J Math Teacher Educ (2014) 17:393–395
DOI 10.1007/s10857-014-9285-4

Research into teachers' knowledge and the development of mathematics classroom practices

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Published online: 3 August 2014

Researchers in mathematics teacher education share a commitment to understanding the knowledge and classroom practices of teachers across the professional continuum. Whereas our field has made progress in identifying important domains of teacher knowledge and key pedagogical practices that support students' learning of mathematics, many questions remain about the nature of teachers' knowledge in different domains, how different domains of teacher knowledge relate to one another and to particular pedagogical practices, and how teachers develop the knowledge needed to enact certain practices in the classroom. The articles in this issue of the Journal of Mathematics Teacher Education take on these questions with a focus on two primary areas: teachers' knowledge related to algebra and developing the complex practice of designing questions and organizing mathematical discussions.

Fostering students' algebraic thinking can be challenging, particularly for teachers whose experiences learning algebra were predominated by symbolic procedures and traditional instruction. How do teachers learn to teach challenging subject matter, such as algebra, in meaningful ways? In "Upper Primary School Teachers' Mathematical Knowledge for Teaching Functional Thinking in Algebra," Karin Wilkie reports about a study of teachers' mathematical knowledge for teaching functions, relations, and joint variation. A questionnaire was designed to gather data about teachers' understandings in four domains: specialized content knowledge (SCK), knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of curriculum (KC). Two rubrics were used to analyze teachers' survey responses and characterize their levels of understanding in the four domains. Results of this analysis revealed both strengths and weaknesses in teachers' SCK and KCS, but only weaknesses in the teachers' KCT and KC. The author suggests that perhaps teachers were able to perform SCK tasks successfully by using algebraic procedures but lacked conceptual understandings that might have enabled

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them to demonstrate other forms of knowledge (e.g., demonstrate KCS by interpreting a student's mistake on a task). These findings illustrate the notion that although a teacher's SCK may be strong, his or her KCS or KCT may be weak. Drawing on the idea that strong SCK is not sufficient for effective algebra instruction, Wilkie offers specific suggestions in each of the four domains for professional development designed to enhance teachers' mathematics knowledge for teaching about functions, relations, and joint variation.

How prospective teachers' algebraic knowledge relates to the kinds of questions they ask students is the subject of the article, "Exploring The Relationship Between K-8 Prospective Teachers' Algebraic Thinking Proficiency and the Questions They Pose During Diagnostic Algebraic Thinking Interviews." Leigh van den Kieboom, Marta Magiera, and John Moyer apply an algebraic thinking framework to investigate aspects of prospective teachers' subject matter content knowledge (CK) and pedagogical content knowledge (PCK) and the relationship between them. They did so by examining prospective teachers' own algebraic thinking proficiency, based on analysis of written solutions to 125 algebra tasks, and the types of questions prospective teachers posed during 1-on-1 algebraic interviews with middle school students. The researchers found that the prospective teachers' algebraic thinking proficiency was related to the types of questions they asked of students during interviews. Whereas the prospective teachers found to have higher algebraic thinking proficiency posed probing questions to investigate student thinking or help students clarify their thinking, prospective teachers with lower algebraic thinking proficiency posed only questions classified as checklisting or instructing. Overall, checklisting (prompting) questions made up almost half of the questions that prospective teachers asked, with probing questions making up 18 % of the total questions. With some clear parallels to the findings about teachers' SCK knowledge by Wilkie, these researchers suggest that prospective teachers will need to improve their proficiency with algebraic thinking in order to offer effective instruction to their students. In particular, the authors recommend that an important goal of teacher education should be to help prospective teachers develop their CK along with their PCK so that the two domains are mutually strengthened.

As highlighted by van den Kieboom et al.'s study, posing effective questions is a complex practice for teachers to enact. How might teacher education activities support prospective teachers in learning to pose effective questions to students? In "Using Representations, Decomposition, and Approximation of Practices to Support Prospective Elementary Mathematics Teachers' Practice of Organizing Discussions," Andrew Tyminski, V. Serbay Zamback, Corey Drake, and Tonia Land report about their study of the influence of teacher education activities on prospective teachers' ability to organize a mathematical discussion. The researchers designed a series of activities based on the constructs *representations*, *decomposition*, and *approximations of practice* to help prospective teachers understand and use five practices for orchestrating mathematical discussions. To assess the impact of the methods course activities, the researchers invited prospective teachers to plan a discussion around ten student strategies for solving $349 + 175$ (strategies with which the prospective teachers had worked previously during their methods course) by identifying a goal for the discussion; choosing which student strategies to share, in what order, and why; and creating at least four questions to ask during the discussion. The authors found that the goals written by prospective teachers varied depending on their views of the purpose of a mathematical discussion. All of the prospective teachers' goals included providing opportunities for students to communicate their thinking, while 21 of 47 teachers also expressed a goal of extending student thinking and 12 of 47 aimed to help students make connections within and across strategies. In

selecting student work, the prospective teachers tended to choose efficient, clear strategies that would allow students to make connections. In general, the questions designed by the prospective teachers were consistent with the goals they expressed. Most wrote clarifying and leading questions, with relatively few questions that encourage students to make mathematical connections. Here we see connections to the results of the study of van den Kieboom et al. The authors make several recommendations for revisions to their series of teacher education activities and make a case for the value of focusing teacher education activities on goal setting as a starting point for developing effective mathematical discussions.

The three articles in this issue of JMTE provide novel insights into teachers' knowledge of challenging subject matter (algebra) and the development of a complex pedagogical practice (organizing mathematical discussions). The articles suggest important implications for the design of professional development and teacher education on the basis of empirical findings related to algebra knowledge for teaching (Wilkie), algebraic thinking interviews (van den Kieboom et al.), and teacher education activities intended to help prospective teachers orchestrate mathematical discussions (Tyminski et al.). Further, these reports offer new questions and directions for future research and provide robust frameworks and methodological tools for use in that important work.