Session Title:
Preliminary Measures of Secondary Teachers’ Mathematics Pedagogical Content Knowledge

MSP Project Name:
Mathematics Teacher Leadership Center (Math TLC)

Presenters:
Shandy Hauk, WestEd

Authors:
Shandy Hauk, WestEd (Lead)
Allison Toney, University of North Carolina Wilmington (Lead)
Billy Jackson, University of West Georgia
Alisa Breitstein, University of Northern Colorado
David Glassmeyer, University of Northern Colorado

Feedback Session

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Summary:
The Math TLC offers opportunities for current math teachers, including teachers from rural areas, to participate in (1) a distance delivered master’s degree program in mathematics for secondary teachers and/or (2) a mathematics Teacher Leadership program for teachers and district personnel in grades 4-12. Among project goals is enriching participants’ pedagogical content knowledge (PCK). Building on the Learning Mathematics for Teaching project (for K-8 teachers) and earlier work among secondary teachers by the PIs, we are developing written and observational measures of PCK. In this session, we offer epitomizing examples from the instruments, early results from their use pre/post program, and solicit feedback. The focus for the session is the PCK grounded in teachers’ anticipations about student thinking.

Section 1: Description of product, tool, process, curriculum, or instrument:
The instruments are a pair of measurements of secondary mathematics teacher pedagogical content knowledge (PCK) under development by the Math TLC research team. The pair consists of a written test-like instrument and a real-time observation protocol. Both tools are informed by the theory and development of instruments for K-8 teacher pedagogical content knowledge from the Learning Mathematics for Teaching (LMT) project at University of Michigan. Early development of the Math TLC secondary teacher PCK theory development has been reported, (Hauk et al, 2009) in No Teacher Left Behind: Pedagogical Content Knowledge and Secondary Mathematics Teacher Professional Development and is based on a four-part description of fundamental components in PCK that refines the 3-part LMT model. The component names are curricular content knowledge, discourse knowledge, anticipatory knowledge, and implementation knowledge. Unlike the standard linear model underpinning the LMT
instrument for K-8 teachers, the Math TLC design theory is overlapping (non-linear). Each year the written instrument has about 22 items. About half of the items have multiple-choice options only. Each of the other items is accompanied by an open-ended extension that focuses the respondent’s attention on one of three aspects: curricular content knowledge, discourse knowledge, or anticipatory knowledge (note that we do not claim to capture implementation knowledge – a form of action knowledge that must be enacted – on the written instrument).

Over the five years (to date) of its development, the instrument has used original and modified released items from the LMT tests, Educational Testing Service (ETS) primary and secondary teacher Praxis exams, and items reported on in the research literature on advanced mathematics learning. Each item is coded with a triple of zeros and ones (e.g., (1, 0, 0) if only curricular content knowledge is involved, (1, 1, 0) if curricular and discourse knowledge are the focus; (1, 0, 1) where curricular and anticipatory knowledge are foregrounded, etc.).

The research team has followed standard psychometric practices in developing both the written and the observation instruments, including cognitive interviews as part of item development and multi-rater rubric development and calibration. Each revision of the written instrument maintains “equater” items for comparison across administrations. Teachers completing the test have taken a test form as pre/post/post (once per year) across a two-year involvement with the Math TLC (e.g., Form A1 was revised to Form A2 and then to Form A3 for Cohort 1; equated but different tests, Form B1-B2-B3 were completed by Cohort 2). To date, we have data on 20 to 200 responses for each item from project teachers. Upon administration of each form, research team members develop a rubric to score teacher participants’ work. Multiple-choice items received a score of 1 for a correct answer and a score of 0 for an incorrect answer. Open response questions receive a score of 0, 1, or 2, based on a scoring rubric agreed upon by the researcher team. Rubrics are developed, consistent with previous years’ work, at each administration.

Also based on work by the LMT research group, the Math TLC research team has designed an observation protocol (with follow-up interview) for real-time sampling to document teacher implementation knowledge in use as well as the PCK in knowledge of the mathematical terrain enacted in a lesson. The protocol includes teaching practices such as interpreting student work, talking explicitly about ways of reasoning, and encouraging diverse mathematical competencies. It also has discourse knowledge aspects like the type of mathematical language used or encouraged by a teacher in the classroom (academic, technical, and/or general), and directs observers to note when the teacher provides or encourages mathematical descriptions, explanations, and/or justifications. Unlike the LMT project, in which a team of three researchers viewed and reviewed video to analyze and code classroom instruction, our protocol involves pairs or individual members of the research team observing teacher participants teaching in their own classrooms in real-time. The protocol uses a “three minutes on, three minutes off” paradigm, in which the observer watches a teacher’s instruction for three minutes “on”, recording brief notes/checkmarks on the protocol form. Then, during the following three minutes “off,” the observer completes markings for each of 20 categories of observed behavior for the “on” three minutes of instruction. For each 3 minutes “on,” the observer marks one of the following in each of the 20 categories: present and appropriate (PA),
present and inappropriate (PI), not present and appropriate (NPA), or not present and inappropriate (NPI—a code very rarely used, given that only 3 class meetings are observed; appropriateness is highly contextual to classroom norms and 3 observations, generally, is not sufficient to determine what those norms are).

Though not a focus of the session, the observation protocol is accompanied by post-observation interview items that explore teachers’ (1) experiences with mathematics as a student and as a teacher, (2) work within a particular class, as well as the mathematics from the class, and (3) perceptions of students’ experiences with mathematics. Additionally, the observation interview explores the cultural background of the observed classrooms and how the teacher uses this knowledge in preparing lessons.

Section 2: Question, issue, or challenge that is the primary focus of the session:

Driving Question: How do we document change in mathematics pedagogical content knowledge and classroom practice among in-service secondary mathematics teachers when teachers have rich mathematical understanding (grades 7 to 12)? The accepted framing of mathematical knowledge for teaching has centered on the question: What mathematical reasoning, insight, understanding, and skills are required for a person to teach mathematics? Many have worked to develop measures to address this question, most notably Ball and colleagues (Ball, Thames, & Phelps, 2008; Hill, Ball, & Schilling, 2008). In their work they have defined three types of pedagogical content knowledge (PCK): knowledge of curriculum, knowledge of content and students, knowledge of content and teaching. This view, aimed at grades K-8 and knowledge of several things, does not presume a broad and deep existing mathematical background for the teacher. Current theory and measurement tools for PCK do not allow exploration of such questions as: What is the interplay among conceptually-rich mathematical understandings, experience of teaching, and culturally-mediated communication in defining and growing algebra PCK? …proof PCK? …other aspects of secondary mathematics instruction PCK? Other researchers have offered a supplement to the Ball et al. view: it is the idea that for some, PCK is “predicated on coherent and generative understandings of the big mathematical ideas that make up the curriculum.” (Silverman & Thompson, 2008, p. 502). In this framing, PCK grows when a teacher gets better at the transformation of personal and intimate forms of mathematical knowing. Our purpose is to describe and illustrate an unpacking of this idea and our methods of assessing it.

Section 3: Types of people who you think might be most interested in discussing this and offering feedback:

We believe offering instruments and soliciting feedback will be most effective if the audience consists of those who have already struggled with the process of measuring pedagogical content knowledge (e.g., PIs, project directors, and higher education STEM and ED faculty, evaluators, and researchers).

Section 4: How will you structure this session? What is your plan for participant interaction?

The particular focus of feedback is on the challenge of obtaining a useful measure of Anticipatory Knowledge while keeping a keen eye on Discourse Knowledge. Here, “anticipatory knowledge” includes the ways of knowing and thinking that a teacher
brings to bear when planning and instructing that anticipate the challenges of learning. Included in this category is knowledge of student thinking, thought processes, and communication about that thinking. All of these kinds of knowing are related to a teacher’s orientation towards noticing difference (a central aspect of Discourse Knowledge). Key questions here about a teacher’s PCK are: How might students be seen as “other” by the teacher in ways that support or hinder instruction? Is the existence of difference minimized, perhaps to the extent that a teacher over-generalizes about the efficacy of an approach? In what ways are the nuances of difference part of the anticipations by the teacher in planning, instructing, and reflecting on instruction? We will offer participants two examples to illustrate the constructs in action. Vignette 1 represents Teacher Pat in the third year of teaching experience; Vignette 2 represents Pat’s classroom again, after three more years that included professional work related to generating and sustaining conceptually-focused discourse during instruction. Before the vignettes, we provide brief definitions of “anticipatory” and “discourse knowledge” and make a foray into some related ideas in intercultural orientation. These illustrative vignettes are not definitions. They are offered as anchors for discussion and feedback. In sharing the instruments and early results with the audience, we will select 3 exemplar items from the written instrument and 3 from the observation protocol to solicit feedback on how to foreground anticipatory and/or discourse knowledge in item prompts or observation protocol wording.