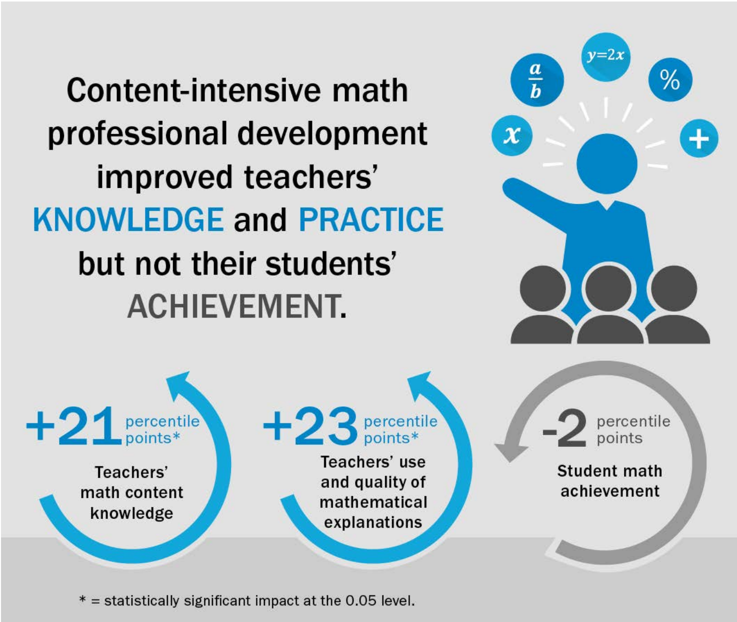
NCEE STUDY SNAPSHOT September 2016

Focusing on teachers' mathematical knowledge:

The impact of content-intensive professional development



A 93-hour professional development program focused on deepening math content knowledge had a positive impact on fourth-grade teachers' knowledge and some aspects of instructional practice. It did not, however, have a positive impact on student achievement. The impacts imply that a teacher with average math knowledge (at the 50th percentile) who receives the professional development would become among the top-third of teachers (with knowledge at the 71st percentile). A teacher who is average at explaining math concepts in class would improve from the 50th to the 73rd percentile.

The policy context

Recent results from national and international assessments continue to show a need for improvement in math achievement among U.S. students. For example, 60 percent of grade 4 students scored below the proficient level on the 2015 National Assessment of Educational Progress.[1]

In an era of increasingly rigorous state standards, teachers at all grade levels face heightened expectations to deepen their students' understanding of math concepts. Teachers may benefit from professional development (PD) that strengthens their own conceptual understanding of math, particularly elementary school teachers who are less likely to formally study math in college than secondary teachers are. To date, there is limited convincing evidence on the effectiveness of intensive, content-focused PD, a gap this study intended to address.

[1] National Center for Education Statistics. (2015). *The nation's report card.* Washington, DC: Institute of Education Sciences, U.S. Department of Education.

Program details

This study examined the implementation and impact of a 93-hour PD program that focused on deepening teachers' general math knowledge but also covered some math knowledge relevant to teaching. The core of the PD was *Intel Math*, an intensive 80-hour workshop delivered in summer 2013 that focused on deepening teachers' knowledge of grades K–8 math.[2] Two additional PD components, *Mathematics Learning Community*[3] and *Video Feedback Cycles,*[4] totaling 13 hours were delivered during the 2013–14 school year to reinforce the math content in Intel Math and help teachers apply the content to improve their instruction. The Mathematics Learning

[2] Intel Foundation. (2009). *Intel Math, Version 2.5*. Santa Clara, CA: Author.

[3] Regional Science Resource Center at the University of Massachusetts Medical School. (2011). *Mathematics Learning Community*. Malden, MA: Commonwealth of Massachusetts, Department of Elementary and Secondary Education.

[4] The Video Feedback Cycle component was based on emerging research on individualized feedback for teachers. For example: Allen, J. P., Pianta, R. C., Gregory, A., Mikami, A. Y., & Lun, J. (2011). An interaction-based approach to enhancing secondary school instruction and student achievement. *Science, 333,* 1034–1037.

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Community involved five structured, 2-hour collaborative meetings in which teachers reviewed math content and analyzed student work on topics covered in Intel Math. The Video Feedback Cycles involved three rounds of individualized, video-based coaching that provided feedback to teachers on the quality and clarity of their mathematical explanations. The feedback was based on video analysis of their lessons using a structured observation rubric called the *Mathematical Quality of Instruction* (MQI).[5]

Study approach

Grade 4 teachers from 94 schools in six districts and five states participated in the study and were randomly assigned within schools to either a treatment group that received the study PD or a control group that did not receive the study PD. The final analysis sample included 165 teachers from 73 schools. The study addressed the following questions:

1. Was the study PD implemented with fidelity? What were the features of the PD as implemented? To what extent did teachers participate in the PD?
2. What was the impact on teachers' content knowledge, teachers' classroom practices, and student achievement of offering content-focused PD relative to business-as-usual PD?

To address these questions, we assessed teachers' math content knowledge in summer 2013 (prior to the study PD), fall 2013 (after Intel Math), and spring 2014 (after the entire study PD was delivered) with an adaptive assessment covering content emphasized by the study PD.

We assessed teachers' instructional practice in fall 2013 and spring 2014 by video-recording three lessons per teacher (instructing their own students), and then rating these lessons using the MQI rubric. The MQI was developed by education professors at Harvard University and the University of Michigan. It was selected because it is a structured rubric that is widely used in studies of classroom math instruction. The MQI uses a 4-point scale to rate three dimensions of instructional practice, which are briefly summarized in Box 1. A score of "not present" indicates that the practice was not present in the classroom. Scores of "low," "mid," or "high" indicate that the practice was present in the classroom at that particular level. For *Richness of Mathematics* and *Student Participation in Mathematics*, "high" scores correspond to the highest quality of instruction. For *Errors and Imprecision*, "high" scores correspond to the lowest quality of instruction because they indicate that errors and imprecision were common and obscured the math in the lesson.

Box 1. Dimensions of instructional practice measured with the MQI

Richness of Mathematics	Emphasizes the conceptual aspects of math, including the use and quality of mathematical explanations
Student Participation in Mathematics	Focuses on teachers' use of student mathematical contributions, explanations, questioning, and reasoning
Errors and Imprecision	Focuses on incorrect, unclear, and imprecise use of math

There were two measures of 4th grade student achievement in spring 2014. The first, administered by the study team in all study districts, was an adaptive assessment aligned with the content covered in the study PD. The second was the state math assessment, which provided policy-relevant test scores.

To better understand teachers' PD experiences and how faithfully the PD was implemented, we administered a teacher survey in spring 2014 and collected a variety of PD implementation data throughout the school year (e.g., PD attendance records).

Findings highlights

The study found that:

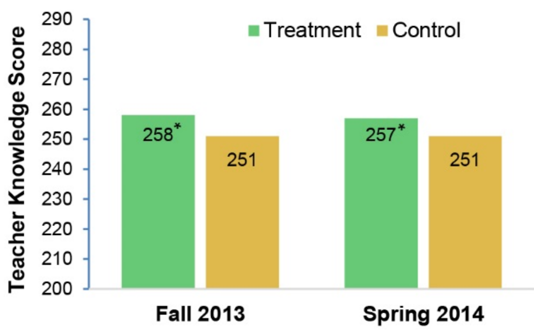
- **The PD was well implemented, with math instructional quality evident most of the time and high rates of teacher participation.** On average, 96 percent of the expected 80 hours of Intel Math and 100 percent of the expected 13 hours of the Mathematics Learning Community and Video Feedback Cycles were delivered. Math instructional quality, measured with the MQI, was evident during most of the whole-

[5] Mathematics Instrument Development Group. (2013). *Mathematical quality of instruction.* Cambridge, MA: Author.

group discussion of math content.[6] On average, treatment teachers participated in more than 90 percent of the delivered hours for each component of the PD program (98 percent of Intel Math, 90 percent of the Mathematics Learning Community, and 97 percent of the Video Feedback Cycles). Overall, treatment teachers reported having participated in 95 more hours of math-related PD than did control teachers during the year of the study.

- **The PD had a positive impact on teacher knowledge.** Treatment teachers' average knowledge score was 7 points higher than control teachers' average score in the fall and 6 points higher in the spring (Figure 1). These differences imply that a typical control teacher would have improved from the 50th percentile to the 74th percentile in the fall and to the 71st percentile in the spring, had the teacher received the study PD.

Figure 1. Teacher knowledge scores

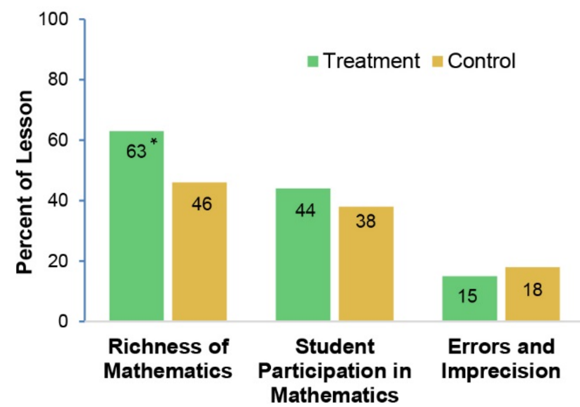


Source: Fall 2013 and spring 2014 teacher knowledge tests (*N* = 73 schools; 79 treatment teachers and 86 control teachers). The teacher knowledge test was based on items created by the Northwest Evaluation Association (NWEA). The scores are reported on the scale used by the test developer, which takes into account the difficulty of individual test items.

* Impact is statistically significant at the 0.05 level, two-tailed test.

- **The PD had a positive impact on teachers' *Richness of Mathematics* in the classroom.** The study measured instructional practice by scoring video-recorded lessons of teachers on the three MQI dimensions of instructional practice (see Box 1). The PD's effect on *Richness of Mathematics* in the spring was statistically significant and positive. An average treatment teacher demonstrated *Richness of Mathematics* at a mid or high level during 63 percent of a typical lesson, compared with 46 percent for an average control teacher (Figure 2).[7] This 17 percent difference corresponds to an improvement of 23 percentile points. The impact on *Student Participation in Mathematics* and *Errors and Imprecision* in the spring were in the expected direction but not statistically significant.

Figure 2. Percentage of an average teacher's lesson demonstrating three dimensions of Mathematical Quality of Instruction



Source: Spring 2014 MQI scores (*N* = 73 schools; 79 teachers and 158 lessons for the treatment group and 86 teachers and 172 lessons for the control group).

* Impact is statistically significant at the 0.05 level, two-tailed test.

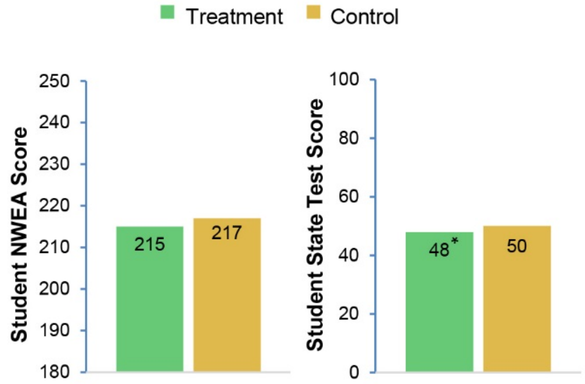
- **Despite the PD's positive impact on some teacher outcomes, the PD did not have a positive impact on student achievement.** On average, treatment teachers' students scored 2 percentile points lower than control teachers' students on both spring 2014 student achievement measures (see Figure 3). The difference between treatment and control group students was statistically significant for the state math assessment but not the study-administered assessment.[8]

[6] "Evident" means that *Richness of Mathematics* and *Student Participation in Mathematics* were present at a low, mid, or high level, while *Errors and Imprecision* were not present.

[7] "Demonstrated" means that teachers were rated at a mid or high level on one or more elements of the *Richness of Mathematics* dimension (e.g., linking representations, mathematical sense-making, multiple procedures or solution methods).

[8] However, the impact on state assessments was sensitive to sample definition and the inclusion of covariates. It was not statistically significant in any of our sensitivity analyses.

Figure 3. Student math scores



Source: Spring 2014 NWEA test (N = 73 schools; 79 teachers and 806 students in the treatment group; 86 teachers and 891 students in the control group). District administrative records of Spring 2014 state test (N = 73 schools; 79 teachers and 1,760 students in the treatment group; 86 teachers and 1,917 students in the control group). The NWEA score is reported on the scale used by the test developer, which takes into account the difficulty of individual test items. The state score is reported as Normal Curve Equivalents, which run from 0 to 100 and are similar to percentile ranks but on an equal-interval scale.

* Impact is statistically significant at the 0.05 level, two-tailed test.

- **Teacher knowledge and instructional practices were generally not correlated with student achievement.** The study PD assumed that teachers' content knowledge is related to instructional practice, which in turn is related to student achievement. Contrary to these assumptions, both knowledge and instructional practice in the study were generally not statistically significantly associated with student achievement (estimates of association between 0.00 and −0.05). The only teacher measure statistically significantly associated with student achievement was the *Errors and Imprecision* dimension of instructional practice (estimates of association between −0.20 and −0.21). A teacher who had higher *Errors and Imprecision* was predicted to have lower-scoring students on both the state and study-administered math assessments.

Concluding thoughts

Together these results show that the study PD improved teachers' knowledge and some aspects of classroom practice but did not improve student achievement. This may be partially explained by the finding that math content knowledge and instructional practice, as measured in this study, were generally not correlated with student math achievement. The one exception to this pattern was *Errors and Imprecision*, on which the study PD did not have a statistically significantly impact. Thus, future research might focus on identifying PD that will improve this aspect of practice. Future research might also seek to identify other aspects of knowledge and practice to target with PD that are more strongly related to improved student achievement.

IES develops these study snapshots to offer short, accessible summaries of complex technical evaluation reports. For the full report with technical details, see http://ies.ed.gov/ncee/pubs/20164010.

Garet, M. S., Heppen, J. B., Walters, K., Parkinson, J., Smith, T. M., Song, M., Garrett, R., Yang, R., & Borman, G. D. (2016). *Focusing on mathematical knowledge: The impact of content-intensive teacher professional development* (NCEE 2016-4010). Washington, D.C.: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.