Connecticut State Department of Education Evidence-Based Practice Guide

Supporting Local Education Agencies' (LEA) Use of ESSA Title Funds

Science

DRAFT

Under ESSA, there are four tiers, or levels, of evidence. Throughout this guide, the level indicator key is used to identify the evidence level at a quick glance.

Tier	Evidence Level	Evidence Descriptor
1	Strong Evidence	Supported by one or more well-designed and well-implemented **randomized control experimental** studies.
2	Moderate Evidence	Supported by one or more well-designed and well-implemented **quasi-experimental** studies.
3	Promising Evidence	Supported by one or more well-designed and well-implemented **correlational** studies.
4	Demonstrates a Rationale	Practices that have a well-defined **logic model** or **theory of action**, are supported by research, and have some effort underway to determine their effectiveness.

Interventions applied under Title I, Section 1003 (School Improvement) are required to have strong, moderate, or promising evidence (Tiers 1-3) to support them. All other programs under Titles I-IV can rely on Tiers 1-4.

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Systems

The Connecticut State Department of Education adheres to research supporting school-wide, systemic, multi-tiered approaches to science instruction, including screening, intervention, progress monitoring and fidelity of implementation.

Evidence-based practice and rationale	Grade band	Evidence level and source
Teach Next Generation Science Standards (NGSS) Scientific and Engineering Practices (SEP's), Discipline Core Ideas (DCI's), and Cross-Cutting Concepts (CCC's) using a developmental progression. *The use of 3-Dimensional Science teaching and learning will be the basis of all future science education.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Corcoran, Thomas B.; Mosher, Frederic A.; and Rogat, Aaron. (2009). Learning Progressions in Science: An Evidence-Based Approach to Reform. *CPRE Research Reports.*
	K-5	**Tier 2, Moderate** **Source**: Schwarz, Christina V.; Reiser, Brian J.; Davis, Elizabeth A.; Kenyon, Lisa; Acher, Andres; Fortus, David; Shwartz, Yael; Hug, Barbara; Krajcik, Joe (2009). Developing a learning progression for scientific modeling: Making scientific modeling accessible and meaningful for learners. Journal of Research in Science Teaching 46(6): 632-654. http://hdl.handle.net/2027.42/63556
Use progress monitoring. *By continually monitoring a child's progress, teachers can gather the information they need to match lessons to an individual child's knowledge level.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** National Research Council. 2014. Developing Assessments for the Next Generation Science Standards. **Washington, DC: The National Academies Press.** https://doi.org/10.17226/18409.
	K-5	**Tier 2, Moderate** **Source:** Gersten, R., Compton, D., Connor, C.M., Dimino, J., Santoro, L., Linan-Thompson, S., and Tilly, W.D. (2008). Assisting students struggling with reading: Response to Intervention and multi-tier intervention for reading in the primary grades. A practice guide. (NCEE 2009-4045). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.
	K-5 **6-8** **9-12**	**Tier 1, Strong** **Source:** Using Progress Variables to Interpret Student Achievement and Progress (BEAR Technical Report No. 2006-12-01) (2007).

Evidence-based practice and rationale	Grade band	Evidence level and source
Provide explicit and systematic intervention instruction. *Struggling students should receive explicit instruction to ensure that they have the foundational skills and conceptual knowledge necessary for understanding grade-level content.*	**9-12**	**Tier 1, Strong** **Source:** Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2008). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. Science Education, doi: 10.1002/sce.20328
	K-5 **6-8** **9-12**	**Tier 1, Strong** **Source:** National Research Council. 2005. How Students Learn: History, Mathematics, and Science in the Classroom. Washington, DC: The National Academies Press.
	K-12	**Tier 4, Demonstrates a Rationale** **Source:** National Research Council. 2015. Guide to Implementing the Next Generation Science Standards. Washington, DC: The National Academies Press. https://doi.org/10.17226/18802
Dedicate time each day to teaching science, and integrate science instruction throughout the school day. Begin formal Science education in Kindergarten. *Current science objectives should be coordinated with activities in the classroom and lessons in other subject areas so children can master skills and extend concepts.*	**K-8**	**Tier 1, Strong** **Source:** National Research Council. 2008. Ready, Set, SCIENCE!: Putting Research to Work in K-8 Science Classrooms. Washington, DC: The National Academies Press. https://doi.org/10.17226/11882
	K-8	**Tier 1 Strong** **Source:** McClure, E. R., L. Guernsey, D. H. Clements, S. N. Bales, J. Nichols, N. Kendall-Taylor, and M. H. Levine. 2017. STEM starts early: Grounding science, technology, engineering, and math education in early childhood. New York: The Joan Ganz Cooney Center at Sesame Workshop
	K-5	**Tier 1, Strong** **Source:** NSTA Position Statement on Elementary Science https://www.nsta.org/about/positions/elementary.aspx
	K-5	**Tier 2, Moderate** **Source:** Cervetti, G. N., J. Barber, R. Dorph, P. D. Pearson, and P. G. Goldschmidt. 2012. The impact of an integrated approach to science and literacy in elementary school classrooms. *Journal of Research in Science Teaching* 49(5): 631–658

Instructional Practice

The Connecticut State Department of Education adheres to research that supports the explicit instruction practices of conceptual understanding, procedural skill and fluency and application in science.

Evidence-based practice and rationale	Grade band	Evidence level and source
Asking Questions and Defining Problems *A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Osborne, J.F., Collins, S., Ratcliffe, M., Millar, R., and Duschl, R. (2003). What "ideas about science" should be taught in school science?: A Delphi study of the "expert" community. *Journal of Research in Science Teaching, 40*(7), 692-720 **Tier 1, Strong** **Source:** National Research Council. 2007. Taking Science to School: Learning and Teaching Science in Grades K-8. Washington, DC: The National Academies Press.
Developing and Using Models *A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Nercessian, N. (2008). Model-based reasoning in scientific practice. In R.A. Duschl and R.E. Grandy (Eds.), Teaching Scientific Inquiry: Recommendations for Research and Implementation (pp. 57-79). Rotterdam, the Netherlands: Sense. **Tier 1, Strong** **Source:** Lehrer, R., and Schauble, L. (2006). Cultivating model-based reasoning in science education In R.K. Sawyer (Ed.), The Cambridge Handbook of the Learning Sciences (pp. 371-187). Cambridge, England
Planning and Carrying Out Investigations *Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Duschl, R.A., Bybee, R.W. Planning and carrying out investigations: an entry to learning and to teacher professional development around NGSS science and engineering practices. IJ STEM Ed 1, 12 (2014) doi:10.1186/s40594-014-0012-6 **Tier 4, Demonstrates a Rationale** **Source:** STEM Teaching Tools, http://stemteachingtools.org/brief/19

Evidence-based practice and rationale	Grade band	Evidence level and source
Analyzing and Interpreting Data *Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.*	**K-5** **6-8** **9-12**	**Tier 2, Moderate** Source: Egger, Anne E., and Carpi, Anthony (2008) Data Analysis and Interpretation, Visionlearning Vol. POS-1 (1) **Tier 4, Demonstrates a Rationale** **Source:** Cheryl A. McLaughlin, Cheryl A. (2013) Engaging Middle School Students in the Analysis and Interpretation of Real-World Data. Science Scope. Vol.37. No.3 http://www.naturalinquirer.org/UserFiles/File/McLaughlin%20Reprint.pdf **Tier 1, Strong** **Source:** Metz, Steve, (2014) Analyzing and Interpreting Data. The Science Teacher. Volume: 81.8 **Tier 1, Strong** **Source:** Gott, R., Duggan, S., and Roberts, R. (2008). Concepts of Evidence and Their Role in Open-Ended Practical Investigations and Scientific Literacy Durham, England: Durham University **Tier 2, Moderate** **Source:** Zucker, Andrew A.; Tinker, Robert; Staudt, Carolyn; Mansfield, Amie; Metcalf, Shari, Learning Science in Grades 3-8 Using Probeware and Computers: Findings from the TEEMSS II Project Journal of Science Education and Technology, v17 n1 p42-48 Feb 2008
Using Mathematics and Computational Thinking *In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships*.	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** National Research Council. 2013. The Mathematical Sciences in 2025 Washington, DC: The National Academies Press. https://doi.org/10.17226/15269 **Tier 2, Moderate** **Source:** Ogborn, J., Kress, G., Martins, I., and Mcgillicuddy, K. (1996). Explaining Science in the Classroom Buckingham, England: Open University Press

Evidence-based practice and rationale	Grade band	Evidence level and source
Constructing Explanations and Designing Solutions *The products of science are explanations and the products of engineering are solutions.*	**K-5** **6-8** **9-12**	**Tier 2, Moderate** **Source:** Ogborn, J., Kress, G., Martins, I., and Mcgillicuddy, K. (1996). Explaining Science in the Classroom Buckingham, England: Open University Press **Tier 1, Strong** **Source:** Duit, R. (1991). On the role of analogies and metaphors in learning science Science Education, 75(6), 649-672
Engaging in Argument from Evidence *Argumentation is the process by which explanations and solutions are reached.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Chi, M. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. Topics in Cognitive Science, 1, 73-105 **Tier 1, Strong** **Source:** Resnick, L., Michaels, S., and O'Connor, C. (2010). How (well-structured) talk builds the mind. In R. Sternberg and D. Preiss (Eds.), From Genes to Context: New Discoveries about Learning from Educational Research and Their Applications (pp.163-194). New York: Springer

Evidence-based practice and rationale	Grade band	Evidence level and source
Obtaining, Evaluating, and Communicating Information *Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Norris, S., and Phillips, L. (2003). How literacy in its fundamental sense is central to scientific literacy. Science Education, 87, 224-240 **Tier 2, Moderate** **Source:** Lemke, J. (1998). Multiplying meaning. In J.R. Martin and R. Veel (Eds.), Reading Science (pp. 87-113). London, England: Routledge **Tier 1, Strong** **Source:** Tenopir, C., and King, D.W. (2004). Communication Patterns of Engineers. Hoboken, NJ: Wiley **Tier 2, Moderate** **Source:** Council of Chief State School Officers and National Governors Association. (2010). Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects. http://www.corestandards.org/assets/CCSSI_ELA Standards.pdf [June 2011] **Tier 2, Moderate** **Source:** Yarden, A. (2009). Reading scientific texts: Adapting primary literature for promoting scientific literacy. Research in Science Education, 39(3), 307-311

Professional Learning

The Connecticut State Department of Education the following evidence-based models of teacher professional learning that is collaborative, ongoing and deepens teachers' content and pedagogical knowledge.

Evidence-based practice and rationale	Grade band	Evidence level and source
Provide professional learning that is intensive, ongoing and connected to practice. *Intensive professional learning that includes applications of knowledge to teachers' planning and instruction influences teaching practices and leads to gains in student learning.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad. Dallas, TX. National Staff Development Council
Align professional learning with school priorities and goals. *Professional learning that is an integral part of a larger school reform effort is more effective than isolated professional learning activities.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad. Dallas, TX. National Staff Development Council
Focus on student learning and the teaching of specific curriculum content. *Professional learning is most valuable when it provides opportunities to do hands-on work that builds the knowledge of academic content and how to teach it to students.*	**K-5** **6-8** **9-12**	**Tier 4, Demonstrates a Rationale** **Source:** National Research Council. 2015. Guide to Implementing the Next Generation Science Standards. Washington, DC: The National Academies Press. https://doi.org/10.17226/18802 **Tier 1, Strong** **Source:** Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad. Dallas, TX. National Staff Development Council

Evidence-based practice and rationale	Grade band	Evidence level and source
Build relationships among teachers. *The benefits of productive relationships include better instruction and more success in solving the problems of practice.*	**K-5** **6-8** **9-12**	**Tier 1, Strong** **Source:** Wei, R. C., Darling-Hammond, L., Andree, A., Richardson, N., Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad. Dallas, TX. National Staff Development Council
Implement Professional Learning Communities (PLC). *PLCs affect both teaching practice and student achievement when there is collaboration, focus on student learning, and continuous teacher learning.*	**K-5** **6-8** **9-12**	**Tier 2, Moderate** **Source:** Vescio, V., Ross, D., Adames, A. (2007). A review of research on the impact of professional leaning communities on teaching practice and student learning. Teaching and Teacher Education, Vol. 24, Issue 1, Jan.2008. 80-91.
Provide instructional coaching. *Effective instructional coaching has the structural conditions that support coaching, a guided, content-based focus, and instructional leadership by the coaches.*	**K-5** **6-8** **9-12**	**Tier 2, Moderate** **Source:** Instructional Coaching: Professional Development Strategies That Improve Instruction. Annenberg Institute for School Reform

Extended Learning

The Connecticut State Department of Education supports evidenced-based models of extended learning that focuses on scientific content and skills to reduce learning loss and the achievement gap.

Evidence-based practice and rationale	Grade band	Evidence level and source
Maximize student attendance and participation. *Student participation is affected by issues of access and convenience, as well as by the adequacy and attractiveness of the services and features provided in the program. Minimize the barriers to participation, especially for the students most in need of program services and most likely to benefit from them.*	**K-5** **6-8**	**Tier 4, Demonstrates a Rationale** **Source:** 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
	K-5 **6-8** **9-12**	**Tier 4, Demonstrates a Rationale** **Source:** Structuring Out-of-School Time to Improve Academic Achievement (NCEE 2009-012)
Adapt instruction to individual and small group needs. *Supplementing learning from the school day and providing targeted assistance to students whose needs extend beyond what they can receive in the classroom instruction must be focused and targeted. Closely aligning the content and pacing of instruction with student needs will result in better student performance. Determining the right level of difficulty and pace and the most appropriate skills to teach is critical to effectively individualizing instruction.*	**K-5** **6-8** **9-12**	**Tier 4, Demonstrates a Rationale** **Source:** Structuring Out-of-School Time to Improve Academic Achievement (NCEE 2009-012)
Use an assessment system to improve quality. *Formative, interim and summative evaluations are instrumental in any program improvement effort. Programs should have internal mechanisms to monitor staff performance, collect data related to program implementation, and conduct independent evaluations of program implementation and student impact.*	**K-5** **6-8** **9-12**	**Tier 4, Demonstrates a Rationale** **Source:** National Research Council. 2014. *Developing Assessments for the Next Generation Science Standards.* Washington, DC: The National Academies Press. https://doi.org/10.17226/18409
		Tier 4, Demonstrates a Rationale **Source:** Structuring Out-of-School Time to Improve Academic Achievement (NCEE 2009-012)