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THE QUESTION

What is the best way to provide professional learning to teachers when they lack key content knowledge in mathematics?

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Educational leaders have long wrestled with how to help schools meet ambitious science, technology, education and mathematics (STEM) practice standards. Transforming instructional practice to meet those standards requires both teachers and students to re-envision their classroom roles, with students taking greater responsibility for disciplinary thinking and reasoning, and teachers supporting them in doing so. With new science and math standards implementation in full swing, leaders are again challenged to build professional development opportunities that help teachers achieve these goals.

In schools where teachers possess weaker subject matter knowledge, this challenge is heightened. Studies of past standards-based reforms suggest that less knowledgeable teachers may transform investigation-based tasks into direct instruction, represent subject matter as facts and procedures rather than as disciplinary principles and practices, stymie student thinking, or even deliver inaccurate content. For this likely-substantial population of teachers, the learning demands of standards-based reform are steep.

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THE EVIDENCE

The Content Knowledge Approach

To date, scholars have explored two strategies for addressing this problem. One focuses on improving teachers' subject matter knowledge directly, in hopes that better knowledge will support higher-quality enactment of the new standards. In this model, content experts deliver direct instruction on mathematics or science topics, and teachers conduct investigations and solve problems; sometimes, program designers add a secondary focus on content-specific instructional strategies, to help teachers apply their learning in their classroom.

However, studies over the past decade reveal that professional development intended primarily to improve teachers' content knowledge did not consistently promote improved student outcomes. In mathematics, where the majority of such programs occurred, two large studies showed modest improvements in teacher knowledge, very small impacts on classroom practice, and no impacts on student outcomes. Even programs that more equally attended to content knowledge and teaching strategies did not reliably return positive student impacts.

Content Knowledge Through Curriculum Materials

The second strategy involves tackling teachers' content knowledge challenges indirectly, through the curriculum materials used in the classroom. Specifically, STEM programs that feature teacher learning about new curriculum materials see larger positive student impacts than programs that feature only teacher professional development or curriculum materials alone. In a recent study, **colleagues and I** found these programs that combined professional development and new curriculum yield, on average, a ten-percentile-point difference in achievement gains between students in participating and non-participating classrooms. Programs consisting solely of professional development or curriculum materials only yielded a six-point difference. Similar themes have appeared in reviews of the preK literature, as well.

The professional learning programs focused on curriculum materials often allowed teachers several days together to collaboratively work through the materials' investigations, tasks and problems, examine the development of concepts across time, and plan for classroom implementation. Notably, these activities are quite different than the half-day "how to turn the page" workshops typically provided to teachers upon receipt of new materials.

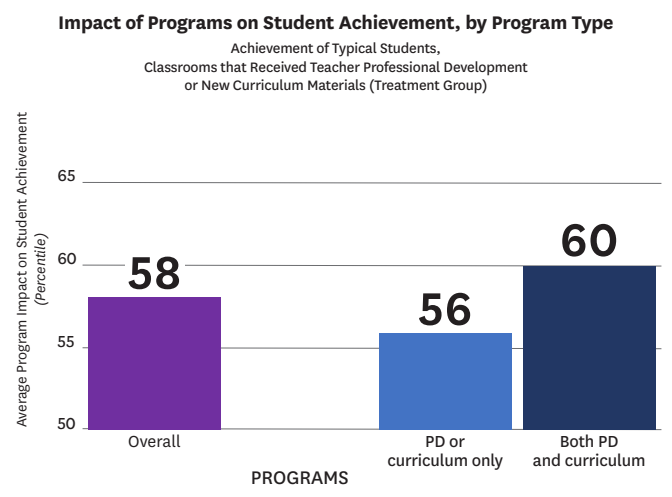
There are likely several mechanisms through which the extended study of curriculum materials works to support student learning. Doing the curriculum's problems and tasks obviously familiarizes teachers with the content and instructional strategies contained in the materials. For instance, while content-focused professional development may communicate the many ways to calculate 35 x 25, curriculum-focused professional development allows teachers to learn the specific calculation methods and the actual representations their textbook uses to teach this topic. And while conventional professional development may familiarize teachers with new standards and instructional strategies, teachers are often told to "do it yourself" when they return to classrooms, constructing new practice from existing materials, or from what they find on the internet. Professional development focused on curriculum materials, by contrast, actually gives teachers something concrete to "bring back" to the classroom to implement standards. In fact, new evidence from a video study of U.S. mathematics classrooms suggests that instructional quality is stronger when teachers use a standard curriculum of any type, rather than cobbling together materials from various sources. Finally, studying new materials with colleagues may also create networks of teachers who collaborate beyond formal professional development to resolve the inevitable hiccups that occur with the implementation of any new program.

Additional Recommendations

The empirical evidence supports a recommendation to focus teachers' learning on the curriculum materials they will use to implement new standards. This goes for both teachers with weaker content knowledge and for those with stronger knowledge, who also benefit from studying new materials. Beyond this recommendation, the research literature provides two other pieces of advice for those interested in supporting standards-based practices and student learning.

First, recent analyses show that some professional development delivery formats seem especially effective. For instance, professional development that took place in a summer workshops was slightly more effective than programs that took place at other times. Programs drawing multiple teachers from the same school, rather than just one or two teachers per school, were also more effective. Finally, programs saw better effects when they featured a meeting after the start of program implementation; these meetings allowed teachers to troubleshoot problems, consult with one another, and talk with a coach or facilitator familiar with the program.

Second, high quality **evidence** suggests that intensive coaching experiences can bring about strong improvements in teacher practice and modest improvements in student outcomes. While most coaching studies take place outside of STEM, these findings suggest the power of 1:1 observation and feedback to teachers.



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*, 0162373719849044.

CONCLUSION

Extended professional development around standards-based materials is likely not the norm in most schools and districts. Prioritizing such professional development will require making space for it, first by removing less effective forms of professional learning, and then by creating processes and routines that help teachers feel comfortable studying the materials they use. Doing so can help increase the chances that teachers will implement standards-based curriculum materials, and implement them well.

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