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Editorial

Reconceptualizing the Roles of Researchers and Teachers to Bring Research Closer to Teaching

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In this editorial, we elaborate our vision of the changing roles of researchers and teachers in a future world in which research has a much more direct and meaningful impact on practice (Cai et al., 2017). In previous editorials, we have described characteristics of this future world, including setting research agendas based on instructional problems teachers want to solve (Cai et al., 2017a), developing authentic partnerships between researchers and teachers and connecting multiple partnerships to solve common problems (Cai et al., 2017a, 2018a, 2018b), using new technologies to collect and analyze data on the relationships between students' instructional and learning histories that would enable teachers to plan more effective lessons (Cai et al., 2018a, 2018b), taking advantage of connected partnerships and new data-gathering technologies to build a knowledge base accessible to all teachers facing similar instructional problems (Cai et al., 2018a, 2018b, 2018d), and creating new incentives to appropriately reward researchers and teachers for improving the learning opportunities for all students across classrooms within their school district or state (Cai et al., 2017a). We have alluded to the changing roles this vision would require, including researchers developing hypothetical learning trajectories for concepts that are implicated in teachers' instructional problems (Cai et al., 2017b) and teachers accepting professional responsibilities for contributing to knowledge that improves instruction in all classrooms in their district or state rather than just in their own classroom (Cai et al., 2017a). In this editorial, we create a more complete picture of the new professional roles of researchers and teachers in this future world that intertwines research and practice.

Reconceptualizing the Roles of Researchers and Teachers

Reconceptualizing roles means reconsidering how the complementary expertise of researchers and teachers could be blended to solve the most significant instructional problems identified by teachers. Because it can be deceptively easy to make general arguments about redefining the roles of teachers and researchers in a hypothetical future, we believe it is important to dig into the specific details of how those roles would change. To do so, we will build on our previous description of a system of collaboration between teachers and researchers (Cai et al., 2018a). In that system, we described several key phases of work in an example of building up professional knowledge on the teaching and learning of fraction ordering. Here, we will draw on the kinds of work outlined in that system to illustrate how we envision the new roles of teachers and researchers.

Forming Partnerships and Identifying Instructional Problems

Teachers' expertise can play a leading role in identifying and formulating important problems of practice. Teachers directly interact with students around mathematics, and they are well positioned to raise red flags when those interactions consistently go awry or fail to produce the desired outcomes. In the example discussed in our previous editorials, Mr. Lovemath became concerned when his students were unable to complete fraction comparison tasks unless he reminded them about common denominators. He recognized that this was a problem of practice that could potentially benefit from collaborative work. Because teachers are necessarily focused locally, what they see is framed by their students, their lesson, their curriculum, their classroom, and their school. Moreover, teachers' conceptions and beliefs about mathematics, teaching, and learning influence how they perceive and identify instructional problems.

Researchers can provide useful alternative perspectives that shape the way problems of practice are perceived. For example, researchers could bring a focus on important mathematical practices from the *Common Core State Standards for Mathematics* (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) that a teacher might not emphasize because the curriculum does not highlight them. In the case of the fraction-ordering task, Mr. Lovemath's collaborator, Ms. Research, contributed her research-based perspective on the benefits of eliciting and comparing multiple strategies even when a standard procedure (e.g., using common denominators) could be directly taught (Cai et al., 2017b). In fact, because many of the same important problems of practice can be found across classrooms in different contexts, researchers can play a critical role in creating teacher–researcher partnerships. Researchers can connect groups of teachers who are interested in solving the same problems by using their professional networks of educators, their knowledge of district teachers' instructional problems gained from time spent in schools, and new technologies that draw on professional and social-media networks to find teachers looking to solve similar instructional problems. Moreover, because researchers have a unique outsider's perspective that may be broader than that of teachers, they can help assess the compatibility of potential partnerships in terms of both learning goals and contexts (e.g., students with reasonably similar prior knowledge).

In addition, researchers can help teachers identify problems that impede the creation of learning opportunities accessible to all students, problems that are tied to larger issues of class, race, gender, and identity (Langer-Osuna & Esmonde, 2017; Lubienski & Ganley, 2017; Martin, Rousseau Anderson, & Shah, 2017). Mr. Lovemath and Ms. Research could begin addressing these problems by, for example, examining the discourse of students working on a group task. Their collaborative analysis could reveal patterns of participation where some students are positioned as lacking contributions even though their individual work showed that they had useful ideas to share. Identifying such patterns could open up additional instructional strategies that would begin addressing a problem that was more pervasive than Mr. Lovemath expected.

Specifying, Teaching Toward, and Assessing Learning Goals

For us, the aim of every mathematics lesson is to help all students achieve a set of cognitive and noncognitive learning goals (Cai et al., 2017c). To make progress on a problem of practice, the teacher and researcher partners must develop and carefully specify a set of shared learning goals that are not being achieved by all students. To support collaborative efforts to improve students' learning, those learning goals must be carefully analyzed, broken down into subgoals, and organized in logical and empirically valid sequences or learning trajectories. Although this role has often been relegated to curriculum developers and teachers, the decomposition of learning goals into sequences of subgoals that are at a useful grain size draws on theoretical and empirical work in mathematics education—the expertise of researchers. This is legitimate work for researchers to address, and it is a critical role for researchers to play in partnerships (Cai et al., 2017b). In our example, Ms. Research took on this role by identifying subsidiary learning goals required to reach the desired learning goal of understanding and strategically using multiple strategies for fraction comparison.

With a set of well-defined, specific learning goals established, it is important to assess whether students are achieving those goals. To do so, teachers within a partnership need common assessment items to measure and compare students' progress across teachers and to understand how students in different contexts are responding to instruction. The work of designing assessments for classroom use has also often been the province of teachers, curriculum developers, and testing services. However, researchers should have expertise in assessment design and evaluation of this kind and should take a more active role in the creation or adaptation and validation of useful assessments.

Useful assessments will provide information about the effectiveness of particular instructional choices. Connecting students' responses with instructional activities within a classroom can be pursued by teachers and researchers working together, each contributing their special expertise. For example, teachers might assess student responses by looking for different types of errors that students typically make. Researchers might analyze the same responses by characterizing different ways that students think about the concepts. In the framework we have described, these role boundaries begin to break down as teachers and researchers jointly analyze student responses to develop hypotheses about how particular instructional choices might have led to particular student conceptions. To that end, teachers could make use of their professional knowledge of these students and this context (e.g., what these students learned in the previous grade, what knowledge this population of students typically brings with them), and researchers could make use of their research-based knowledge (e.g., common strategies used by students at this grade level to compare fractions).

Useful common assessments employed across classrooms can also reveal the effectiveness of particular instructional choices. Researchers can take the lead in designing and executing a comparison of learning patterns across classrooms where teachers are using, say, different instructional tasks. If students have similar

entry profiles, their responses in different classrooms could be connected to particular instructional activities. Teachers in the same partnerships or teachers in different partnerships who are trying to solve the same instructional problems will likely be interested in learning what kinds of student response profiles are associated with different lesson designs. Teachers and researchers could study these profiles together and generate hypotheses about better solutions that could be tested in future implementations of lessons with the same learning goals.

Studying and Refining Implementation

As we have proposed in earlier editorials, the final phases of collaborative work around problems of practice begin with testing hypotheses generated during earlier phases about a promising set of instructional tasks to help students achieve the target learning goals. Iterations of this phase carefully study different approaches to implementing those tasks. Teachers bring to this process a deep knowledge of their students. This knowledge can inform the collaborative partners about their students' current ways of thinking about related concepts, about the relevant proficiencies students might bring to these tasks, and about the specific enactment of the instructional activities that might be most effective. Researchers would bring ideas about how to compare the outcomes of different enactments across classrooms by capturing critical differences in enactments, designing common assessment items sensitive to these different enactments, and interpreting different student responses that might be associated with these different enactments.

Teachers and researchers could then jointly generate hypotheses about how different aspects of lesson enactment create different learning opportunities for students. Together, teachers and researchers could decide on the most promising enactments—those that might work best for different students. They could then refine the instruction and begin to generate additional and increasingly nuanced hypotheses about the contexts and conditions under which the enactments should be tested and refined in future iterations.

A Summary of Roles

The new professional roles played by teachers and researchers enable them to apply their unique areas of expertise as well as to blend their knowledge to improve teaching and learning in ways neither could do alone. With the aim always in sight—to conduct research that solves teachers' instructional problems—we can summarize the new roles that researchers and teachers play in this new world. Table 1 specifies the roles that we believe will help teacher–researcher partnerships close the research–practice gap.

The roles specified in Table 1 assume that the community has not yet established an extensive knowledge base that could be accessed to address particular instructional problems. Over time, the professional knowledge base will become a repository for large-scale, longitudinal data on instruction and students' mathematical thinking and learning in a wide variety of contexts (Cai et al., 2018d). When such a knowledge base begins to appear, the roles played by researchers and

teachers might change in some ways. This might be especially relevant for researchers who are interested in studying the issues surrounding instructional problems in a broader sense. The knowledge base would represent a rich resource for the development of empirically based learning trajectories for students with specified profiles, cross-context comparisons that afford testing hypotheses about the effects of particular classroom conditions, contextual variables critical for sustaining continuous improvement of teaching, and data to conduct retrospective conceptual replications (Cai et al., 2018c).

Changes to the Training of Teachers and Researchers

To fully take on these new roles, researchers and teachers would need to be trained differently than they are now. Although teachers are already equipped to play some of

Table 1
Roles of Researchers and Teachers in New Productive Partnerships

Researchers	Teachers	Joint work
• Help create partnerships by identifying teachers who face similar instructional problems	• Identify persistent instructional problems	• Define precisely the instructional problem
• Unpack mathematical concepts targeted by the instructional problem and create learning trajectories	• Implement instruction from planned lessons	• Identify learning goals implicated in the problem
• Synthesize relevant research	• Anticipate students' needs and responses	• Situate the learning goals in a learning trajectory
• Propose options for the kinds of data that could be collected on student learning	• Adapt instruction so that all students experience the same learning opportunities	• Apply available research to help solve the problem
• Collect data across classrooms and search for patterns	• Collect data on students' learning using common formative assessments	• Formulate hypotheses about learning opportunities needed to solve the problem
• Provide an outsider's holistic and broad perspective	• Propose suggestions for improving the lesson for students	• Plan lessons to create the identified learning opportunities
	• Provide an insider's nuanced and reality-based perspective	• Create common assessment items to be used within and across classrooms
		• Analyze data to revise hypotheses and refine lessons

the roles we have described, other roles require different training. Similarly, researchers' training currently equips them to play some, but not all, of the roles we have described.

In addition to the typical knowledge and skills they now acquire, researchers would need to learn how to orient themselves to problems of practice. They would need to commit to collaborating with teachers to solve these problems rather than focusing solely on their own broader research interests. This would require training in decomposing learning goals into subgoals and using these decompositions to hypothesize learning trajectories that include the targeted learning goals as a feature of each trajectory. Researchers would need to acquire a broader set of methodological skills, both qualitative and quantitative, including skills related to creating common valid assessments that allow comparing student learning across classrooms, detecting patterns in these cross-classroom data, exploring the potential reasons for variations in outcomes, understanding the data characteristics needed to hypothesize and test cause-and-effect relationships between teaching and learning, and writing scientific research reports using the new kinds of data gathered by teacher–researcher partnerships.

In addition to the typical knowledge and skills that teachers now acquire, they would need to learn how to participate in collaborations that work to solve instructional problems. They would need to commit to solving not only their own problems but also those of their colleagues so as to advance the professional practice of teaching. Teachers would need to learn to identify substantive instructional problems, plan and implement different modes of instruction (even when the mode of instruction is not their typical practice), uncover and record their students' thinking during instruction using formative assessments, anticipate student responses to planned instructional activities, and design assessment items that measure students' achievement of specified learning goals.

Major cultural changes are needed to realize these new roles and work practices. For example, as we have suggested before (Cai et al., 2017a), researchers would need to be accountable for improving the learning of all students in their local school district, and they would need to be recognized by the incentive structure in their university for the Improvement Science work required to achieve this goal. Certainly, the work of mathematics education researchers already aims to contribute to the improvement of mathematics education in general. However, the key cultural change lies in researchers becoming more accountable to solve specific problems in teachers' classrooms. Reciprocally, teachers would need to be accountable for improving the learning of all students in their school district, not just that of the students in their class. In addition, teachers would need to experiment with different instructional approaches and see themselves as active members of the profession of teaching. Together, these cultural changes mean that researchers would need to pay attention to specific students in specific classrooms, whereas teachers would need to broaden their view to think about helping not only their students but all students with similar learning needs.

These are cultural changes because they require everyone in the educational system to change their expectations for the kind of work that researchers and

teachers are supposed to do. Cultural changes are difficult and take time to occur, which is why our envisioned world is set in the future. We envision that innovative teacher–researcher partnerships will themselves help promote these cultural changes. In turn, doctoral programs that train researchers and teacher education programs that train teachers will need to make corresponding changes to support these cultural changes. Perhaps this future could be realized sooner if the major paradigms under which educational researchers work were to align with solving teachers' instructional problems. We will complete this series of editorials in January 2019 with a proposal for changing our dominant research paradigms.

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