Building a Knowledge Base for Teaching: Design and Test of Research-based Toolkits for Lesson Study

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This NSF-funded research developed and tested two toolkits designed to deepen the mathematical content of lesson study. The toolkits focused on (1) area of polygons (AOP) and (2) proportional reasoning (PR), and each toolkit of materials contained mathematical problems with student work, research articles, curriculum materials (many of them from high-achieving countries), lesson videos, and tools designed to support lesson study.

The twenty lesson study groups (ten per toolkit) were located in ten districts in five states (California, Florida, Massachusetts, Minnesota, and New York). Groups each used a toolkit to conduct a lesson study cycle in which they studied the assigned mathematical content and its teaching-learning, planned and conducted a "research lesson" to bring to life their ideas about teaching the topic, observed and collected data on student learning, and used the data to refine their ideas about the teaching and learning of the topic.

Lesson study was predicted to impact three areas of teachers' development: mathematical knowledge for teaching; beliefs and learning dispositions; and professional learning community. We located, adapted, revised or developed measures for each component of our conceptual model of lesson study. Pre- and post assessments were administered to all study participants and to comparison teachers recruited by participants from their own settings. A description of the measures and findings for each area of the conceptual model follows.

A. Development of Mathematical Knowledge for Teaching

Scales to measure teachers' knowledge of AOP and PR were developed by drawing items from established assessments (e.g., LMT, 2005, 2007; UCMSP, 2006; IES/NAEP, 2007; items were multiple choice or short-response format). In addition, we developed two open-response tasks (one for each toolkit topic) to supplement the items from established assessments, since available assessments target specific aspects of knowledge that may or may not be the focus of a particular lesson study group's work. The open-response items provide room for teachers to reveal knowledge and formulate ideas rather than respond mainly to pre-formulated alternatives. We also adapted two assessment items asking teachers to rate their own knowledge of the toolkit topics, and examined teachers' written reflections about what they learned from lesson study.

We computed scores for the two knowledge scales drawn from established assessments, and examined score changes from pre- to post-assessment for teachers who used the topic-relevant toolkit versus all other teachers. We found no significant differences between the toolkit-supported lesson study groups and the comparison groups for either toolkit topic. Two-level HLM analyses for each subscale confirmed the lack of association between group toolkit assignment and teachers' mathematical knowledge.

In contrast, the open-response knowledge items indicate that teachers who participated in toolkit-supported lesson study (compared with non-participants and participants in the other toolkit group) added significantly more ideas related to the

mathematical topic studied over the research period. Teachers assigned to the PR toolkit added on average 1.46 new proportional reasoning ideas to their posttest responses, compared to .68 ideas added by comparison teachers; teachers assigned to the AOP toolkit added on average 2.1 area of polygon ideas, compared to 1.3 ideas added by comparison teachers (differences between toolkit and comparison groups are statistically significant for both topics, as measured by t-test). In both cases, the pattern of added ideas for teachers assigned to the toolkits reflected toolkit content, such as multiplicative relationships (for the PR toolkit) and *meaning* of area (for the AOP toolkit). Again, two-level HLM analyses confirmed the finding that for both topics, assignment to a toolkit group was significantly associated with teachers' mathematical knowledge as measured by the open-response tasks.

Regarding teachers' self-ratings of knowledge, teachers in the AOP toolkit group showed significantly greater increases from pre- to posttest in ratings of their AOP knowledge than comparison teachers. PR toolkit users did not show a comparable increase in self-rated PR knowledge.

Teachers' written reflections provide an overview of teachers' self-perceived learning, Coding of these data suggest that teachers' learning was concentrated in the areas of curriculum, pedagogy and student thinking. These areas were not a focus of assessment in the current study, but may be fruitful areas for further research on lesson study.

B. Development of Teachers' Beliefs and Learning Dispositions

A second hypothesized pathway by which lesson study may influence instruction is by shaping teachers' beliefs and dispositions related to improvement of teaching. Three measures of teachers' beliefs and learning dispositions were developed from the survey data:

1. *Interest and Enjoyment in Learning Mathematics* (which included 6 items asking teachers to rate their agreement or disagreement with statements such as 'I enjoy teaching mathematics' and 'I like solving mathematics problems.')
2. *Expectations for Student Achievement* (which included 6 items asking teachers to rate their agreement or disagreement with (reverse coded) statements such as 'My expectations about how much students should learn are not as high as they used to be' and 'No matter how hard I try, some students will not be able to learn aspects of my subject matter.'
3. *Perceived Efficacy of Improvement*, a single item asking teachers to rate their agreement or disagreement with the item, 'By trying a different teaching method, I can significantly affect a student's achievement.'

We found impact of toolkit-supported lesson study on two of the three measures. Teachers in the toolkit groups rated their interest and enjoyment in learning mathematics significantly higher than the comparison teachers at posttest (but not pretest). In addition, teachers in toolkit-supported lesson study groups significantly increased their agreement with the perceived efficacy item from pretest to posttest. HLM analyses for these outcome measures did not reveal any impact of the assignment to toolkit-supported lesson study versus a comparison group.

C. Development of Professional Learning Community

To measure the third area of lesson study impact, we developed a 4-item *Collegial Learning Effectiveness* scale. Teachers rated their agreement or disagreement with statements such as 'I have learned a lot about student thinking by working with colleagues' and 'I find it useful to solve mathematics problems with colleagues.' Teachers in toolkit-supported lesson study groups showed a significantly greater increase in perceptions of collegial learning effectiveness than did teachers in the comparison group. HLM analyses revealed a significant positive association between toolkit-supported lesson study and increased perception of collegial learning effectiveness.

To summarize, toolkit-supported lesson study showed a significant impact on open-response measures of teachers' mathematical knowledge and on teachers' self-rated knowledge of AOP, but not on standardized measures of teachers' knowledge. Toolkit-supported lesson study also showed an impact on teachers' interest and enjoyment in learning mathematics, perceived efficacy, and perceived effectiveness of the collegial learning.

This study was the first systematic, relatively large-scale study to: (1) support lesson study with high-quality mathematics resources; (2) conduct lesson study at a distance from the researchers; and (3) design and apply a model and measures to capture the impact of lesson study. The toolkit's positive impact on some indices of teachers' learning, improvement-related beliefs, and perceived effectiveness of collegial learning suggests important potential for locally-led lesson study supported by mathematical resources.