KEY TAKEAWAYS

All children need high quality early science learning experiences, but some really need them. Research suggests that at-risk learners have lowest readiness for school science, compared to other domains of learning.

Science supports children's learning and school readiness in other areas. Science learning experiences foster language and literacy development, and they also are linked to math learning and executive function skills.

Children are ready and eager to engage in science exploration, from their earliest years. Despite this early competence and motivation, most early learning programs do not do enough to build on children's early science competencies.

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EDUCATION REFORM

Science in the Early Years

Foundations for future learning are laid in the earliest years of a child's life. Research shows that, while mutable, the course of school achievement – or lack of it – is often set before children reach the kindergarten door. This understanding has led to education policies that stress the importance of supporting reading skills in the preschool years because lack of reading readiness is linked to lower school achievement and school difficulties such as grade retention and dropout. Strong emphasis has been put on making certain that all children are proficient readers by third grade.[1] Recent research shows, however, that early mathematics skills and general knowledge in science and social studies might be even more important for school achievement, not just in math and science but in reading as well. Knowledge of the natural and social worlds seems to be more predictive of reading achievement than are early reading skills.[2]

"Knowledge of the natural and social worlds seems to be more predictive of reading achievement than are early reading skills."

What's Inside

This issue of *The Progress of Education Reform* explores the benefits of including a strong science curriculum in the early years and includes recommendations for policymakers.

Although science has not traditionally received the curricular attention afforded language arts/literacy and mathematics, science content knowledge and practice skills are recognized as critical for students across age bands. For K-12 science, the Next Generation Science Standards (NGSS) provide research-based standards developed by academic researchers, educators and state-level policymakers to ensure that U.S. students graduate from high school prepared for college, for career and for citizenship.[3] Although it is a K-12 document, the NGSS acknowledge that children arrive at kindergarten with skill levels, knowledge and dispositions that support – or limit – school readiness and achievement in science. Most states have adopted science learning and teaching expectations for preschool and some, such as Massachusetts, are aligning their preschool learning standards to the NGSS. The National Science Teachers Association (NSTA) recently issued a position statement that recommends teachers and education providers provide science learning experiences for children that engage them with the content and processes of science and that reflect an understanding of how these experiences connect to the content and practices described in the NGSS. The National Association for the Education of Young Children (NAEYC) recently endorsed the NSTA statement, which affirms that engaging with science and engineering practices in preschool can form the basis for a lifetime of science learning in K-12 classrooms and beyond.[4]

Research suggests that while many young children arrive at school ready and eager to learn science, many others have had limited opportunities to engage with the content and practices of science due to family circumstances and lack of instructional quality in their early learning environments. This issue of *The Progress for Education Reform* outlines the case for including strong science curriculum and instructional supports in the early years by outlining the foundational skills and knowledge that young children bring to the science-learning endeavor, describing ways that science experiences support learning in other critical domains such as language arts, literacy and math, and presenting evidence that supporting science knowledge and skills in the early years yields school readiness and achievement benefits in later years. Implications and recommendations for practice, research and state policy are given.

Key Takeaways

Children are ready and eager to engage in science exploration, from their earliest years, but most early learning programs do not do enough to build on competencies in science.

Research reveals that children entering kindergarten already have a great deal of knowledge about the natural world, including concepts related to physics, biology, psychology and chemistry.[5] They also possess dispositions and thinking skills that support later, more sophisticated, scientific reasoning. Young children question where cow babies come from, observe that people have eyes of different colors and generate explanations for this difference.[6] Older preschoolers are able to interpret simple data patterns and show some understanding of how different patterns support different conclusions.[7] In short, from their earliest years, children have ideas about how the world works and they investigate and refine these ideas by exploring and questioning the world around them.

Despite children being ready and eager to engage with the content and practices of science, very little science teaching occurs in preschool classrooms. Teachers spend little time engaged in either planned or spontaneous science-relevant activities and rarely spend time in the discovery area or science table during children's free-choice time.[8] This situation is disturbing because adults play a critical role in helping children learn science content and skills. They can provide a "climate of curiosity" for children, can prepare the learning environment in ways that invite exploration and questions, can support and extend children's spontaneous investigations, and can help children attach language to the experiences that they are having.[9] Teacher-guided investigations tend to be longer, broader, more focused on relevant comparisons and supportive of more accurate understandings.[10]

Science learning experiences support children's learning and school readiness in other areas.

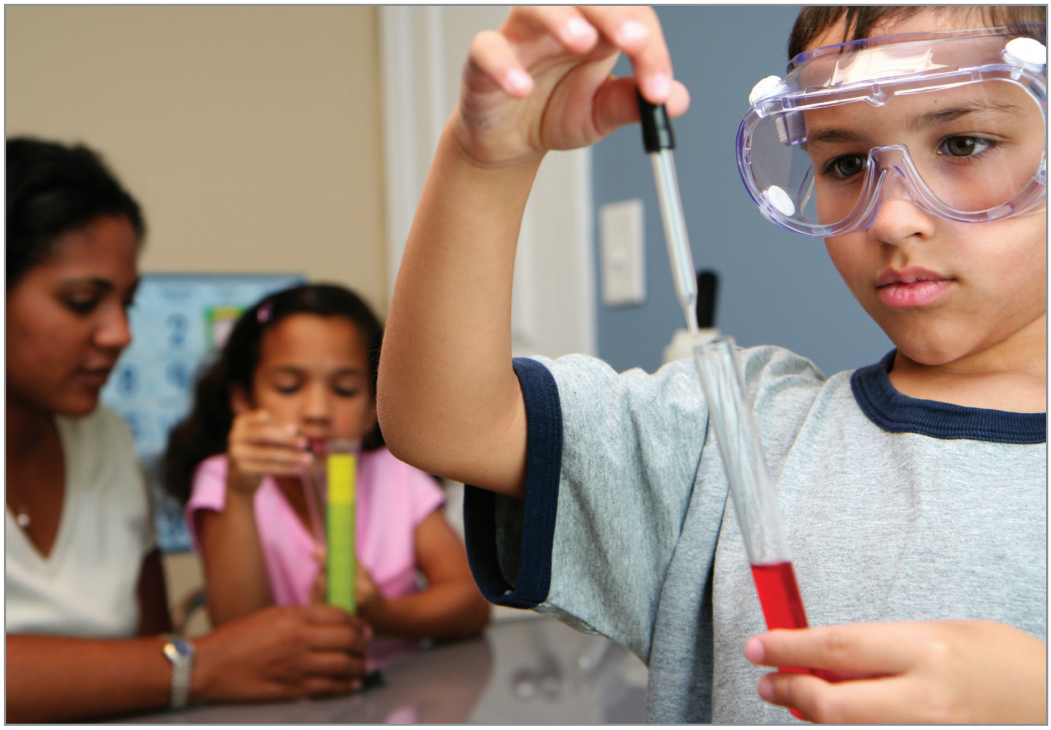
Supporting science learning is important in and of itself, but scientific explorations also provide rich contexts for language and literacy development. Science interactions support vocabulary development by exposing children to new words in meaningful contexts, as children and teachers describe their activities. Imagine a set of experiences to create play dough. As children and teachers explore the ingredients and eventually combine them, they use rich language to describe what they are doing (observe, predict, measure, mix), what they are observing (flour, salt, oil, water, dough), and the attributes of objects and events (sticky, oily, grainy, fluffy, more than, less than). Exposure to rich vocabulary words predicts vocabulary development, which predicts reading achievement,[11] and high-quality science programs can lead to gains in receptive vocabulary for low socioeconomic status (SES) learners.[12] Science provides children with opportunities to engage with informational text, a genre that is underused in early education[13] and that reading standards documents suggest should be emphasized much more in classrooms.[14] Science does not detract from literacy development; in fact, it contributes to the goal that all children read with understanding by grade 3.

> "... from their earliest years, children have ideas about how the world works and they investigate and refine these ideas by exploring and questioning the world around them."

The links between mathematics and science are many. This overlap includes reasoning that supports classification, seriation, identifying patterns, problem solving, prediction, measurement, deductive and inductive reasoning, and data collection and representation.[15] While mathematics skill development seems to require instructional time that is completely focused on math concepts,[16] science learning experiences provide authentic opportunities to use math for a purpose, for example, when counting and apportioning seeds into bags for a sprouting experiment, tracking and charting the number of seeds that have sprouted under various conditions, and recording and interpreting numerical data patterns to draw conclusions.

Children's executive function skills – including inhibitory control, working memory and cognitive flexibility – predict school readiness and later school achievement.[17] These skills depend on brain maturation, but they can also be strengthened through practice. Science requires explanation and reflection, and both executive functioning and children's science skills are enhanced when teachers engage children in the kinds of learning experiences that require reflection on prior beliefs (predictions) and actual outcomes and revision of beliefs in light of evidence.[18]

Further evidence that early science experiences build science skills, as well as skills in other critical areas, comes from an evaluation of a science program developed and implemented in Head Start classrooms by the Miami Museum of Science. The evaluators report that participation improved children's readiness in science and in non-science domains including approaches to learning, creative arts, language and literacy, and early math.[19] As noted above, children's school readiness in science and social science has been found to predict science achievement at grade 5, in addition to math and reading achievement at grade 5, even more strongly than reading readiness does.[20]



All children need early science learning experiences; some really need them.
All children will benefit from the opportunity to engage with the concepts and processes of science; however, our most at-risk learners need these experiences even more. A recent review reports that, among eight Head Start Learning Outcomes, children arrived at kindergarten with lower readiness scores in science than in any other domain.[21] Ironically, when they arrive at preschool they are less likely to be provided with opportunities to develop science content area knowledge.[22] Studies suggest that teachers of low-SES students believe that memorization and rote tasks are more important than activities that emphasize reasoning and problem-solving, whereas teachers of mid-SES students are more likely to emphasize the latter conceptual tasks.[23] Coupled with the general lack of science (and math) in preschools, results such as these suggest that school-readiness problems in these domains, especially among underserved populations, are unlikely to improve without changes in policy and practice.

> Science does not detract from literacy development; in fact, it contributes to the goal that all children read with understanding by grade 3.

Recommendations for Research, Policy, and Practice

Research-based Curriculum and Instruction
Very little science happens in early care settings, and what does happen tends to consist of single activities, disconnected from what came before and what will come next. Children actively construct knowledge and this process is facilitated when the to-be-learned information is connected to what came before.[24] This vision of instructional quality is consistent with recommendations that educators focus on learning trajectories for core concepts, rather than trying to teach a little bit of everything.[25] A number of evidence-based curricula for early science exist and some comprehensive curricula are expanding their supports for science. Policymakers should support rich, connected, evidence-based science learning experiences in funded programs, and research funds should be allocated to further explore the approaches that best support school readiness for science.

Stronger Professional Preparation
The link between lead teacher educational background and child outcomes is not straightforward; however, educational researchers suggest that fine-grained analyses are likely to yield links between learning outcomes and the amount of practicum offered in teacher preparation programs.[26] Teacher preparation programs do not typically emphasize science content, pedagogy or opportunities to practice teaching science, focusing instead on social-emotional development and literacy.[27] As a result, even among preschool teachers who have degrees, lack of knowledge and comfort result in little science teaching for children. The requirements in teacher preparation programs should be changed to include strong coursework that strengthens adults' knowledge of science content itself, of how children learn this content and of how best to support learners as they engage with science.

Stronger Professional Development
These same recommendations hold true for professional development for in-service preschool educators. Teachers report being uncomfortable teaching science. Some of this discomfort comes from their negative attitudes and experiences with science during their own schooling while other teachers are unsure how to plan learning experiences for preschoolers. They also say that the heavy emphasis they are expected to put on literacy and social-emotional development, leaves little time to do science.[28] Professional development that engages teachers with strategies for creating or identifying curriculum that offers science-learning experiences that are also strong language- and literacy-learning experiences has the potential to support more efficient, comprehensive and effective education in the preschool classroom.

The content of professional development must change, and so must the typical schedule for it. If – and this is a big if – teachers are given opportunities to improve their practice in science, it is often in the form of once-and-done workshops, which are unlikely to yield any real change in attitudes or in instruction. The evidence is clear that more intensive, individualized, practice-based approaches are required to change practice and improve instructional quality.[29] These kinds of professional development approaches are not inexpensive, but money spent on quick, but ineffective, approaches is simply wasted. Recommendations include involving educators across multiple grade bands to improve articulation in teaching approach, a strategy that is recognized in K-12 education but not generally extended into pre-kindergarten,[30] and involving educators in different roles (e.g., teaching assistants, supervisors) so that all adults who are in a position to support children's science learning are operating with a common, evidence-based vision of how best to do that.

Conclusion

Young children possess curiosity, dispositions and foundational knowledge that position them well to learn the content and practices of science. Engaging with science and constructing knowledge about it has positive effects on readiness and achievement in science, but also in reading and math. Scientific thinking supports, and is supported by, executive function skills. Many children are at risk for lack of school readiness and achievement, in part because their early-care settings are of low instructional quality for early science. The key to improving science learning is improving science teaching. To better educate children, we need to better educate those who care for them. Professional development providers for pre-service and in-service educators must offer teachers the opportunity to learn science content, to understand how children develop science content, and to practice and apply evidence-based pedagogical techniques. Education leaders should turn a critical eye on the science teaching and learning expected for early education in their school, district or state, then determine whether there is any evidence that children and their teachers are receiving the instructional opportunities they need and deserve. Only then can we begin the hard work of ensuring that we are providing the best chance for children to become science-ready as kindergartners, science-achieving K-12 students, science-literate citizens and perhaps, if they wish, science professionals.

Endnotes

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ECS RESOURCES

Kindergarten Online Database 2014
Trends in kindergarten policy across the 50 states
http://www.ecs.org/html/educationIssues/Kindergarten/KDB_intro_SF.asp

State Policy Database: P-3 – Kindergarten, Updated weekly
http://www.ecs.org/html/educationIssues/Kindergarten/KDB_intro_SF.asp

State Pre-K Funding: 2013-14, January 2014
http://www.ecs.org/clearinghouse/01/10/34/11034.pdf

2013 Legislative Session: P-3 Policies, November 2013
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Math in the Early Years: A Strong Predictor for Later School Success, October 2013
http://www.ecs.org/clearinghouse/01/09/46/10946.pdf

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