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CSAI Update

Early Learning and Science Standards

Standards for early learning (e.g., children ages 0–5; prekindergarten, preschool, and younger) vary widely in their technical quality and specificity. The Center on Standards and Assessment Implementation (CSAI) recently conducted a literature review to determine the landscape in early learning standards and science, specifically centered on the topics of engineering and domain-specific learning.

Though many sources noted that inquiry-based learning activities are the natural domain of young children, very few studies or articles refer specifically to engineering or design-based processes and terms. In addition to the literature review, CSAI also conducted a scan of states' early learning standards to determine which states were incorporating more detailed recommendations in science for their early learners.

This report is divided into three sections:

- **References: State Early Learning Science Standards**
- **References: Early Learning and Science Standards**
- **References: Inquiry-Based Learning for Young Children**

Please note that some referenced articles may be located behind paywalls. Additionally, the list of state early learning science standards is not exhaustive.

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References—State Early Learning Science Standards

STATE	SUMMARY	LINK
Arizona	Science begins on p. 127. Published May 2013.	https://cms.azed.gov/home/GetDocumentFile?id=585c4b55aadebe14288f2532
California	Science begins on p. 48. Referred to as 'foundations' rather than standards; non-binding on LEAs or other entities. Research-based discussion on developmentally appropriate content. Focuses on older early learners, four and five years of age. Divided into strands (scientific inquiry, physical, life, earth). Published 2012.	https://www.cde.ca.gov/sp/cd/re/documents/preschoolfoundationsvol3.pdf
Colorado	Divided by specific content strands (physical, life, earth/space).	http://www.cde.state.co.us/sites/default/files/documents/coscience/documents/science_preschool_kindergarten.pdf
Georgia	Science begins on p. 65. Contains indicators for each year from 0 to 5 years old. Adopted 2013.	http://www.gelds.decal.ga.gov/Documents/GELDS_Resource_Guide.pdf
Illinois	Science begins on p. 55. A footnote indicates that the NGSS were consulted in revising these standards. Mentions engineering as part of the scientific process and includes two standards specific to engineering. Has some domain-specific content. Revised September 2013.	https://www.isbe.net/Documents/early_learning_standards.pdf
Maryland	Science begins on p. 91. Includes domain-specific indicators for each year from 1 to 4 years old, followed by Kindergarten and Grades 1 and 2 (but most domain-specific content is for the older group). Adopted 2016.	http://earlychildhood.marylandpublicschools.org/system/files/filedepot/4/msde-pedagogy-report-_appendix_2016.pdf
Massachusetts	Pre-Kindergarten section begins on p. 25 of the full standards document. Adopted 2016.	http://www.doe.mass.edu/stem/review.html Full standards document: http://www.doe.mass.edu/frameworks/scitech/2016-04.pdf Appendix V, The Case for an Integrated Approach in Grades Pre-K–8: http://www.doe.mass.edu/frameworks/scitech/2016-04/AppendixV.pdf Appendix VI, Importance of Science and Engineering in Early Education: http://www.doe.mass.edu/frameworks/scitech/2016-04/AppendixVI.pdf

STATE	SUMMARY	LINK
Minnesota	Contains indicators for each year from 0 to 5 years old, with attention to "specific expectations across the developmental spectrum." Updated May 2017.	http://education.state.mn.us/MDE/dse/early/ind/ Science document: http://education.state.mn.us/mdeprod/idcplg?IdcService=GET_FILE&dDocName=MDE059810&RevisionSelectionMethod=latestReleased&Rendition=primary
Mississippi	Separate standards documents for 3- and 4-year-olds include multiple domains in science (physical, life, science, earth, technology) and inquiry. Adopted 2013.	http://www.mde.k12.ms.us/ESE/EC
Montana	Science begins on p. 67. Includes indicators from infancy through preschool, along a developmental continuum (not tied to particular ages). Broken down by Benchmarks (what the child can do), Indicators (behaviors), and Learning Opportunities (experiences to support development). Adopted 2014.	http://opi.mt.gov/Portals/182/Page%20Files/Early%20Childhood/Docs/14EarlyLearningStandards.pdf
New Hampshire	Science begins on p. 30. Indicators every 9 months from birth to 3 years old, then for 4–5 year olds. Aligned to kindergarten readiness indicators. Adopted 2011.	https://www.dhhs.nh.gov/dcyf/cdb/documents/nh-early-learning-standards.pdf
New York	Divided into separate documents for physical, life, and earth/space. Edited version of NGSS.	http://www.p12.nysed.gov/ciai/mst/sci/nys-p12-science-ls.html
Ohio	Science begins on p. 39. Divided into age bands (infants, young toddlers, older toddlers, pre-k). Divided into domains (inquiry, earth/space, physical, life). Most elements apply to pre-kindergarten only. Adopted 2011.	http://education.ohio.gov/getattachment/Topics/Early-Learning/Early-Learning-Content-Standards/Birth-Through-Pre_K-Learning-and-Development-Stand/ELSD-Cognition-Standards.pdf.aspx

STATE	SUMMARY	LINK
Rhode Island	Indicators at 9 and 18 months, then every year until 5 years old. Adopted 2013.	http://rields.com/wp-content/uploads/2013/08/RIELDS_S_082013.pdf
Tennessee	Document 1 for birth through 48 months. Science begins on p. 19. Adopted 2013. Document 2 for 4-year- olds. Science begins on p. 26. Adopted 2012.	https://www.tn.gov/education/instruction/academic-standards/early-learning-development-standards.html Document 1: https://www.tn.gov/content/dam/tn/education/standards/tnelds/std_tnelds_birth-4yo.pdf Document 2: https://www.tn.gov/content/dam/tn/education/standards/tnelds/std_tnelds_4yo.pdf
Texas	Science begins on p. 101. End of pre-k outcomes. Divided into physical, life, and earth/space. Gives examples of child behavior and teacher instructional strategies. Revised 2015.	https://tea.texas.gov/pkg.aspx

References—Early Learning and Science Standards

The resources in this section discuss the relationship between early childhood development and learning, as well as the landscape of standards and other documentation for young children.

REFERENCE	SUMMARY
Blazer, C., & Miami-Dade County Public Schools. (2012). Pre-kindergarten: Research-based recommendations for developing standards and factors contributing to school readiness gaps. *Information Capsule*, 1201.	This paper reviews the special considerations related to early development and learning, noting the potential drawbacks of attempting to apply standards documents to these areas. It outlines criteria for high quality standards development. It also includes a discussion of program standards, and reasons behind preschool readiness gaps.
DeBruin-Parecki, A., & Slutzky, C. (2016). Exploring pre-K age 4 learning standards and their role in early childhood education: Research and policy implications. Research Report. ETS RR-16-14. *ETS Research Report Series*.	This policy report "presents a national study of pre-K age 4 learning standards" advancing "current knowledge regarding the purpose, history, and development of pre-K age 4 learning standards, comprehensiveness of standards documents, standards-related supports for teachers, and pre-K to kindergarten alignment." The authors found "extensive variation across titles, organization, terminology, and enriching materials." It includes "recommendations to inform state and federal early childhood leaders, education-focused philanthropic foundations, and others in the field of early childhood education."
Hill, R. (2014, June 9). *Should preschools "teach" science?* Retrieved November 07, 2017, from https://www.parentmap.com/article/should-preschools-qteachq-science	This article describes the uneven landscape of preschool standards across various states, with special attention on science.
Neuman, S. B., & Roskos, K. (2005). The state of state pre-kindergarten standards. *Early Childhood Research Quarterly, 20*(2), 125-145. doi:10.1016/j.ecresq.2005.04.010	This article argues that "coherent, quality standards and their benchmarks (indicators) must be solidly grounded in research, and reflect age-appropriate outcomes for young children." It reviews key predictors of early literacy and mathematics achievement and summarizes recommendations from organizations that have examined the quality of state K-12 standards. It also examines how states are organizing their standards and benchmarks in these content domains in early learning. Finally, it highlights benchmarks based on this summary of research that reflect clear, rigorous, and developmentally appropriate expectations for young learners.
Saçkes, M., Trundle, K., & Flevares, L. (2009). Using children's literature to teach standard-based science concepts in early years. *Early Childhood Education Journal, 36*(5), 415-422. doi:10.1007/s10643-009-0304-5	"This paper discusses the benefits and limitations of using children's literature in introducing science concepts to young children. The manuscript also provides an overview of preschool science standards of 12 states and presents lists of appropriate children's literature suitable to use in teaching science concepts targeted in those preschool science standards." The paper identifies common content areas and themes across multiple states, but does not discuss whether they are developmentally appropriate.

References—Inquiry-based Learning for Young Children

The resources in this section address developmentally appropriate scientific practices for young children, with the most popular topic being inquiry-based learning. Several examples of appropriate activities are discussed, with particular attention to children's natural affinity for exploration and its fit with the scientific process.

REFERENCE	SUMMARY
Berger, C. (n.d.). Creating an engineering design process for the preschool classroom. Retrieved November 15, 2017, from http://blog.eie.org/creating-an-engineering-design-process-for-the-preschool-classroom	This article describes the Wee Engineer development process in general terms, referencing an "age-appropriate engineering design process" that gives children the language they need to talk about problem solving.
Bosse, S., Jacobs, G., & Anderson, T. (2009). Science in the early years: Science in the air. *Young Children*, (Vol. 64, No. 5).	This article published by the National Association for the Education of Young Children describes ways to create an environment that promotes science and undertaking in-depth explorations. It contains a section on building language and scientific literacy and some discussion of appropriate activities/concepts according to domain.
Brenneman, K., Stevenson-Boyd, J., & Frede, E. C. (2009). Math and science in preschool: Policies and practice (Issue 19, Policy Brief). *Preschool Policy Brief*. National Institute for Early Education Research. Retrieved November 7, 2017, from http://nieer.org/wp-content/uploads/2016/08/20.pdf	This policy brief published by the National Institute for Early Education Research "addresses the development of mathematics and science understanding in preschool children, reviews the current knowledge base on educational practices in these domains, identifies areas that require further study, and outlines recommendations for early education policy in mathematics and science." An extensive bibliography is included.
Conezio, K., & French, L. (2002). Science in the preschool classroom: Capitalizing on children's fascination with the everyday world to foster language and literacy development. *Young Children*, (Vol 57, No. 4).	This article published by the National Association for the Education of Young Children describes science as an approach to an activity and gives examples of activities, such as cooking, that preschool teachers may already be comfortable incorporating into their classrooms. The authors draw from their experience designing an NSF- and USDOE-funded preschool science curriculum.

REFERENCE	SUMMARY
Davis, M. E., Cunningham, C. M., & Lachapelle, C. p. (2017). They can't spell "engineering" but they can do it: Designing an engineering curriculum for the preschool classroom. *Zero To Three*, *37*(5), 4–11.	"Engineering is Elementary (EiE) is a curriculum project of the Museum of Science, Boston, that promotes and supports engineering literacy and educational equity for all children. Building on the success of its award-winning curriculum for grades 1–5, the team has recently turned its attention to Wee Engineer, a research-based engineering curriculum for preschool programs. The cornerstone of the new curriculum is an age-appropriate engineering design process (EDP) that reflects both authentic engineering practices and the pedagogy of the preschool classroom. This article introduces the research and the design decisions behind the Wee Engineer EDP, and highlights how other developmentally appropriate elements in the curriculum support early STEM learning."
Hachey, A., & Butler, D. (2009). Seeds in the window, soil in the sensory table: Science education through gardening and nature-based play. *Young Children*, (Vol. 64, No. 5).	This article published by the National Association for the Education of Young Children describes nature-based play as integrating "motivating and meaningful activity with the three elements of science education – attitude, process skills, and content," and outlines how each of these elements can be implemented in the preschool classroom.
Hoisington, C., & Winokur, J. (2015). Gimme an "E"! *Science & Children, 53*(1), 44–51.	This article identifies ways to organize the classroom to encourage building explorations. It includes specific connection to NGSS DCIs while noting that PEs are not appropriate for this level.
Hollingsworth, H. L., & Vandermaas-Peeler, M. (2017). 'Almost everything we do includes inquiry': Fostering inquiry-based teaching and learning with preschool teachers. *Early Child Development and Care, 187*(1), 152-167. doi:10.1080/03004430.2016.1154049	This pair of studies focuses on preschool teachers' efficacy in teaching science and their inquiry-based teaching practices. A few teachers indicated knowledge of the steps of the inquiry process; after training, some were able to implement the initial steps, but often did not follow through the entire set. Findings highlight the need for professional development around science inquiry.
Lippard, C. N., Lamm, M. H., & Riley, K. L. (2017). Engineering thinking in prekindergarten children: A systematic literature review. *Journal of Engineering Education, 106*(3), 454–474. doi:10.1002/jee.20174	This literature review notes that research regarding engineering in early childhood is limited, yet growing along with interest in this topic. The authors review "research regarding interactions, materials and activities that promote prekindergarten children's engineering thinking, and in turn how this engineering thinking is related to developmental outcomes." Out of more than 2,000 papers, 27 papers pertained to children age five or under and to engineering. They addressed the following research questions: What (a) interactions and (b) materials and activities promote prekindergarten children's engineering thinking? What developmental outcomes are related to children's engineering thinking?

REFERENCE	SUMMARY
McClure, E. R., Guernsey, L., Clements, D. H., Bales, S. N., Nichols, J., Kendall-Taylor, N., & Levine, M. H. (2017). *STEM starts early: Grounding science, technology, engineering, and math education in early childhood.* New York: The Joan Ganz Cooney Center at Sesame Workshop. Retrieved November 15, 2017 from http://joanganzcooneycenter.org/publication/stem-starts-early/	This report "is the culmination of a deep inquiry supported by the National Science Foundation that aims to better understand the challenges to and opportunities in STEM learning as documented in a review of early childhood education research, policy, and practice and encourages collaboration between pivotal sectors to implement and sustain needed changes. The report features research by the FrameWorks Institute on some common misconceptions around early STEM learning, and how reframing the conversation can help the public overcome these often problematic ways of thinking, leading to a greater understanding of the importance of prioritizing and investing in STEM learning opportunities for all children." Section Three notes that "the realms of early technology and engineering are less well understood" or sometimes missing in early childhood, but are often included in young children's activities as less explicit subjects (p. 16). Appendix A, a metaanalysis of NSF awards in STEM, demonstrates that very few projects study the 0–4 age group, and many of those projects focus on Math. No projects focused on engineering exclusively for this age group.
Moomaw, S., & Davis, J. A. (2010). STEM comes to preschool. *YC Young Children, 65*(5), 12–18.	This article focuses on an integrated approach, but does specify that "physics and engineering interest begins early" when describing activities with pendulums and inclines.
National Research Council. 2007. *Taking science to school: Learning and teaching science in grades K-8*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11625	Chapter 3 "reviews research on young children and provides an overview of the knowledge and skills they bring to school which provide a foundation for learning science." This paper suggests that a strand framework should be introduced at the kindergarten level (p. 52), and notes skills/knowledge that children should have by the end of preschool, not earlier. It covers physics, biology, psychology, substances and their transformations (chemistry), earth systems and cosmology, and scientific reasoning.
Piasta, S. B., Pelatti, C. Y., & Miller, H. L. (2013). Mathematics and science learning opportunities in preschool classrooms. *Early Education and Development, 25*(4), 445–468. https://doi.org/10.1080/10409289.2013.817753	This study observed and coded instruction in preschool classrooms to determine amount and type of math and science learning opportunities experienced by preschool children. Researchers observed wide variability in the number and quality of these opportunities, and noted that high quality math and science experiences to all preschool children may require additional professional development for their teachers. The authors note that the majority of science learning opportunities focused on investigation and observation skills, the living world (animals, plants, humans), and the physical world (seasons, weather, magnetism, recycling/environmental issues) (p. 10).

REFERENCE	SUMMARY
U.S. Department of Education. (2017, June 28). Let's Talk, Read, and Sing about STEM! Retrieved November 07, 2017, from https://www2.ed.gov/about/inits/ed/earlylearning/talk-read-sing/index.html	This toolkit created by the U.S. Departments of Education and Health and Human Services, in partnership with Too Small to Fail, features tip sheets for families, preschool teachers, and infant/toddler teachers on "easy ways to incorporate STEM concepts and vocabulary into everyday routines, and suggestions for activities to engage young children in STEM learning."
Worth, K. (2010). Science in early childhood classrooms: Content and process. Retrieved November 07, 2017, from http://ecrp.uiuc.edu/beyond/seed/worth.html	This conference paper from SEED (STEM in Early Education and Development) "addresses the question of what the nature of science teaching and learning in the early childhood classroom should be. It proposes four basic ideas: (1) doing science is a natural and critical part of children's early learning; (2) children's curiosity about the natural world is a powerful catalyst for their work and play; (3) with the appropriate guidance, this natural curiosity and need to make sense of the world become the foundation for beginning to use skills of inquiry to explore basic phenomena and materials of the world surrounding children; and (4) this early science exploration can be a rich context in which children can use and develop other important skills, including working with one another, basic large- and small-motor control, language, and early mathematical understanding. The paper describes a structure for learning through inquiry and criteria for the selection of appropriate content for young children. It concludes with a discussion of implications for the classroom, focusing on child-centered curriculum, the role of materials, the use of time and space, the key role of discussion and representation, and the teacher's role." The paper includes a diagram of the inquiry process of young children.

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REFERENCE	SUMMARY
Worth, K., & Grollman, S. H. (2009). *Worms, shadows, and whirlpools: Science in the early childhood classroom*. Retrieved November 7, 2017, from http://files.eric.ed.gov/fulltext/ED481899.pdf	"This book offers guidance in integrating inquiry-based science into the early childhood curriculum, focusing on content and providing examples of the work of children and teachers from a variety of early childhood settings, including Head Start, kindergarten, day care, and preschool programs. Part 1 of the book provides an overview of important characteristics of a high-quality science program for children ages 3 to 5 and some of the important tasks teachers perform to make it a reality. Part 2 concerns the content of science education for young children and begins with a chapter on inquiry, describing the important skills, ways of thinking, and attitudes that are at the heart of scientific understanding and at the core of an effective early childhood science program. Chapters follow on life, physical, earth, and space sciences. Each of these four chapters begins with an overview of the science concepts and ideas that should guide the development of science curriculum for young children, followed by composite stories drawn from early childhood classrooms that illustrate critical aspects of science content and science teaching. Each story is accompanied by a commentary highlighting particular teaching strategies and child learning. Part 3 of the book includes questions that practitioners frequently ask about inquiry-based science in early childhood classrooms, including the relative importance of science content versus science inquiry skills, the role of child-initiated activity and children's play, and the place of science in a curriculum focused on literacy, mathematics, and social skills." This book contains chapters devoted to separate domains (inquiry, life, physical, earth/space).

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