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Guest Editorial…
Do You Need a PhD to Teach K–8 Mathematics in Ways Respected by the Mathematics Education Community?

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The genesis of this editorial was a conversation about an article in which Ball (1991) provided descriptions of three teachers' approaches to working with their students. In Ball's article, teachers without PhDs in mathematics or mathematics education struggled to engage their students in developing meaningful concepts of mathematics. They could not provide multiple interpretations of concepts—particularly representations that provided concrete explanations or tie-ins to the real world. They demonstrated only stepwise approaches to doing mathematics, clinging tightly to procedures and algorithms, and provided no evidence that they had a deeper understanding of the mathematics. In stark contrast, the same Ball article offered a vignette of Lampert's teaching that illustrated a rich mathematical experience for students. Lampert provided multiple perspectives, introduced multiple representations, and demonstrated a deep understanding of both mathematics and student learning throughout the episode described.

Given the number of articles in the literature painting the 'typical' mathematical experience as one that is impoverished, and the growing body of literature written by PhD researcher-teachers, I wondered, "Do you need a PhD to teach elementary and middle school mathematics in ways that mathematics educators would value?" After all, the Balls, Lamperts, and McClains[1] in the literature offer high-quality mathematics instruction, attend to student thinking, provide opportunities for knowledge construction, and introduce students to a variety of tools they can use later (e.g., visual representations and problem solving strategies). Further, these researcher-teachers seem to have a gift for promoting student thinking and moving an entire class forward by scaffolding lessons, questioning students, and creating a classroom community where learners consider each other's work critically and interact meaningfully. The reality, however, is that not all mathematics teachers have PhDs and it is unlikely that most ever will.[2]

In working through this question both with the graduate students with whom I work and in preparation for this editorial, I have developed some ideas both about researcher-teachers as a "special" group and about why having a PhD might matter. Based on my thoughts I would like to propose two conjectures about researcher-teacher efforts. First, I conjecture that we should consider the way we think about researcher-teachers versus research on/with teachers. Second, I propose that certain features of PhD programs can be applied to teacher professional development and/or undergraduate education to support all teachers in creating richer mathematics learning experiences for their students. This editorial explores these two conjectures in more detail.

Researcher-Teachers as a Special Group

In order to understand some of the unique qualities of the teaching exemplified by researcher-teachers, it is worthwhile to consider why they do what they do so well. There are a variety of factors that impact both the way these people teach and the way we, as consumers of research, read about their teaching. First, researcher-teachers teach well because they have significant knowledge of mathematics and how children learn mathematics. There is no doubt that teachers, with or without PhDs, who have strong pedagogical knowledge and strong content knowledge, create richer

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learning experiences for their students (e.g., Ball, Lubienski, & Mewborn, 2001).

Further, in the process of earning a PhD, researcher-teachers presumably develop reflective dispositions, grapple with their own epistemological beliefs, and define their visions of learning and teaching. This produces teachers who critically examine the world around them and who are introspective in ways that are productive for achieving the classroom environment valued by mathematics education researchers and described in the NCTM Standards (NCTM, 2000). By developing this disposition, researcher-teachers are in a unique position to make critical changes to the classroom environment as needs are identified. Too often, regular classroom teachers do not have the time or skills to analyze formal or informal data about their students and their teaching. In fact, many classroom teachers have only been exposed to the most basic concepts of student learning theory and research. As a result, even if they tried to make sense of the data presented in their classroom, they would be ill-equipped to make important changes based on those data.

In addition, researcher-teachers have some pragmatic luxuries that typical teachers do not have. For example, they usually only teach one subject to one class per day, while a typical elementary teacher might teach four subjects to one class, and a middle school teacher might teach one or two subjects to four or five classes each day. This provides the researcher-teacher with more time for reflection and refinement. To be fair, researcher-teachers typically do have other work responsibilities – they do not simply teach for 50 minutes and "call it a day." However, their situation is very different from that of a typical classroom teacher. Researcher-teachers have support with the reflection process from others studying the classroom, and often have no additional responsibilities such as conducting parent conferences, developing individualized plans for certain students, and attending the team meetings common in many teachers' daily experience. While this difference should not be viewed or used as an excuse for classroom teachers to avoid improving their practice, it is undeniable that a researcher-teacher's job is fundamentally different from that of the typical classroom teacher.

In addition to teaching expertise and workload, researcher-teachers have some advantages over teachers when participating in others' studies. Unlike most "typical" teachers, researcher-teachers are, by definition, philosophically aligned with and invested in the goals of the research. They already have agreement with the researcher about what good teaching and learning look like – after all, they are typically either the researcher (e.g., Ball, 1990a and Lampert, 2001) or they are a full member of the research team (e.g., McClain in Bowers, Cobb, & McClain, 1999). The importance of this is profound. A researcher-teacher wants the *same* (not negotiated or compromised) outcomes as the researcher, because she either is the researcher or is a member of the research team. The researcher-teacher, therefore, attends to those issues and aspects of the classrooms and student learning that are the focus of the research. Further, the researcher-teacher provides unlimited, or nearly unlimited, rich access to her thinking for the research effort because, again, she has a vested interest in capturing that thinking. Thus, teacher and researcher alignment in terms of goals, values, and expectations is important.

One potential disadvantage for researcher-teachers worth noting is the potential for bias to confound the research. After all, the researcher-teacher has a biased view of the teaching being studied because it is her own. Further, because she is invested in the research and because she is a member of the research team, it is possible that her teaching is biased to make the research work. That is, if the researcher is looking for particular aspects of teaching, such as student-teacher interactions, the researcher-teacher may attend to those interactions more in the course of instruction than she would under other circumstances. Clearly, the impact of this on the research is determined by both the research questions and the data collection and analysis techniques used.

Research On/With Teachers

In order to understand the differences between researcher-teacher research and research on or with full-time teachers, it is necessary to explore some of the issues involved with doing research on/with teachers. Research in regular classrooms differs in some significant ways from the researcher-teacher work alluded to in this editorial. To highlight some of these differences, I offer examples from my own experience in working with middle grades mathematics teachers.

One major difference I alluded to is the values a teacher holds. In the course of my career, I have been fortunate to work with several "good" teachers. However, the ways in which they were "good" were direct reflections of their own values and the values of the system within which they were working. Sometimes, they were good in the eyes of the administrators with whom they worked because they

kept their students under control. Sometimes they were good for my research in that their practice had the elements I was interested in, thus making it easier for me to find the kinds of interactions I was looking for in their classrooms. Sometimes they were good in that they were predisposed to reflective practice allowing me, as a researcher, easier access to their ideas through observation and interviews. The quality of the teachers, though, depended on what measure they were held up against and what measures they, personally, felt they were trying to align with.

Another important aspect of working with teachers is a lack of access to certain aspects of their thinking. For example, I have never been able to analyze a data set without thinking, at some point, "I wonder what she was thinking when she did that?" or "Did she not understand what that student was asking?" Acknowledging this lack of access to a teacher's thinking requires researchers to be careful in their analysis of the teacher's actions and beliefs and to explain how thinking and actions are interpreted. Further, at times, such limitations require researchers to analyze situations from their own perspectives as well as from the teacher's perspective to understand a situation.

As a practical example of the influence of researcher and teacher alignment issues, I offer two situations from my own work: one addressing the "good" teacher issue and the other addressing the need to understand the situation from the teacher's perspective. My goal in presenting these two examples is to highlight issues that arise in research with teachers who are not members of the research team. In one study (Orrill, 2001), I worked with two middle school teachers (one mathematics and one science) in New York City to understand how to structure professional development to support uses of computer-based simulations. My goal for the professional development was to enhance teachers' attention to student problem-solving skills in the context of computer-based, workplace simulations. The mathematics teacher was considered to be "good" by her principal and other teachers. In my observations of her classroom, I found that she taught mathematics in much the same way as the "typical" teachers we read about in case study after case study. She offered many procedures but provided inadequate opportunities for students to interact with the content in ways that would allow them to develop deep understanding of the mathematical concepts underlying those procedures. However, this teacher had remarkable skill in classroom management, which was highly valued in her school. Further, she had developed techniques that supported her students in achieving acceptable scores on the New York standardized tests. By these standards, she was considered "good." When she used the simulations I was researching, she maintained the same kinds of approaches, particularly early in the study. She kept students on task and directed them to work more efficiently. Given my goal of understanding how to promote problem solving, her interactions with the students were inadequate and impoverished. She typically did not ask the students questions that provided insight into their thinking and she did not allow them to struggle with a problem. Instead, she directed them to an efficient approach for solving the problem they were working on, which effectively kept them on task and motivated them to move forward. While this presented a challenge to me as the researcher, it would not be fair for me to "accuse" her of being less than a good teacher when she was clearly meeting the expectations of the system within which she worked. This is clearly a case in which there was a mismatch between what I, the researcher, valued and what the teacher and system valued. Had I been researching my own practice or the practice of a research team member, this tension would have been removed.

As a second example, a teacher I have worked with more recently proved a perplexing puzzle for my team as we considered her teaching. A point of particular interest was the teacher's frustration with poor student performance on tests – regardless of what students did in class, a significant number failed her tests. In my analysis of this case, I recognized that this teacher's beliefs about teaching and learning significantly differed from my own. Until I realized this, I was unable to understand the magnitude of the barrier the teacher felt she was facing. At the simplest level, she believed that her role as a good teacher was to present new material and provide an opportunity for students to practice that material. The students' job, in her view, was to engage in that practice and develop an understanding from it. Therefore, when students were not succeeding, she became extremely frustrated since she had presented information and provided opportunities for practice. In her worldview, student success was out of her hands – she had already done what she could to support them. As the researcher in that setting, it was difficult to understand her frustration because I was working from a constructivist perspective. Specifically, I was looking for an environment in which the teacher provided students opportunities to develop their own thinking via an

assortment of models, experiences, and collaborative exchanges. Student test failure, for me, was an indicator that learning was not complete and that students needed different opportunities to build and connect knowledge. It took considerable analysis for me, as a researcher with a different perspective and different goals, to understand how the teacher understood her role and how she enacted her beliefs about her role in the classroom.

My point in these two examples is that in much research there are significant and important differences in the worldviews of the participants and the researcher. These differences can lead to frustrations in data collection, hurdles in data analysis, and, in the worst cases, assessments of the teachers that are simply not fair. For example, in the early 1990's there were many articles written about the implementation of the standards in California (e.g., Ball, 1990b; Cohen, 1990; Wilson, 1990). In many of these cases, the teachers struggled to implement a set of standards that were written from a particular perspective that they did not fully understand. This led to implementations that were far from ideal in the eyes of the researchers who understood the initial intent of the standards. Too often, teachers were presented by researchers as hopeless or inadequate—in contrast, the teachers reportedly perceived themselves as adhering to these new standards. Likely, if the researchers and teachers had philosophical alignment afforded by the researcher-teacher approach the findings would have been tremendously different. After all, had these studies focused on researcher-teachers, the teacher and the researcher would have had a shared understanding of the intent of the standards and had a shared vision of what their implementation should look like.

PhD Program Features That Could Be Useful In Teacher Development

While not all people who hold PhDs are good teachers, certain habits of mind are developed as part of the process of earning a PhD that can significantly impact the learning environment a teacher designs. Given the high-quality of teaching exhibited by the researcher-teachers referred to in this article, it seems likely that there are aspects of the PhD program that could be adapted for teacher professional development.

First, the researcher-teacher typically has developed solid pedagogical knowledge, content knowledge, and pedagogical content knowledge. This comes from having time and encouragement to read about different practices in a focused way, participating in shared discourse with colleagues, conducting research in others' classrooms, and having other similar experiences. This is in stark contrast to the elementary or middle grades teacher who has typically had four years of college—with courses spread across the curriculum—and only limited "life experience" to relate to in the courses that help develop these knowledge areas. Second, one of the most powerful outcomes of earning a PhD is the development of a concrete picture of a desired learning environment that looks beyond issues of classroom management and logistics to focus on the kinds of learning and teaching that will take place. Third, PhDs develop a rich, precise vocabulary aligned with that of the standards-writers and the researchers. In becoming a researcher, the holder of the PhD becomes active in the conversation of the field—meaning that person has developed a refined vocabulary and vision that is shared, in some way, by the field. This is not to say that there is a definitive definition of K-8 mathematics education that is shared across the field of mathematics education, rather that there is a shared way of discussing and thinking about mathematics education that allows a more consistent enactment of standards and practices.

Finally, many researcher-teachers implement or develop a "special" curriculum. In the case of Lampert (2001), the teacher was creating open-ended problems each day to support mathematical topics. In other cases, the research team has developed materials for the researcher-teachers to implement. Often, these materials are far richer than traditional mathematics textbooks. While there may not be a single disposition that could be pulled from the process of earning a PhD that allows researcher-teachers to be successful implementers of non-traditional materials, it is clear that there is something different between PhD-holding researcher-teachers and other teachers. Likely, part of this ability is related to the knowledge constructs the researcher-teachers have that allow them to implement those materials. In my own work, I have found that teachers who are not well-versed in the curricula, who lack conceptual knowledge, or who lack the pedagogical content knowledge to see connections between various mathematical ideas do not know how to utilize these kinds of materials to make the experiences mathematically rich for their students. Clearly, some attention to the aspects of earning a PhD that relate to these dispositions would benefit preservice and inservice teachers.

Teacher Development

While it may not be feasible, or even reasonable, to expect teachers to pursue doctoral degrees, there may be some characteristics of doctoral education that are worthwhile for consideration as components or foci of professional development and undergraduate programs. To frame this section, I want to draw on the work of Cohen and Ball (1999) who have argued that the learning environment is shaped by the interactions of three critical elements: teachers, students, and materials/content. This model assumes that for each element a variety of beliefs, values, and backgrounds work together to create each unique learning environment. Considering the classroom from this perspective is critical to understanding why the solutions to the problems highlighted in research on and with teachers are complex.

What We See Now

A quick overview of my definition of the "typical" classroom may be warranted at this point. Based on the classrooms described in the literature and those I work in, the typical mathematics classroom remains focused on teachers' delivering information to the students, typically by working sample problems on the board. Students are responsible for using this information to work problems on worksheets or in their books. Students are asked to do things like *name the fractional portion of a circle that is colored in* or to work 20 addition or multiplication problems. Many teachers use manipulatives or drawn representations to introduce new ideas to their students. However, their intent is to provide a concrete example and move the students to the abstract activities of arithmetic as quickly as possible or to use the manipulative to motivate the students to want to do the arithmetic. Mathematics learning in these classrooms is more about developing efficient means for working problems than developing rich understandings of why those methods work. Referring back to the Cohen and Ball triangle of interactions, the interactions in these classrooms could best be characterized by what follows. The teacher interprets the materials/content and delivers that interpretation to the students. The students look to teachers as holders of all information. Teachers are to provide guidance when students are unable to solve a problem, to provide feedback about the "rightness" of student work, and to find the errors students have made in their work. The students interact with the materials by working problems. The students may or may not interact with the concepts at a meaningful level – that depends on the teacher and the activity. In these classrooms, success is measured in the number of problems students can answer correctly, often within a specific amount of time.

How Features of PhD Programs May Change This

To enhance the interactions among teachers, students, and materials/content there are a number of elements from doctoral training that may be worth pursuing. First, teachers can use guided reflection as a means to step out of the teaching moment to consider critical aspects of the teaching and learning environment. Through reflection, teachers have the opportunity to align their beliefs and practices (e.g. Wedman, Espinosa, & Laffey, 1998) and to make their intent more explicit rather than relying on tacit "gut instinct" (e.g., Richardson, 1990). The reflective practitioner can learn to look at a learning environment as a whole by considering how students and materials are interacting, looking for evidence of conceptual development, and thinking about ways to improve their own role in the classroom. The researcher-teachers (Ball, Lampert, and McClain) cited in this article all reported using reflection regularly as part of their practice.

Another element of the PhD experience worth consideration is the development of solid content and pedagogical knowledge. Teachers who do not understand mathematics cannot be as effective as those who do. For example, teachers who do not know how to use representations to model multiplication of fractions cannot use that pedagogical strategy in their classrooms. Teachers who lack adequate content or pedagogical knowledge cannot know what to do when a student suggests an approach to solving a problem that does not work—too often the only approach the teacher has is to point out errors to the student and demonstrate "one more time" the "right" way to work the problem. I assert that combining teacher development of content knowledge and pedagogical knowledge with the development of a reflective disposition will lead to the emergence of pedagogical content knowledge. By pedagogical content knowledge, I refer to knowledge that is a combination of knowing what content can be learned/taught with which pedagogies and knowing when to use each of these approaches to teach students.

Some of the habits of mind developed in a doctoral program in education translate directly into practice without focusing on the entire teacher-student-materials interaction triad. For example, one potentially powerful factor to address is the teacher-student interaction. PhD programs in education offer

tremendous opportunities for thinking about this relationship in meaningful ways, and in the researcher-teacher work, attention to this interaction is ubiquitous. It is absolutely critical to support teachers in learning to listen to students and respond to them in meaningful ways. Further, given the poor grounding most teachers have in learning theory, it may be that developing a theoretical understanding of how people learn should be a part of this (this is supported in recent research such as Philipp, Clement, Thanheiser, Schappelle, & Sowder, 2003). Finally, focusing professional development on techniques for questioning that allow the teacher to access student understanding will provide teachers with ways to access student thinking.

Conclusion

While it is not realistic to expect that all classroom teachers will earn doctoral degrees, there are elements that go into the attainment of a PhD that can lead to improved classroom teaching. Therefore, it seems reasonable to capitalize on what we know about the process of getting and having a doctorate versus more traditional routes to becoming a teacher.

Granted, there are aspects of researcher-teachers' activities that are not addressed simply by considering their educational background or their role in the research team. For example, high quality materials are extremely important. Further, it is vital that teachers are supported in learning how to interact with those materials (and the content they are trying to convey) if we want to raise the bar on teaching and learning. No one can create rich learning experiences around materials they do not understand. On the other hand, researcher-teachers have been able to find ways to capitalize on even the weakest of materials. For example, Lampert (2001) discusses how she was able to use the topic ideas from the traditional textbook her school used to develop rich problems that allowed students prolonged and repeated exposure to critical mathematics content—it is clear that the typical teacher is unable to capitalize on materials in these ways. Certainly, there is an appropriate place in professional development efforts to support teachers' use of materials.

While this article has only begun to explore the differences between a typical classroom teacher's environment and that of a researcher-teacher, it appears that researcher-teachers have some advantages over other teachers. They are better able to understand and address what is going on in the classroom, as well as the material they are expected to work with. Researcher-teachers are also better able to communicate with others in the field and to understand input from the research. Unfortunately, it is not practical to expect most teachers to earn a doctoral degree. The question then becomes, "What elements can we take from earning an advanced degree that will help teachers in the classroom?" By incorporating these elements into teacher education and professional development programs, we can greatly improve classroom instruction.

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[1] I cite examples of each of these researcher-teachers' work throughout this editorial. This list is not exhaustive.

[2] Reasons why I believe this is true range from the lack of incentives relative to the effort required to earn a PhD to the mismatch between the intent of PhD programs and what teachers do in their everyday lives. This is not to assert that earning a PhD is not helpful for a teacher, rather that it is not likely in the current educational system.