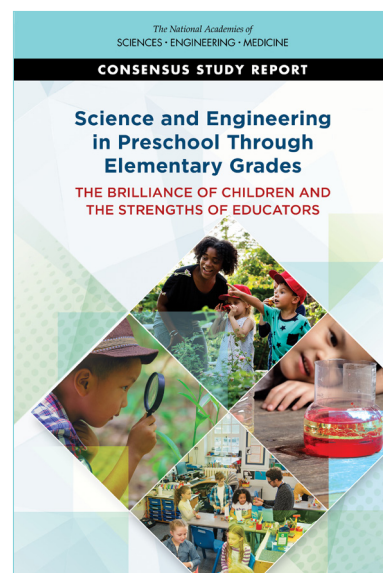


Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators

Children are curious. Whether wondering where the water goes when it rains or asking how a toy car works, their questions and enthusiasm can set the stage for learning almost from infancy. This curiosity has sparked a major rethinking of how and when children are introduced to science and engineering in school. Educators now realize that the years from preschool through the elementary grades offer the opportunity for children to be better prepared for these subjects in middle school and high school, giving them access to possible careers in science and engineering. Helping children to understand science and to solve real-world engineering and design problems will support them in being informed decisionmakers about issues that matter in their lives and allow them to experience the wonders of the natural and designed worlds.

Although the opportunity for a new approach exists, many challenges remain. The Carnegie Corporation of New York and the Robin Hood Learning + Technology Fund commissioned the National Academies of Sciences, Engineering, and Medicine to examine the research on effective approaches to early science and engineering instruction. *Science and Engineering in Preschool Through Elementary Grades: The Brilliance of Children and the Strengths of Educators* (2021) lays out those challenges and ways to overcome them. The authoring committee consisted of experts in educational systems, early childhood education and development, elementary science learning and pedagogy, professional learning, assessment, curriculum materials, and content integration.

This report also reflects the context in which it was written—during a global pandemic that closed most schools for a year or more and in the midst of a historic national conversation about race and equity in the United States. It is clear that the missed schooling has affected children’s learning and well-being, even if it is not yet known how or to what degree. It is also clear that all children have not been affected equally: Schools, like all of society, reflect the unequal availability of high-quality instruction and resources. Black, Brown, and Indigenous children as well as emergent multilingual learners usually attend schools with fewer resources than are available in schools that serve predominantly White children. Thus, the overall challenge is to identify effective approaches to science and engineering instruction in preschool through 5th grade that support the success of every child, including those that have been marginalized in science and engineering, including Black, Brown, and Indigenous children and other children of color, children with learning disabilities and/or differences, emergent multilingual learners, and children marginalized on the basis of gender.



Five key areas are central to a new approach: (1) making science and engineering education a priority in preschool through elementary grades; (2) supporting children’s learning, engagement, and proficiency with science and engineering; (3) developing innovative curriculum materials and integrating science and engineering with other content areas; (4) supporting teachers; and (5) supporting transformative school and district leaders. Issues related to equity and justice are threaded throughout, reflecting their pervasiveness in U.S. society.

MAKING SCIENCE AND ENGINEERING EDUCATION A PRIORITY

In the United States today, children in elementary classrooms receive instruction in science for an average of only about 20 minutes a day and for only a few days a week; even less time is spent on engineering instruction. Even this minimal instructional time is not evenly distributed: Schools that serve mostly Black, Brown, and Indigenous children generally offer less science and engineering instruction than schools that serve mostly White children. In addition, children who are receiving academic supports, such as for English-language development, have often been pulled out of science and engineering learning experiences, further limiting their opportunities to learn.

This report recommends that state policy makers ensure that science and engineering is comprehensively, frequently, and consistently taught in preschool through elementary school. The policies should also ensure that children are not being pulled out of science and engineering instruction for remediation in other subjects. It calls on district and school leaders to allocate the necessary resources—time, money, materials, and teachers—to support equitable science and engineering learning opportunities.

SUPPORTING CHILDREN’S LEARNING

Four ideas are key to understanding children’s learning in science and engineering:

1. Learning is a social and cultural process.
2. Learning is a process of identity development.
3. Children move through a range of cultural contexts in which they learn science and engineering, and variations in these contexts shape what and how each child learns.
4. Learning in these disciplines is not neutral because the disciplines themselves are not neutral.

While all children are curious, every child is a unique individual with particular strengths and background, being raised in a particular context. Science and engineering learning from preschool through elementary school is a social and cultural process that involves identity formation, and it occurs in a historical and political context. Children need to be provided with opportunities to explore questions that matter to them and realize that they can develop answers and solve problems. Along with schools and other formal settings, families, out-of-school activities, and digital media can all serve to expand children’s opportunities to explore and make sense of the world around them.

This report recommends that teachers design their science and engineering instruction around interesting and relevant phenomena and that leverage children’s natural curiosity and give children opportunities for decisionmaking, sensemaking, and problemsolving. Teachers should also design instruction that promotes norms for a caring, collective culture and supports opportunities for collaboration and collective thinking. In addition, teachers, as well as school and district leaders, should engage and collaborate with families and local community leaders to mutually support children’s opportunities for engaging in science and engineering.

DEVELOPING CURRICULUM AND INTEGRATING SCIENCE AND ENGINEERING WITH OTHER CONTENT AREAS

Just as scientists and engineers draw on other content areas, such as reading and graphic design, children’s work in science and engineering can be integrated with other subject areas. In particular, there are key opportunities for integrating science and engineering with English language arts, mathematics, and computational thinking. Integration across content areas both contributes to building meaningful bridges and eliminates the silos that are less and less reflective of how scientists and engineers actually work and, more broadly, of modern life.

This report recommends that curriculum developers work in partnership with researchers, teachers, school and district leaders, and families and community leaders to develop preschool through elementary science and engineering curriculum materials that are coherent and equitable. In selecting curricula, state and district leaders should rely on a robust evidence-based review, selection, and implementation process to ensure that the science and engineering units build toward the vision of the Framework. They should also provide teachers with sustained professional learning opportunities for using and adapting curriculum materials.

SUPPORTING EDUCATORS

Teachers in preschool through elementary school usually teach all subject areas, including science and engineering, as well as often covering such nonacademic fields as art and music. They also support children's social, emotional, and physical well-being. Although these teachers are unlikely to be experts or even deeply educated in all fields, they bring a commitment to and understanding of children, and are themselves inquisitive about the world. To build on those assets to implement a new approach to science and engineering education, teachers need and deserve a wide variety of supports across their preservice and professional careers.

Preservice teacher education needs to include experiences with science and engineering practices and with supporting children in engaging in those practices. Throughout their careers, teachers need ongoing professional learning opportunities, adequate physical and digital resources, and appropriate curriculum materials. Because the preschool through elementary teacher workforce—composed mainly of White women—is often starkly different from the children they teach, teachers may need support in being responsive to and supportive of the cultural and linguistic backgrounds of the children in their classrooms, especially with regard to science and engineering.

This report recommends that teacher educators and those involved in ongoing professional opportunities for teachers—as well as school and district leaders—stress the importance and value of teaching science and engineering; understand and address the needs and goals of classroom teachers; support teachers in connecting their professional learning with their classroom practice; emphasize authentic and equitable science and engineering content and disciplinary practice; allow for meaningful integration of science and engineering with other subjects; and support teachers' effective use and adaptation of science and engineering curriculum materials. Schools of education should provide professional learning opportunities for their science teacher education faculty on how to work toward equity and justice in teacher education.

This report also recommends that the federal government reassess its support for teaching and learning of science and engineering in preschool through elementary school to prioritize efforts that diversify the teacher workforce; support research and development that works across content areas to support teacher educators, teachers, and children in making meaningful connections; and emphasize the study of equitable curricular resources and of initial and ongoing teacher professional learning experiences that support teachers in working toward equity and justice in preschool through elementary science and engineering.

SUPPORTING TRANSFORMATIVE SCHOOL AND DISTRICT LEADERS

School and district leaders set the organizational culture and priorities for teachers. Thus, their role is key in transforming science and engineering education for preschool through elementary school. They need to emphasize the importance of science and engineering through policy and management, including structures around instructional time, resources, and staffing. Staffing structures sometimes include the use of science specialists, departmentalization, or team teaching. This could also include integrating science and engineering with other classroom activities.

Education leaders, like teachers, also need professional learning experiences throughout their careers: Those experiences will shape principals' supervision of teachers and thus teachers' opportunities to learn. Professional learning opportunities can be supported and enhanced with science and engineering organizations and universities.

This report recommends that district leaders provide professional learning opportunities for principals, center directors, and other school leaders to enhance leaders' capacity for providing instructional leadership for science and engineering. These professional learning opportunities should focus on science and engineering practices and support leaders in understanding the multiple ways science and engineering are valuable for children.

COMMITTEE ON ENHANCING SCIENCE AND ENGINEERING IN PREKINDERGARTEN THROUGH FIFTH GRADES

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For More Information . . . This Consensus Study Report Highlights was prepared by the Board on Science Education based on the Consensus Study Report, *Science and Engineering in Preschool through Elementary Grades: The Brilliance of Children and the Strengths of Educators* (2021). The study was sponsored by the Carnegie Corporation of New York and the Robin Hood Learning + Technology Fund. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242 or <https://www.nap.edu/author/BOSE/>.

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