sequence should provide a coherent progression of science skills and content. Topics and activities should build on one another so that children develop progressively more complex knowledge and skills. Content should align with science benchmarks and standards in your state.¹¹

In-depth Studies of Key Concepts

Children gain deeper knowledge when they have a variety of experiences that relate to the same concept. For example, a unit on biological change and life cycles could include examining how plants grow and change, the life cycle of a butterfly, and a study of what humans need to grow and survive.¹² This kind of study enables children to build on their knowledge and to make connections among the science concepts that they are learning.

Focus on Practices and Content

Science literacy includes a knowledge of the practices of scientific inquiry as well as knowledge of science concepts and ideas. A pre-K science curriculum should integrate these aspects of science literacy by building children's knowledge through guided participation in scientific inquiry.

Selected Read-Aloud Texts for Teaching Science¹⁰

- *My Five Senses* by Ailiki (HarperCollins, 1989)—human body.
- *How a Seed Grows* by Helen J. Jordon (Harper Trophy, 1992)—plants.
- *The Very Hungry Caterpillar* by Eric Carle (Philomel, 1969)—life-cycles.
- *What Do You Do with a Tail Like This?* by Steve Jenkins and Robin Page (Houghton Mifflin, 2003)—animal body parts.
- *Dinosaur Bones* by Bob Barner (Chronicle Books, 2001)—dinosaurs.
- *Your Big Backyard Magazine* (National Wildlife Federation)—science magazine for children ages 3-7.

Conclusion

In pre-K, children should develop new science knowledge in three key areas: physical science, life science, and earth science. Pre-K teachers promote children's science learning when they engage children in scientific inquiry, teach science vocabulary, provide opportunities to explore using science tools and materials, and integrate science with math and literacy. The goal is to provide children with engaging science experiences that appeal to their natural curiosity while providing coherent opportunities to learn foundational science concepts and skills.

Suggested Reading

- American Association for the Advancement of Science. *Benchmarks For Science Literacy*. New York: Oxford University Press, 1993.
- Center for Science, Mathematics, and Engineering, National Research Council. *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, D.C.: National Academy Press, 2000.
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National Research Council. *National Science Education Standards*. Washington, D.C.: National Academy Press, 1996.

Neuman, S. B., Roskos, K., Wright, T. S., and Lenhart, L. *Nurturing knowledge: Building a Foundation for School Success by Linking Early Literacy to Math, Science, Art, and Social Studies*. New York: Scholastic, 2007.

Useful Websites:

<http://nieer.org/standards/>—National Institute for Early Education Research State Standards Database: Lists science content standards by state.

<http://www.goenc.com/>—goENC: Provides articles, lesson ideas and curriculum resources for teaching math and science. Requires paid subscription.

<http://www.naeyc.org/>—National Association for the Education of Young Children: Provides journal, magazine, and position statements related to early childhood education.

<http://www.project2061.org/publications/bsl/online/>—American Association for the Advancement of Science: Benchmarks for science literacy.

¹ National Research Council. Michaels, S., Shouse, A. and Schweingruber, H. *Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms*. Washington, D.C.: National Academies Press, 2007.

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³ Gelman, R., Brenneman, K. "Science Learning Pathways for Young Children." *Early Childhood Research Quarterly*, 19, 2004: 150-158.

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Also see <http://nieer.org/standards/domain.php?DomainID=1> for a complete list of states that implement standards in this domain.

⁵ French, L. "Science as the Center of a Coherent, Integrated Early Childhood Curriculum." *Early Childhood Research Quarterly*, 19, 2004: 138-149.

⁶ Center for Science, Mathematics, and Engineering, National Research Council. *Inquiry and the National Science Education Standards: A Guide*

for Teaching and Learning. Washington, D.C.: National Academy Press, 2000.

⁷ Neuman, S. B., Roskos, K., Wright, T. S., and Lenhart, L. *Nurturing Knowledge: Building a Foundation for School Success by Linking Early Literacy to Math, Science, Art, and Social Studies*. New York: Scholastic, 2007.

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¹⁰ Neuman, S. B., Roskos, K., Wright, T. S., and Lenhart, L.

¹¹ American Association for the Advancement of Science.

National Research Council. *National Science Education Standards*. Washington, D.C.: National Academy Press, 1996.

¹² Gelman and Brenneman.





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