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STEM instructional improvement efforts that benefit students

Findings from meta-analyses of Pre-K – 12 STEM professional development and curriculum programs reveal best practices for the type, focus, and format of programming.



A summary of findings from
Lynch and colleagues,
2019 and 2024

This report summarizes findings from:

Lynch, K., Hill, H. C., Gonzalez, K. E., Pollard, C. (2019). Strengthening the research base that informs STEM instructional improvement efforts: A meta-analysis. *Educational Evaluation and Policy Analysis*, <https://doi.org/10.3102/0162373719849044>

Lynch, K., Gonzalez, K., Hill, H. C., & Merritt, R. (2024). A meta-analysis of the experimental evidence linking mathematics and science professional development interventions to teacher knowledge, classroom instruction, and student achievement. EdWorkingPaper: 24-1023, <https://doi.org/10.26300/r79z-tf23>

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Improving STEM education is a top priority in the U.S.

The science, technology, engineering, and mathematics (STEM) workforce accounts for 24% of the total U.S. workforce, up from 21% a decade ago. To support this workforce, estimates suggest the U.S. invests \$12 billion annually towards STEM education.¹

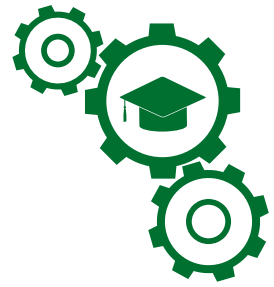
Yet, students' STEM skills across the U.S. are declining: on international assessments of student achievement, for example, 4th and 8th graders scored significantly lower on math assessments in 2023 compared to 2019.²

STEM instructional improvement efforts are a key lever for supporting teachers so that they can improve students' skills across STEM disciplines.

Instructional improvement efforts typically include curriculum materials and professional development programs that aim to improve instructional quality and student learning.



Do instructional improvement efforts work?



In randomized experimental design studies, professional development improved teachers' instructional practices.

SMD = 0.488, 95% Prediction Interval [0.116, 0.860]

An average teacher who received PD would be expected to rank about **19 percentile points higher** on measures of classroom instruction than an average teacher who didn't receive PD.

In experimental and quasi-experimental design studies there was a positive, moderate association between STEM instructional improvements and students' math and science achievement

SMD = 0.21, 95% Prediction Interval [-0.165, 0.583]

86%

There is an 86% chance that implementing STEM instructional improvement efforts in the future will improve student math and science achievement.*

*Assuming the teachers and programs are similar to those included in these meta-analyses.

What are the best practices?

The authors looked for differences across instructional improvement program types, focus, and formats to see if certain approaches were associated with better student learning outcomes.

Approaches linked to the highest levels of student learning outcomes:

The use of professional development combined with new curriculum materials.

Professional development



Curriculum materials

Professional development focused on:



Improving teachers' content/pedagogical content knowledge



Improving teachers' understanding of how students learn



Improving the use of content-specific formative assessment

Professional development structured as:



Meetings to troubleshoot program implementation



Summer workshops to begin the learning process



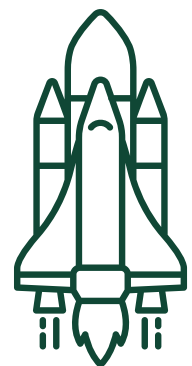
Same-school collaboration among colleagues

What are real-world examples?



Who?	Middle school science teachers
What?	A three-day training to learn about changes to the Investigating Earth Systems curriculum materials
What else?	Teleconferences every two weeks to share implementation challenges and connect with colleagues to share strategies for overcoming challenges ³

Who?	Elementary school teachers
What?	A four-day summer training to learn about the Great Explorations in Math and Science Space Science Curriculum Sequence
What else?	Professional development included activities, discussions, and reflections on pedagogies that underpin student-centered methods to engage students ⁴



Which schools, programs, and student outcomes were included in these studies?

For the 2019 review:

Schools



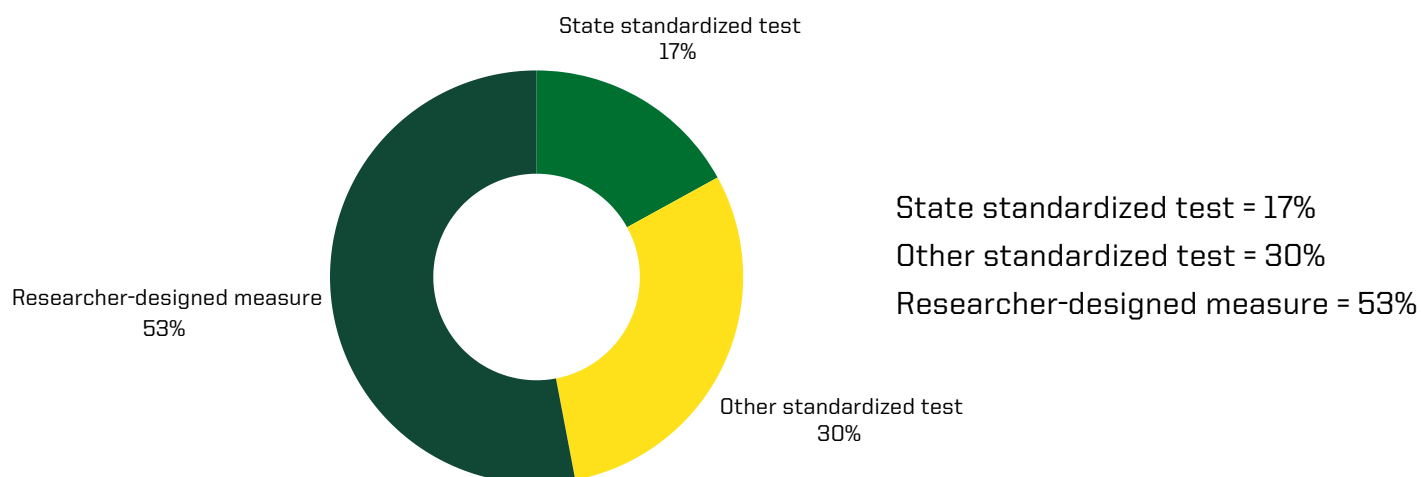
Programs

Study included only professional development: 22%

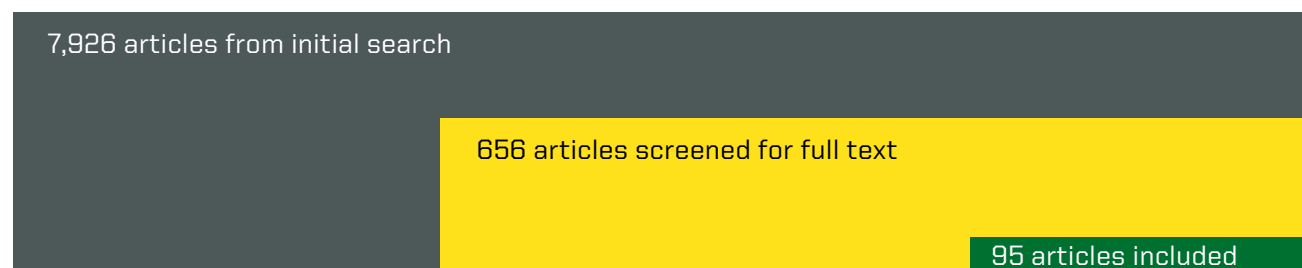
Study included both professional development and new curriculum materials: 75%

Study included only new curriculum materials: 9%

Outcomes



Methods



To account for the nested nature of the data, the meta-analysis used robust variance estimates.

Which schools, programs, and student outcomes were included in these studies?

For the 2024 review*:

Schools

Some studies included multiple grades.

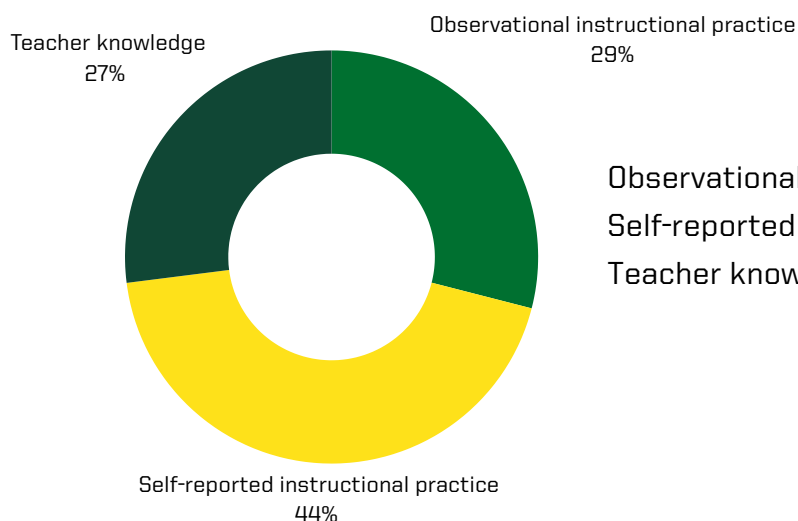


Programs

Study included only professional development: 46%

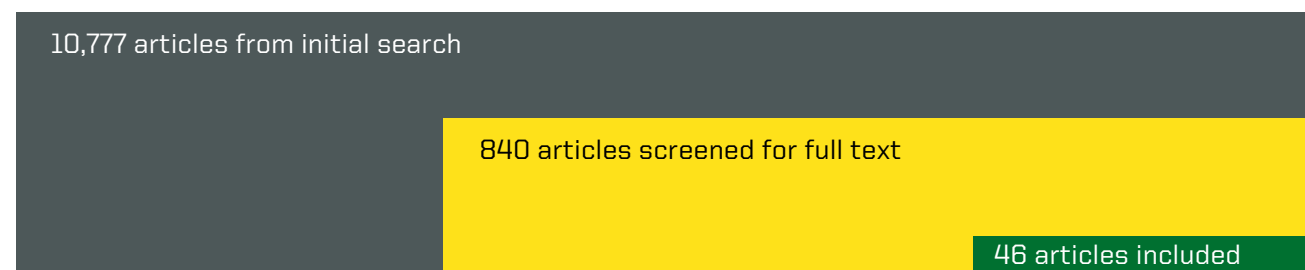
Study included both professional development and new curriculum materials: 54%

Outcomes



Observational instructional practice = 29%
Self-reported instructional practice = 44%
Teacher knowledge = 27%

Methods



*The studies included in the 2019 and 2024 reviews were largely overlapping

Additional Analyses

No other study characteristics were significantly related to outcomes, including whether the study involved one district, multiple districts, and/or states; whether the study was conducted in the United States or abroad; and whether the study was conducted in an urban versus nonurban setting. These results should be interpreted cautiously, however, given limited evidence available for these analyses.

Limitations to note

In both studies, the authors reported findings that indicated potential publication bias in the full sample; however, additional analyses detected potential publication bias only among peer-reviewed studies. The findings summarized here focused on the full sample. In the 2019 review, authors also used codes to capture the rigor of the design as well as aspects of program implementation including potential selection bias, general and differential attrition bias, and selective reporting. The authors noted they were unable to capture other potential sources of bias such as performance and detection bias, or biases stemming from participants' and researchers' knowledge of whether participants were in the treatment or control group.

References:

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4. Granger, E. M., Bevis, T. H., Saka, Y., Southerland, S. A., Sampson, V., & Tate, R. L. (2012). The efficacy of student-centered instruction in supporting science learning. *Science*, 338(6103), 105-108.

For a complete list of references documenting these benefits, see page 3 of the original article.

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The HEDCO Institute for Evidence-Based Educational Practice is dedicated to strengthening connections between research and practice in K-12 education in the United States.

Part of the University of Oregon's College of Education, the HEDCO Institute provides education leaders with relevant, accessible, and reliable information about the latest research so they can implement evidence-informed practices and policies.



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