

Professional Competence in Teaching of Mathematics in Selected High Schools of India and U.S.: The Interplay of Cognition, Conceptions, and Context

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Abstract

The aim of this paper is to present a synopsis of my dissertation research involving a qualitative, grounded theory study. The purpose of this cross-cultural study was to analyze classroom practices of mathematics teachers recommended as competent by their principals in two selected high-achieving high schools of India and the United States. A socioconstructivist-interpretivist framework was used to analyze teaching with a view of developing models of professional competence that characterize mathematics teaching in these two cultural contexts. Even though a comparison of mathematics teaching in the two settings revealed certain global strategies, conceptions, and patterns of effective mathematics teaching, a noticeable feature of the mathematics teaching in the Indian setting was an emphasis on imparting conceptual understanding and the use of precise mathematical language during classroom discourse. This emphasis was observed to a lesser extent in the United States. While the findings are in accord with the existing literature, the substantive theory provides new insight in that it underscores the importance of looking at professional competence as both the possession of various components of teacher's professional knowledge base and the process of activating those components in actual teaching situations. The study has implications for teachers, educators, administrators, and researchers.

Introduction

The widespread concern about mathematics achievement in the United States has drawn considerable research attention to the question of teacher quality and instructional practice, and cross-cultural research in mathematics education. Schools and their outcomes are increasingly quantified and compared on a global scale. The publication of results of the Third International Mathematics and Science Studies has sparked the recent U.S. Mathematics education community's interest in the Japanese way of teaching mathematics and the concurrent interest in learning more about effective methods for teaching mathematics that have been practiced in other countries. Cross-cultural research on mathematics teaching practices at the secondary level is sparse. Additionally, voices from developing nations are missing in international comparative mathematics education. In spite of the fact that the international comparative research in mathematics education is problematized on the issues of curriculum, demographic and cultural differences, methodological limitations, and "cultural authorship" (Clarke, 2003, p. 176), it is generally agreed that studies in this domain have high adaptive pedagogical potential. This study investigated classroom practices of mathematics teachers recommended as competent by their principals in two selected high-achieving high schools of India and United States. Grounded theory methodology was used to analyze teaching with a view of developing models of professional competence that characterize mathematics teaching in these two cultural contexts. A socioconstructivist-interpretivist framework (explained in detail elsewhere) used to guide the design of the study required that mathematics teaching and learning should be captured in its wholeness rather than as discrete teacher behaviors. This involved learning about the participants' worlds and their interpretation of self in the context of their work environments. The differences and similarities that characterize effective mathematics teaching and learning in the two settings assisted in developing the models of professional competence and led to an understanding of how the quality of mathematics teaching and learning is influenced by the

context in which this learning occurs. “Purposeful sampling” which seeks information-rich cases that can be studied in depth (Bogdan & Biklen, 1992, p. 71) and criterion-based selection (LeCompte & Preissle, 1993) were used in the selection of the teacher participants. Based on the recommendation of the principals, two teachers were selected from both the settings. In addition, lessons were observed in the classrooms of eight teachers who did not agree to be videotaped and interviewed. A total of 43 lessons were observed in the classrooms of the selected schools. The data collection procedures yielded a data corpus that consisted of transcripts from pre and post-observation interviews, video recordings of a sequence of at least three lessons for each teacher, field notes, and classroom artifacts. A detailed study of teacher cases from both the research settings using the technique of constant comparative analysis yielded a rich conceptualization of the relation between teachers’ professional knowledge base and professional competence in teaching of mathematics.

An Interpretive Summary of the Main Findings and Contribution of the Study to the Literature

Even though a comparison of mathematics teaching in the two settings revealed certain global strategies, conceptions, and patterns of effective mathematics teaching, a noticeable feature of the mathematics teaching in the Indian setting was an emphasis on imparting conceptual understanding and the use of precise mathematical language during classroom discourse. This emphasis was observed to a lesser extent in the United States. Mathematics teaching as observed in the two settings and the participants’ responses suggest that content knowledge combined with experiential knowledge and flexibility play an important role in teacher’s competence in mathematical discourse, organization of instruction, representation of content, persistence, and management of class time. The findings of this study suggest that teacher’s beliefs, their professional knowledge, attitude, and skills shape their preferences and efficacy in curriculum adaptation and differentiation. The school environment provided these teachers and students an impetus to excel. A cognitively demanding supportive classroom environment provided students an opportunity to learn and engage in mathematical tasks.

This study found that the combination of both teacher- and student-centered pedagogy is the hallmark of professionally competent teachers. This study found that the quality of mathematical content knowledge delivered is influenced by a combination of teacher’s epistemological and context-specific conceptions, and their personal philosophies of teaching and learning mathematics. These philosophies are shaped by teachers’ lived experiences of learning and teaching mathematics. The teachers with majors in mathematics and higher degrees in mathematics demonstrated use of mathematically rich language and students in those classes were observed emulating their teachers. The student- discourse observed in the Indian setting involved the use of mathematically rich language and definitions. In contrast, only a few students in the U. S. setting were observed to use precise mathematical language in their discussions. More time was devoted to learning of new content during the 40 minutes period at the selected school in India in comparison to 47 minutes period at the research site in U.S. Due to academic tracking at the research site in U.S., the level and complexity of the content taught varied from class to class depending on the level of the students and the depth of content knowledge of the teacher, whereas uniform common curriculum was followed as per NCERT guidelines and CBSE requirements at the research site in India. It was also observed that not only was common curriculum being followed; common lesson themes were being taught in other schools in New Delhi. Hence, the factors that explain the differences in teaching practices within and across the research settings are the depth of mathematical knowledge, differences in subject-specific conceptions or mathematics-specific pedagogy, and conceptions about mathematics, as well as the depth of teacher’s knowledge of their students.

Another distinguishing feature of the mathematics teaching observed was emphasis on sequential planning of lessons due to the conceptions of Indian teachers about the nature of mathematics as logical and hierarchical. This conception was reflected in their teaching practice and professed conceptions that goal of their teaching is conceptual understanding. It is argued that engaging students in mathematical discourse has the potential to narrow the gap between educational outcomes. The findings suggest that the knowledge of mathematical representations (breaking complex mathematical concepts into forms understandable by students) plays an important role in structuring of lessons. An important finding of the study is that the teacher participants in the two research settings share common conceptions of mathematics teaching such as imparting conceptual knowledge along with procedural skills, developing a culture of mathematical discourse through scaffolding, developing an appreciation of the discipline of mathematics, and a common recognition that mathematics is an essential life tool. These findings are consistent with a recent study of comparison of Hungarian and English teachers' conceptions of mathematics and its teaching (see Paul & Gillian, 2000). Paul and Gillian argue that teachers' conceptions about mathematics and its teaching are determined by "both national and global perspectives" (p. 25). The authors also hint at the existence of global traditions and similar conceptions of teaching mathematics across different educational systems. The findings of the present study provide additional support to this assertion. Cross-cultural studies that investigate teachers' conceptions about mathematics and its teaching are severely lacking at the secondary level. This study, though a small-scale study, attempts to fill this gap in the literature.

In order to achieve the overall purpose of this research, it was necessary to develop portraits of mathematics teaching from both the settings and develop separate teaching models of the teacher participants. The participants taught mathematics from various perspectives: Instrumentalist, Platonist, and Problem-solving or constructivist during the lessons depending on the topic taught and the needs of their students. The enacted teaching models of the participants suggest that competent mathematics teaching demands optimal use of teaching strategies suggested by these perspectives, and professional competence lies in the intuitive use of these strategies in actual teaching situations in order to achieve successful student outcomes. The enacted teaching models of the participants suggest that professionally competent mathematics teachers hold a mix of absolutist and fallible philosophies of mathematics and they teach from various conceptions of mathematics depending on their teaching context. While developing models of professional competence in teaching of mathematics, this study looked for 24 indicators of expertise and competencies (called as professional competencies for the purpose of this study) expected of effective teachers identified from the review of extant literature published in U.S. and internationally to identify and describe competent mathematics teaching during classroom observations. Two more competencies emerged as a result of this study were added to the list of 24 competencies: cognitive process of analysis of self-efficacy and analysis of teaching context.

One of the conclusions that can be drawn from the study is that teachers' decision-making and their pedagogical preferences were shaped by their own interest in the subject and the school context. This competency then is a direct consequence of the ability to analyze the teaching context based on the developed heuristics. Another important finding is that teacher's conceptions were influenced by their personal experiences and thus represent some kind of tacit knowledge. A learning culture characterized by high performance expectations existed at both the settings where teacher efforts were supplemented by school-wide effort. Previous research has found a positive relationship between (a) student achievement and collective efficacy of school (e.g., Goddard, Hoy, Woolfolk Hoy, 2004; Pajares, 1997; Ross, 1992, 1998; Teschannen-Moran, Woolfolk, & Hoy, 1998; 2001); (b) student achievement and teacher efficacy (e.g.,

Allinder, 1994); (c) student motivation and attitude towards mathematics and student-teacher relations (e.g., Midgley, Feldlauger, & Eccles, 1989). This study adds to this body of literature.

While many studies of effective teaching highlight the context specific nature of effective teaching. This study showed that teachers make use of situated possibilities afforded by the specific context in the best interests of the students. This study found that the development of professional competence is characterized by constant engagement in reflection and in responding to challenges, thereby engaging in the kind of learning that extends one's competence. This study contributes to the body of research literature on teacher cases, research on secondary teacher's subject matter knowledge (Cooney, Shealy, & Arvold, 1998; Cooney & Wilson, 1995), and the influence of teachers' conceptions on instruction (e.g., Ball, 1993; Eisenhart et al., 1993; Raymond, 1997; Schifter & Simon, 1992; Shulman, 1987; Thompson, 1992) and on students' dispositions in mathematics. The findings of this study provide additional support to the finding from the Third International Mathematics and Science Study involving teaching at the eighth grade: "teachers' beliefs about mathematics learning and instruction were to some extent related to their preparation" (Mullis et al., 2000, p. 191). The teachers from the Indian setting demonstrated multicultural competence. The findings from the Indian setting suggest that effective mathematics teaching demands mathematical enculturation of students by developing an understanding of the diverse cultural and academic backgrounds of the students. Cultural traditions prevalent in the teachers' work context interact with teachers' pedagogical and mathematical conceptions, and with the instructional context to influence student outcomes. Many researchers (Banks, 2002; Ladson-Billings, 2001) recommend teacher multicultural education in the wake of changing ethnic composition of the United States.

Unique contribution of this study to the literature. This dissertation research is the first cross-cultural classroom study of mathematics teaching conducted in two selected high schools of India and U.S. There is no study to date that has attempted to investigate mathematics teaching using an SCI framework in two different cultural contexts and has looked for the indicators of expertise and effective teaching identified through an extensive review of research conducted in U.S. and internationally. The 26 professional competencies demonstrated by the participants in varying strengths when carefully examined draw from the various aspects of the socioconstructivist-interpretivist (SCI) framework used in this study. In this research, based on the emergent themes and categories, these 26 competencies were classified into three broad domains: Teachers' cognitions, Teachers' conceptions, and Teaching context. The educational significance of the study lies in the generation of theory to enhance the understanding of effective mathematics teaching and learning and to develop a holistic understanding of how quality in teaching and learning of mathematics is influenced by the context in which this learning occurs. During the review of literature, a model to illustrate and analyze professional competence in teaching of mathematics that integrates tools from socio-cognitive, socio-cultural, enactivist, and constructivist theories could not be found in the literature. This study, though a small scale study has attempted to create such model that has potential to inform other substantive fields and rise to a formal theory. The substantive model of professional competence in teaching of mathematics (discussed in detail elsewhere) suggests that the participants' demonstration of professional competence (teacher's professional knowledge base in the context of actual teaching situation) reflected an interplay of cognitions, conceptions, and the context. An important conclusion that can be drawn from this study is that professional competence is the possession of a set of components of professional knowledge base (discussed in detail elsewhere) and the process of activation of these components in the context of actual teaching situations in response to contextual factors. These components chase each other in a cyclical manner emphasizing the role of cultural, historical, and political influences on the professional

competencies of teachers as these influences are deep rooted in cultural traditions of countries. The findings of this study suggest that due to the constructive, integrative, and fallible nature of teacher cognitions, conceptions, and the context, the nature of professional competence is dynamic, constructive, integrative, and fallible.

Implications and Recommendations for Practitioners

The model of professional competence developed as a result of this study offers a tool to teachers, educators, administrators, and researchers to evaluate and understand interaction between various parts of the model. The model can be tested across various teaching contexts. Discourse analyses of the classroom videos made in this study can serve as a resource for promoting discussion on teachers' understanding of students' mistakes and misconceptions, concept and cognitive conflict handling, and reflection during professional development meetings. This study has provided detailed description of the research settings, teaching practices of the teachers, and their conceptions. It is recommended that an online library of lessons from different countries should be developed to build a knowledge base in teaching of mathematics. This should be done with a view to make teaching public in order to enrich this knowledge base and improve the teaching and learning of mathematics. There is much talk about differentiating instruction based on students' needs but this same concept has not been entertained much in teachers' professional development. Due to increasing concern of mathematics education community to improve mathematical proficiency of students and mathematical competency of teachers in order to prepare students for the new millennium, the teacher professional development process should incorporate differentiation to meet the needs of teachers at varying stages of their careers and varying degrees of professional competence as determined by evaluation. In order to reduce the gaps in students' achievement in mathematics, classroom instruction may be videotaped, and later reviewed and discussed jointly by the teachers and the department heads. Non-threatening-constructive feedback with a single goal of improving mathematics teaching and learning to facilitate discussion and reflection on teaching practices should be the ultimate aim of this differentiation. It may be challenging in the beginning but the challenge is not greater than the need, and this differentiation can also be incorporated in the teacher preparation programs.

Building on the contention by Clarke (2003) a detailed case study of good classroom practice in one country might inform classroom practice in another country; this study supports his argument that adaptation of teaching practice should be positioned in the cultural traditions of the country. Within a nation, and even within the same school, teaching practices may differ from class to class and still have some common national patterns of teaching as suggested by Givvin et al., (2005) due to internalized cultural scripts shared by the teachers within a particular education system. Mathematics teaching in India is informed by different cultural values regarding education, the values of effort and hard work, the basic cultural belief that learning mathematics is as essential as learning a language and its long history of mathematics, and its contribution to the world of mathematics. The findings of this study do suggest that professionally competent teachers of mathematics across different education systems do exhibit certain global strategies, conceptions, and patterns of effective mathematics teaching. This finding again is suggestive of globalization and internationalization of mathematics education.

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