Sharpening Teaching Ability in K-8 Mathematics Classrooms

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Abstract

Data were collected via 119 video lessons, interviews with teachers, and students' assessments to identify the features and dimensions of teaching ability. The results show that teaching ability -- competence in applying knowledge in actual classroom -- is the key to effective teaching. K-8 math teachers have their different teaching patterns related to teaching ability in nine dimensions and three aspects of the MSA. The investigation on teaching ability provides not only concrete instruments to measure teaching ability, but also practical guidelines for classroom teachers on how to best apply their knowledge to teach math effectively in a balanced way.

Purposes and Research Questions

Research in mathematics education has repeatedly shown that too few children are leaving elementary and middle school with adequate mathematics skills and understanding (National Research Council [NRC], 2001). To improve student mathematics learning, an increasing body of research has focused on teachers' content knowledge (Ma, 1999), pedagogical knowledge (Darling-Hammond, 2000), and pedagogical content knowledge (An, Kulm, & Wu, 2004). However, how teachers apply these types of knowledge in classroom teaching remains noticeably absent from recent research.

One of such neglected areas is in providing a set of concrete, practical, specific measurable criteria that not only gauge the effectiveness of teaching but also guide classroom teachers to best acquire and use these criteria to teach mathematics effectively. In a discussion on how to prepare effective teachers, Alter & Pradl (2006) reveals, "measuring rods are being employed, but ones that seemingly have only invisible criteria marks on each stick. Not only is what counts as data or evidence never established, but any position can be held as a belief, since seldom is it subject to scientific scrutiny" (p. 43).

TIMSS and other national reports indicate that teaching is one of the major factors relating to students' mathematics learning, and that a major reform is needed in mathematics instruction (National Center for Education Statistics, 1999; Stigler & Hiebert, 1999). To make changes in teaching requires gathering both internal and external evidence that bears directly on what is supposedly being done to create high-quality teachers (Alter & Pradl, 2006).

The goals of this study are to contribute to a better understanding of how to measure teaching ability in mathematics classrooms, to find measurable criteria on teaching ability by identifying the functions, dimensions, and features of teachers' ability for effective teaching, and to examine how different types of teaching abilities result in different learning outcomes.

The following research questions were examined: 1) What are the features and dimensions of teaching ability? Do K-8 math teachers have a similar teaching pattern in their teaching ability? 2) Are these patterns significantly different from one another? How does these differences relate to teaching ability?

Theoretical Framework

Teachers' Knowledge

Teaching mathematics well is a complex endeavor (NCTM, 2000). For many years, research has paid attention to teachers' knowledge (Fennema & Franke, 1992; Cooney& Shealy, 1997; Ma, 1999; An, 2000, 2004). Ma (1999) advocates mathematics teachers have profound mathematical content knowledge, which is referred to as specialized math knowledge by Hill, Rowan, and Ball (2005). In contrast, Darling-Hammond (2000) supports enhancing teachers' pedagogical knowledge. An, Kulm and Wu (2004) argue that the primary knowledge for mathematics teachers is the pedagogical content knowledge (PCK) that connects content and pedagogy (Shulman, 1987; Fennema & Franke, 1992).

For decades, although many studies have attempted to find a correlation between teacher knowledge and student achievement, the results have been disappointing: "Most studies have failed to find a strong relationship between the two" (NRC, 2001, p. 373), which reveals a fact that even with deep PCK, a teacher will not necessarily know how to use it effectively in practice. If teachers' knowledge is not closely related to students' successful learning, what is the key to effective teaching? The study *Adding It Up* states, "Teachers must also *know how* to use their knowledge in practice. Teachers' knowledge is of value only if they can apply it to their teaching; it cannot be divorced from practice" (NRC, 2001, p. 379). However, there are too few well-designed studies that would offer insight into how teachers apply their knowledge in practice.

Teachers' Ability in Applying Their Knowledge

Luo and Li (1999) indicate that possessing profound knowledge does not mean having strong teaching abilities. Bloom's (1956) Taxonomy refers to the difference between knowledge and application, starting from the simplest behavior to the complex. According to Bloom (1956), application refers to the ability to use learned knowledge in new and concrete situations. In the teacher change study, Wu (2004) found uneven abilities in teaching math using representations after teachers acquired the same knowledge in professional development workshops, which suggests that there is a gap between knowing and applying in teaching. Many recent studies have revealed that for effectiveness, not only must teachers know and understand deeply the math they are teaching, but they must also be able to draw on that knowledge with flexibility in teaching (NCTM, 2000). Research calls for challenging teachers to develop, apply, and analyze that knowledge in their own classrooms so that knowledge and practice will be integrated (NRC, 2001). However, too little of the extant research probes the connection between teachers' knowledge, its application in math classrooms, and its contribution to the "ability" to teach. "Ability" is the "power to perform" or "competence in doing" (Frederick et al., 1993). In the proposed study, "ability" refers to "the power to perform a teaching task" that is reflected in the competence of applying knowledge in the classroom.

Using Videotape in the Study of Teaching Ability

In recent years, many classroom studies have used the videotapes because "video is an important and flexible instrument for collecting aural and visual information. It can capture complex behavior and interactions and it allows investigators to reexamine data again and again" (Clement, 2000, p. 577). In addition, "[Video] extends and enhances the possibilities of observational research by capturing moment-by-moment unfolding behavior" (Martin, 1999, p. 79). The successful TIMSS video study (1999) by Stigler and his colleagues provides a very good example for *teachers' perspective study*. The 1999 TIMSS video study used the following procedures to identify the teaching patterns
(Stigler, et al., 1999):

- Collected multiple lessons and contents arrange from 5 to 23 according to teachers' availability
- Interviewed teachers for their perspectives on teaching ability
- Videotaped mathematics teaching across various grade levels

The proposed study builds upon the 1999 TIMSS video study with its own strengths.

Methodology

Subjects

Nine K-8 teachers from six schools in Southern California, U.S.A. participated in this study in the academic year 2005-2006. Of the nine teachers, all have been teaching from three to 30 years. The participating teachers and schools were chosen in an effort to include diverse teaching styles.

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Procedure

The teachers' classroom teaching was observed and videotaped weekly by two researchers. The researchers provided the teacher feedback after each lesson and gave the students a chance to write a reflection about what they had learned from the lesson. Each teacher was interviewed once per semester for an in-depth study of their thinking and beliefs on teaching ability, for verification of their actions in applying knowledge in teaching and for understanding the rationales behind their actions. The students were assessed using the California Math Standards Test (CMST) and other assessments. A total of 119 lessons from nine K-8 teachers were observed and videotaped.

Instruments

Data were collected via 119 video lessons, more than ten from each teacher, interviews with teachers, and students' assessments. Observation instruments were designed based on components of the PCK (An, Kulm, & Wu, 2004). The focus of the interviews was on teachers' perceptions of the development of teaching ability and their dispositions on effective teaching as well as rationales behind their actions in applying knowledge in classroom teaching.

Data Analysis

This study examines the research questions using both qualitative and quantitative methods. Data analysis was ongoing throughout the period of this study. Interviews, field notes of observations, teachers' and students' reflections were analyzed using a qualitative method. The observations and responses from the interviews and reflections will be coded, categorized, and compared for emerging themes (Lincoln & Guba, 1985).

Classroom observation data from 119 video lessons were analyzed using both qualitative and quantitative approaches (Bottorff, 1994; Roschelle, 2000). Data analysis of the videotapes used transcribing (Stigler, et al., 1999) and moment-by-moment (Powell, et al., 2003) methods. The duration and sequence of particular features of teaching across multiple lessons were analyzed and time spent on lesson coverage on common dimensions was assessed. Coding was based on describing the lesson in terms of the instructional activities organized by the teacher for the students; each lesson was coded along nine dimensions. Coding was also based on analyzing the organization of the mathematics content in terms of the Model-Strategy-Application (MSA) in the lesson (Wu, 2006) -- major components for balanced teaching (California Department of Education, 2006). One-way ANOVA was used on these variables. Bonferroni Post Hoc tests were used to evaluate the significance of differences between teachers' performances. T-tests were calculated for comparing students' assessments. Correlations were also calculated to identify the relationships between teachers' teaching ability, their student achievement, and MSA. The family of effect size measures were calculated to indicate the strength of the relationship. Coupling video recording with students' reflection, ethnographic observations, interviews, and other data sources in order to have a more inclusive examination of teaching practice is supported by research conducted by others (Pirie, 1996; Lesh & Lehrer, 2000).

Results

The results of this study show that teaching ability -- competence in applying knowledge in actual classroom environments -- is the key to effective teaching. K-8 math teachers have their teaching patterns in teaching ability reflected in nine dimensions and three aspects of the MSA. Their teaching patterns are significantly different from one another. (Note: This report only reported the results of video analysis. Teacher interview and the relationships between teachers' teaching ability and their student achievement will be reported in articles.)

The Features and Dimensions of Teaching Ability

The results show that teachers spent different amounts of time on each of the nine dimensions although they generally adhere the following teaching pattern:

- Following up on homework
- Stating learning objectives and orienting students toward the lesson
- Reviewing prerequisites
- Presenting new material
- Guided practice
- Independent work for practice
- Assessing performance and providing feedback
- Differential instruction
- Time not spent on math instruction

The teachers' patterns on the nine dimensions are addressed in the Figure 1:

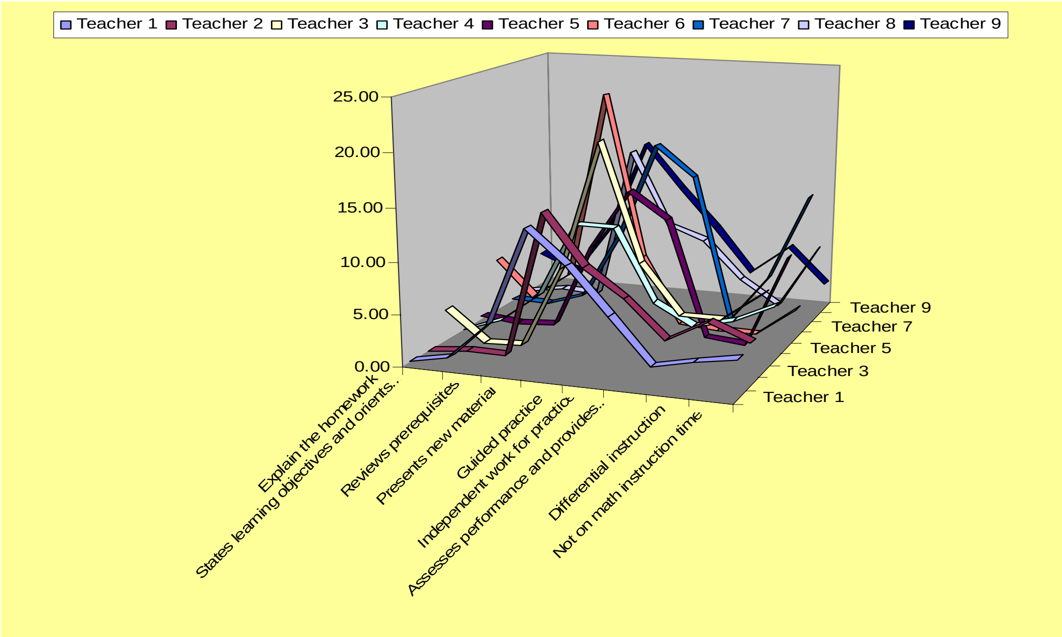

Figure 1

The Differences in Teaching Patterns Related to Teaching Ability in the MSA

The results from the One-way ANOVA show the teachers' patterns on the MSA (See Figure 2). Unbalanced teaching on conceptual understanding, procedural development, and application was identified among the teachers' lessons. The following results show the lacking of balance in regards to the time spent on the MSA from each teacher:

- Model for conceptual understanding
  - **T1 = 4.17, T2 = 3.67, T3 = 3.10, T4 = 13.91, T5 = 8.20, T6 = 1.73, T7 = 9.30, T8 = 1.71, T9 = 14.57, Average = 7.41**
- Strategies for procedural fluency
  - **T1 = 17.83, T2 = 17.00, T3 = 14.60, T4 = 4.64, T5 = 3.60, T6 = 21.82, T7 = 19.35, T8 = 27.86, T9 = 17.95, Average = 17.52**
- Application for real world connection
  - **T1 = 4.58, T2 = 6.58, T3 = 8.60, T4 = 20.82, T5 = 10.60, T6 = 1.09, T7 = 4.22, T8 = 3.00, T9 = 14.43, Average = 8.03**

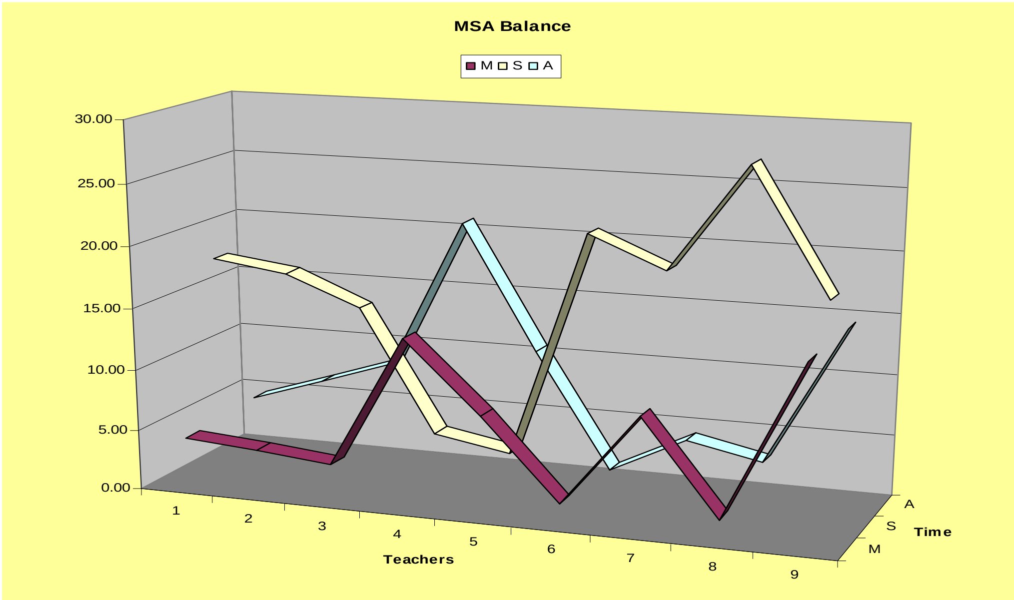

Figure 2

Significance of the Research

Although this study confirmed the TIMSS study in teaching patterns, teachers in this study showed differences in their individual style of teaching ability; statistical analysis showed that there are significant differences between teachers in each dimension of teaching ability.

The results of this study indicate that it is the challenge to investigate the measurable criteria for teaching ability, but it provides a new direction to improve classroom teaching. The investigation of the functions, dimensions, and features of teaching ability in this study provides not only concrete and valid instruments to measure teaching ability, but also concrete and practical guidelines for classroom teachers on how to best apply their knowledge to teach math effectively in a balanced way. Furthermore, this study shows that teaching ability can be acquired through daily practice. It is imperative for math teachers to improve their competence in applying knowledge so that it can have a significant effect on student achievement.

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