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Guest Editorial…

From the Common Core to a Community of All Mathematics Teachers

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As I write now, early in 2011, over 40 states have adopted the Common Core State Standards in Mathematics (National Governors Association Center for Best Practices and the Council of Chief State School Officers, 2010). This is a strong, coherent set of standards that asks students to understand and explain mathematical ideas and lines of reasoning. These standards should act as a framework to support vibrant teaching and learning of mathematics, in which students actively make sense of mathematics, discuss their reasoning, explore and develop ideas, solve problems, and develop fluency with important skills.

Calls for vibrant mathematics teaching and learning and improved student proficiency in mathematics have been steady for a number of years (e.g., National Commission on Excellence in Education, 1983; National Council of Teachers of Mathematics [NCTM], 2000; National Commission on Mathematics and Science Teaching for the 21st Century [NCMST], 2000; National Mathematics Advisory Panel [NMAP], 2008). This new set of standards is one of many initiatives and projects that answer this call. But as strong as the Common Core standards are, they cannot improve students' understanding of mathematics on their own—the standards will not teach themselves. Teachers are certainly key to enacting the standards as they are intended. They need to know the mathematics well, and they need to how to teach it in engaging and effective ways.

Thinking about how to improve mathematics teaching and learning has led me to consider the larger environment in which this teaching and learning takes place. This, in turn, has led me to think about several interconnected groups and communities that are related to PreK-12 mathematics: the group of all mathematics teachers from pre-kindergarten through the college level; the community of mathematics researchers; and the community of mathematics educators, which includes teacher educators and mathematics education researchers. I am a member of all three groups and as I write I am drawing on my own experience as a mathematics researcher and member of a mathematics department; my experience teaching a variety of college-level mathematics courses, in particular, courses for prospective teachers; and my one year of teaching sixth grade mathematics.

In this editorial, I want to make the case for the group of *all* mathematics teachers—from early childhood, to the elementary, middle, and high school grades, through the college and graduate levels, and including mathematics educators who teach teachers—to form a cohesive community that works together with the common goal of improving mathematics teaching at all levels. Although all parts of this community work individually towards improvement, I believe this community should take collective responsibility for improving the quality of all mathematics teaching. In making the case for the community of all mathematics teachers, I will draw on my knowledge of the mathematics research community and how it is set up to work towards excellence in mathematics research. I will also contrast research in mathematics and teaching of college-level mathematics, much of which is done by the same group of people.

What Can Mathematics Research Tell Us About Mathematics Teaching?

Why is it that at no level of mathematics teaching—from elementary school, to middle and high school, to the college level—do we have widespread excellence in mathematics teaching in this country? Of course, there are many examples of outstanding mathematics teaching and mathematics teachers, but, on the whole, there is cause for concern. At the K-12 level, mathematics teaching in the US is widely regarded as needing improvement (NCTM, 2000; NCMST, 2000; NMAP, 2008). Nor does it compare favorably with teaching in other countries, such as in Japan, where students perform well on international

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comparisons of mathematics achievement (Hiebert et al., 2003). At the college level, strong students who decide to leave the fields of mathematics, science, technology, and engineering often cite the quality of instruction as a key factor in their decision (*Undergraduate Science*, 2006; Seymore & Hewitt, 1997).

The state of mathematics teaching in the US is especially perplexing in light of the strong state of mathematics research. The mathematics research community in this country is vibrant and active; it attracts students and researchers from all over the world. Unlike in the case of mathematics teaching, there are no calls for improving the quality of mathematics research. Yet the vibrant mathematics research community is also heavily involved in teaching: For many mathematics researchers, 50% of their job consists of teaching. It is perhaps surprising that mathematicians' excellence in mathematics research has generally not translated into excellence in teaching.

Could the differences in the way mathematics researchers conduct their research and their teaching shed light on why mathematics research is so full of vitality yet mathematics teaching seems to be suffering from malaise? If the conditions that lead to vibrancy in mathematics research could be adapted for and applied to mathematics teaching, could this lead to a similar vibrancy in mathematics teaching? This may seem like a preposterous question to ask, but there are some good reasons to believe the answer may be yes.

What Conditions Make Mathematics Research Strong?

Mathematics research is done within a cohesive community in which members share their work and build on each other's ideas. Five factors strike me as key in making mathematics research so strong. First, mathematics researchers share their work, they discuss it in depth, and they built upon each other's work. Second, the quality of a community member's work is judged from within the community based on peer recognition and admiration, not from outside the community. Third, the mathematics research community is a meritocracy. Leaders in the community are active, enthusiastic community members whose work is admired within the community. Fourth, mathematics researchers have sufficient time to think about their research. And fifth, entry into the mathematics research community requires a high level of education and accomplishment. These five factors combine to create a highly motivating professional environment. Peer admiration within a cohesive, meritocratic community of accomplished professionals provides a strong incentive for developing creative new approaches, sharing good ideas, and building upon each other's work. In such a community, mathematics researchers are motivated to work in an especially deliberate and focused way.

The mathematics research environment helps mathematics researchers to do more than just put in long hours of work; the very nature of the environment fosters an intense kind of work, a deliberate practice of honing and refining, of building on what others have done, and of looking for gaps and weaknesses. According to research on the development of expertise, it is precisely such a deliberate practice, done over a period of ten or more years, which is required for expertise (Ericsson, Krampe, & Tesch-Roemer, 1993; popularized by Colvin, 2008).

Motivation research done over several decades and validated repeatedly in a variety of settings has shown that systems that fulfill people's basic psychological needs for competence, autonomy, and relatedness lead to more internalized forms of motivation, which lead to more successful outcomes. In contrast, systems that people experience as externally controlling by such means as external evaluations, rewards, or punishments, lead to less internalized motivation and less successful outcomes (Deci & Ryan, 2008a, 2008b; Greene & Lepper, 1974; popularized by Pink, 2009)[1]. The mathematics research community fosters relatedness, namely the feeling of being involved with and related to others, because mathematicians share and discuss their work and build on each other's ideas. In the process, the mathematics research community forms opinions about the quality of work, and community members attain a certain standing based on the community's views about the quality of the work. The mathematics research community fosters competence because the quality of work matters in the community. The community fosters autonomy because finding innovative ideas and lines of reasoning leads to peer admiration. For mathematicians, the possibility of raising one's standing *within one's community through the judgment of one's peers*—as opposed to through evaluation from outside of the community—may contribute to internalized motivation and a strong drive and desire to excel.

Comparing Mathematics Teaching With Mathematics Research

Now consider mathematics teaching with respect to the five factors— collaboration, internal evaluation, internal leadership, time, and high standards for entry—which make mathematics research so strong.

First, mathematics teaching is often an isolated activity: Most teachers in the US do not share or discuss their practice in depth and do not have systematic ways of learning from each other. In the US, at the K-12 level, there is a "low intensity of teacher collaboration in most schools" and "the kind of job-embedded collaborative learning that has been found to be important in promoting instructional improvement and student achievement is not a common feature of professional development across many schools" (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009, pp. 23, 25). In contrast, the tradition of Lesson Study in Japan, in which groups of teachers collaborate to create, teach, revise, and publish research lessons, is an important factor in the high quality of teaching in Japan (Stigler & Hiebert, 1999; Lewis, 2002). Lesson Study has been specifically recommended for the new Common Core State Standards (Lewis, 2010). In the current system, at both the K-12 and college levels there is not a culture of looking for and using mathematical and pedagogical knowledge that has been developed by others to help improve mathematical understanding and teaching. Such knowledge does exist (although, of course, we still need more), but the lack of intellectual vigor concerning teaching sometimes makes mathematics teachers at all levels uninterested in considering new ideas. I have heard prospective elementary teachers claim that they do not need to know some mathematical concepts that directly relate to the school mathematics they will teach because the mathematical ideas are unfamiliar to them. Similarly, I have heard mathematicians express disdain for all mathematics education research.

Second, because mathematics teachers do not routinely have opportunities to share or discuss findings about their teaching with any depth, they cannot develop good judgments about each other's teaching. Also, teaching is usually evaluated from outside of the mathematics teaching community. At the college level, student evaluations are commonly used to evaluate teaching; K-12 teachers are evaluated by administrators, who are typically not active mathematics teachers and may have limited knowledge about mathematics teaching. Soon K-12 teachers may be evaluated and rewarded or rated based on their students' performance on standardized tests (Duncan, 2009; *Hearing on FY 2011*, 2010).

Third, it is not clear who the leaders are in mathematics teaching. Textbook authors and professional developers are sources of leadership; individuals may also think of a favorite teacher to emulate. But, in the US, we do not seem to have a detailed and widely shared view of what constitutes effective teaching (Jacobs & Morita, 2002). In contrast, there is evidence that Japanese teachers do have a refined, shared conception of high-quality mathematics instruction (Corey, Peterson, Lewis, & Bukarau, 2010). Highly accomplished teachers in Japan become known through the public research lessons they teach during Lesson Study, thereby becoming leaders in teaching (Lewis, 2002).

Fourth, teachers at all levels have many demands on their time. Most K-12 teachers do not have much time built into their demanding schedules for collaborative planning and thinking, for learning from and with outside experts, and for sharing, testing, and refining lessons or teaching ideas. According to Darling-Hammond et al. (2010, p. 20), "few of the nation's teachers have access to regular opportunities for intensive learning" and "mathematics teachers averaged 8 hours of professional development on how to teach mathematics and 5 hours on the 'in-depth study' of topics in the subject area during 2003-04." At the college level, the requirement to publish, the prestige of publishing research findings, and the dearth of opportunities to write in a scholarly way about teaching leave little or no time for serious, deliberate work that is devoted to teaching improvement. Fifth, as I will discuss below, the mathematical preparation of teachers is often weak.

In sum, at both the college and K-12 levels, mathematics teachers are often not part of a strong professional community that promotes sharing and refining their practices or thinking deeply about mathematics teaching. Mathematics teaching is simply not set up to foster the development of internal motivation and deliberate practice towards expertise in the same way that mathematics research is.

Entry Into the Mathematics Teaching Community

A strength of the mathematics research community is the high standard for entry, namely, a PhD in mathematics, which involves intensive mathematics coursework, rigorous qualifying exams, and original research. In contrast, entry into the mathematics teaching profession is currently varied and often inadequate. Although some teachers receive excellent preparation for teaching mathematics, others are allowed to teach with very little mathematical preparation. The problem is especially severe for elementary teachers. The importance of mathematically knowledgeable teachers has been emphasized (NMAP, 2008), and there are recommendations that teachers take sufficient coursework to examine the mathematics *they will teach* in detail, with depth, and from the perspective of a teacher (Conference Board of the Mathematical Sciences, 2001; Greenberg & Walsh, 2008). But, in practice, the number and nature of the courses that are required often deviate considerably from these recommendations, as documented by Lutzer, Rodi, Kirkman, and Maxwell (2007, tables SP.5 and SP.6). Their research does not even take into account alternative routes to certification, which could require fewer courses still.

The Common Core Standards in Mathematics are rigorous and will put a high demand on teachers. Many of us who teach teachers believe that most will need a much stronger preparation than they are currently getting to be ready to teach these new standards. What constitutes sufficient preparation? Based on my many years as a teacher of mathematics content courses for elementary teachers, I know that it takes far more work than most people realize to be ready to teach mathematics to children. My students (prospective teachers) are bright, hard working, and dedicated; I am not dealing with unmotivated or dull students. Yet it takes a full three semesters of courses (nine semester hours total) for us to discuss with adequate depth the ideas of PreK through grade five mathematics. In addition, I think that further content-heavy mathematics methods courses are necessary for such activities as examining curriculum materials used in elementary school, for studying how children solve mathematics problems, which may include examining videos and written work and interviewing children, and for learning how to question and lead discussions.

It may seem surprising that so much coursework is needed in preparation for teaching elementary school. Yet even the mathematics that the very youngest children learn is surprisingly deep and intricate, and much is known about how children learn this mathematics (see Cross, Woods, & Schweingruber, 2009, for a summary about early childhood mathematics). Even mathematically well-educated people who have not specifically studied early childhood and elementary school mathematics from the perspective of teaching are unlikely to know it well enough to teach it. For example, if a child can count to five, and is shown five blocks in a row, will she necessarily be able to determine how many blocks there are, and, if not, what else does she need to know to do so? Why do we multiply numerators and denominators to multiply fractions, but we do not add numerators and denominators when we add fractions? Where do the formulas for areas and volumes come from? Where does the formula for the mean come from? To teach the Common Core State Standards for Mathematics adequately, teachers will need to have studied all these details and many more. Children deserve to be taught by teachers who have studied such intricacies, inner workings, and subtle points that are involved in teaching and learning mathematics.

If we think of other important professions, such as those in medicine, it is hard to imagine that doctors or nurses would be allowed to enter their professions without taking required coursework that focuses specifically on the knowledge these professionals rely on in their work. Yet in mathematics teaching, there are not such requirements. Would we be comfortable with doctors who had not had courses in chemistry and human anatomy, which underlie their work? Similarly, we should not be comfortable with teachers who have not studied the essential ideas they will need in their work. These essential ideas involve much more than being able to carry out procedures and solve problems in elementary mathematics or even in advanced mathematics.

Governing boards and agencies set a bare minimum of coursework that is required for certification, but currently, the requirements *do not ensure adequate* coursework in mathematics before teaching. In my experience, without requirements from governing boards or agencies, it is difficult to ensure that individual certification programs will require prospective teachers to complete a sufficient amount of suitable mathematics coursework. Without changes, I believe that many teachers will not be ready to teach the Common Core State Standards when they begin teaching.

A Community of All Mathematics Teachers Working Together Towards Excellence

I have argued that mathematics research is strong along five factors—collaboration, internal evaluation, internal leadership, time, and high standards for entry—and that research in psychology indicates that these factors may play an important role in the success of mathematics research. I have also argued that mathematics teaching has considerable weaknesses in the five factors. Therefore it seems that mathematics teaching could benefit from an environment more like the environment of mathematics research. How could we create such an environment?

First, suppose that all of us who teach mathematics could work within collaborative communities in which we share ideas and learn from each other about mathematics and about teaching. A number of small professional learning communities (including Lesson

Study groups and Teacher Circles) exist. But, such smaller professional communities should also band together into a larger community—the community of all elementary, middle grades, high school, and college mathematics teachers and teachers of mathematics teachers. Why should the group of all mathematics teachers view itself as a cohesive community? One reason is the interconnectedness of mathematics teaching. At each grade level, mathematics teaching is intertwined with the teaching at all other grade levels. The mathematics teaching that students experience in elementary school influences what those students learn, which influences what the students will be ready to learn in later grades, which in turn influences the teaching that is possible and appropriate at those higher grade levels. In addition, the mathematics teaching that teachers experience in college surely influences their own understanding of mathematics and their subsequent mathematics teaching.

Suppose that we—the community of all mathematics teachers—were to take collective responsibility for the quality of all mathematics teaching. The judgments we form about each other through the process of sharing our insights, ideas, and successes in improving our students' performance could create a viable system of internal evaluation, so that, as with mathematics research, we might not need to be evaluated from outside the community. Sharing our knowledge within a strong professional community may motivate us to work deliberately, intensively, and continuously over the long term towards excellence in mathematics teaching. Given the electronic means of communication that are now available, we may have opportunities for sharing our work in teaching that were not available in the past. There may be new ways of organizing ourselves and working together that would help us learn useful information from each other and join together as we think about specific areas we are trying to improve in our teaching.

Suppose that leadership within the community of all mathematics teachers were to evolve internally by peer recognition and admiration. Some intriguing research indicates that successful teaching communities that lead to improvements in student outcomes depend on certain kinds of leadership (Bryk, Sebring, Allensworth, Luppescu, & Easton 2010; Penuel, Riel, Krause, & Frank, 2009). So developing appropriate leadership could be important to developing effective communities of teachers.

Suppose that all mathematics teachers had time built into their schedules to work together and to learn from each other and from outside experts, as envisioned by Collins (2010, pp. 27, 36), in which teaching improvement is driven by "the kind of deep focus on content knowledge and innovations in delivery to all students that can only come when teachers are given opportunities to learn from experts and one another, and to pursue teaching as a scientific process in which new approaches are shared, tested, and continually refined across a far-flung professional community."

Suppose that the community of all mathematics teachers were to set professional standards for entry into the community. Although the relationships among teachers' mathematical knowledge and skill, instructional quality, and student learning are not yet well understood and are a matter for research (NMAP, 2008), the mathematics teaching profession has the responsibility of setting reasonable standards for entry that fit with the duties of the profession. We should separate the need for research that can inform and guide us in making improvements in the preparation of teachers from making reasonable demands for entry into the profession, as is common in other professions. Doctors are required to study chemistry and biology because a certain level of knowledge of these subjects is a foundation for practicing medicine. Such a requirement is reasonable even though there may not be research evidence linking the study of biology and chemistry to good practice in medicine. To become a cosmetologist in Georgia requires at least 1500 credit hours of coursework in addition to passing written and practical exams (O.C.G.A., 2011). If we care about mathematics and about students, and if we want mathematics teaching to be treated as the serious profession it is, then we need to insist on higher minimum required coursework for entry into the profession even as we continue to study how to improve teacher preparation. We must also insist that agencies and boards in positions of responsibility for teachers honor our standards.

One final thought about the evaluation of work from within a community by one's peers: Albert Einstein supposedly had a sign outside his office saying, "Not everything that counts can be counted, and not everything that can be counted counts." Although mathematicians do care about numbers of papers published and numbers of presentations, standing within the community is not determined purely by the numbers. An important component is the judgment of quality by one's peers. Similarly, although it makes sense to find out how a teacher's students do on common tests compared to other teachers' students, evaluating teachers purely in this way, without peer judgment in the mix, is counterproductive.

The judgment of one's peers is, of course, subjective and far from perfect, but it might be just what makes us try harder and look more closely at what other people have done. The process of looking closely at what others have done, trying to make improvements upon prior work, and bringing new ideas and insights to this work is precisely the process by which a field advances.

Concluding Remarks

The Common Core State Standards provide all of us with an opportunity for renewal, revision, and transition, and an opportunity to address the call for improving mathematics education that has been loud and clear over many years. But, in this process, two things seem certain: the first is that it will be tempting to make only superficial changes that merely repackage what we are already doing; the second is that we cannot create a top-notch system of mathematics education immediately and in one fell swoop. To create substantive improvements we must be in a system that helps us develop an *authentic desire to improve* and that promotes our internal motivation to do the hard work it will take to move towards excellence over the long term.

I have argued that a key component in the success of the Common Core State Standards in Mathematics will be teaching and that in order to improve mathematics teaching, we must band together to form a cohesive community of mathematics teachers. Such a community should set standards for entry into the community, as do other important professions. I have argued that the possibility of raising one's standing within the community through the judgment of one's peers is likely to be a key driver of excellence. A stronger sense of community among all mathematics teachers, in which we challenge and support each other as we work together towards excellence in teaching, seems like a wonderful and exciting possibility. It is a vision for enlivening mathematics teaching from *within* through peer interactions rather than from *without* through external evaluations that will pit us against each other and sap our motivation. With apologies to John Lennon, you may say I'm a dreamer, but I hope I'm not the only one.

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[1] Additional references can be found at the website http://www.psych.rochester.edu/SDT/index.php.