An Examination of the Instructional Practices of Mathematics Teachers in Urban Schools

Sueanne E. McKinney, Shannan Chappell, Robert Q. Berry, and Bythella T. Hickman

ABSTRACT: Researchers have given increased attention to the teaching and learning of mathematics since the release of the National Council of Teachers of Mathematics (NCTM)'s Principles and Standards for School Mathematics (PSSM). Despite the clear and focused goals, recommendations, and standards set by the NCTM (2000), a majority of classrooms continue to fall short in implementation and direction, especially in urban high-poverty schools. Therefore, the authors investigated the pedagogical and instructional mathematics skills of 99 in-service teachers who taught in high-poverty elementary schools (Grades K–5). The results revealed that many pedagogical practices endorsed by NCTM's PSSM are being used by teachers to foster students' mathematics learning, some more frequently than others. If high-poverty schools are to achieve world-class status in mathematics, widespread efforts are needed to advance the implementation of pedagogical practices supported by PSSM.

KEYWORDS: *high-poverty schools, instructional practices, mathematics pedagogy*

INCREASED ATTENTION HAS BEEN GIVEN to the teaching and learning of mathematics since the release of the National Council of Teachers of Mathematics (NCTM)'s Principles and Standards for School Mathematics (PSSM). This document set forth comprehensive goals to stimulate improvement of mathematics education and mathematical competence for students in Grades Pre-K–12 (NCTM, 2000). This document identifies six fundamental principles that are essential for creating a mathematics learning community that accentuates problem solving, reasoning, and conceptual understandings. The six fundamental principles are equity, teaching, learning, assessment, technology, and curriculum. Taken together, these principles underlie a quality mathematics program.

The PSSM also offers recommendations for classroom teachers for the creation and delivery of quality classroom mathematical lessons. These recommendations were designed to encourage and sustain learning experiences for students and include the following, for example: "allow students to tackle real-life mathematical problems; accept and encourage different approaches to solving a problem; and differentiate mathematics instruction" (Palacios, 2005, p. 16). Despite the clear and focused goals, recommendations, and standards that the NCTM (2000) set, a majority of classrooms continue to fall short in implementation and direction, especially in urban high-poverty schools. For example, Berry (2003) concluded that African American students do not receive the kind of mathematics instruction that the NCTM advocates, which, in turn, affects their mathematics achievement. Other leading researchers support Berry's assertion and have recognized the continuing failure of urban schools in providing culturally responsive mathematics teaching (Brenner, 1998; Campbell, 1996; Ensign, 2003; Ladson-Billings, 1994, 1997).

Sutton and Krueger (2002) stated, "The most direct route to improving mathematics achievement for all students is through better mathematics teaching" (p. 26). They further reported that although significant progress has been made in understanding how children learn mathematics, teaching methodology remains unchanged. Sutton and Krueger also stated, "Many mathematics students spend much of their time on basic computational skills rather than engaging in mathematically rich problem-solving experiences" (p. 26). Palacios (2005) reported that teachers who do not use best practices or who are unskilled in using best practices "are less likely to attempt to reach all students' learning needs or alter their teaching practices" (p. 23).

Because mathematical teaching methodology plays such a significant role in student achievement (Berry, 2003; NCTM, 2000; Sanders & Rivers, 1996), it is feasible to explore the

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instructional practices of teachers in urban high-poverty school contexts since the literature documents limited mathematics opportunities for students in poor communities (Berry; McKinney, Berry, & Jackson, 2007; McKinney & Frazier, 2008; NCTM, 1999, 2000; Palacios, 2005). The following research questions guided the present study: "What pedagogical and instructional practices are used by elementary school in-service mathematics teachers in urban high-poverty schools?" and "To what extent are the identified pedagogical and instructional practices used by elementary school inservice mathematics teachers in high-poverty schools?"

Traditional Versus Alternative Mathematics Methodologies and Pedagogy

Although there have been many changes in instructional methods in the mathematics content area, traditional pedagogical practices continue to dominate mathematics education (Hiebert, 2003; Van De Walle, 2006). Reform efforts are often met with and conflict teachers' own perceptions of how mathematical concepts should be taught and learned (Stenger, 1998). The National Advisory Committee on Mathematics Education (1975) reported, "Teachers are essentially teaching the same way they were taught in school" (p. 77). When elementary school teachers attempt to alter their mathematical instructional methods, the change is more of a slow transition than a profound improvement (Nelson & Sassi, 2007; Stenger). Although traditional pedagogical methods that continue to dominate mathematics education are certainly successful among some students, many students are still left behind when lecture, limited chalkboard instruction, and individual seat work are the prominent instructional delivery methods (Bransford, Brown, & Cocking, 1999; NCTM, 2000; Stigler & Hiebert, 1997; Tharp & Gallimore, 1988; Watson, 2006). Alternative approaches that incorporate the NCTM standards into mathematics instruction can provide students with the necessary skills for applying mathematical knowledge in real-life settings and extend students' understanding of the place of mathematics outside the classroom. Although traditional approaches are extensively teacher directed and emphasize procedural understanding, alternative approaches are more student centered and encourage conceptual understandings and mathematical processes (Hiebert; NCTM). Hiebert identified the following several elements that typify alternative approaches: providing experiences that appreciate discovery, allowing for multiple paths in deriving at the correct answer, building on students' previous knowledge, and promoting student discourse.

The research literature has indicated that students who are taught by alternative approaches tend to develop conceptual understandings of different mathematical concepts without forfeiting basic arithmetic computational skills (Hiebert, 2003; Hiebert & Wearne, 1996; Kamii & Joseph, 1989; Wood & Sellers, 1996). Furthermore, the process standards offered by the NCTM (e.g., problem solving, reasoning, communication) are much more rigorous than what traditional approaches encompass (Hiebert, 1986, 2003; NCTM, 2000).

The Challenges of Teaching Mathematics in Urban High-Poverty Elementary Schools

Educators would agree that urban high-poverty schools encounter an abundance of challenges inimitable to this environment. The educational realities, detrimental effects of poverty, and human despair that often depress these communities can prove to be overpowering for new and seasoned teachers (Haberman, 1995, 2005; Kozol, 1991; Olson & Jerald, 1998; Smith & Ingersoll, 2004; Steinberg & Kincheloe, 2004).

Demographic factors, such as SES, race, and ethnicity, have been linked to disparities in students' mathematics achievement (NCTM, 1999). Although the achievement gap between minority and majority populations has narrowed, mean mathematics scores on the National Assessment of Educational Progress (NAEP; 2002) for students attending urban high-poverty schools are considerably lower when compared with students attending schools in more prosperous districts (NAEP). In addition, areas of growth for minority students have been limited to factual knowledge and computational skills (Berry, 2003; NCTM).

Opportunities in mathematics have also been limited for students in high-poverty schools regarding the curriculum and instruction (NCTM, 1999). The curriculum follows a fixed sequence and concentrates on the practice of basic skills without attending to problem solving and reasoning (NCTM). Regarding instruction, Haberman (1991, 2005) contended that ritualistic teaching acts tend to dominate many high-poverty classrooms, and he describes this routine instruction as the "pedagogy of poverty." Of the core functions that define this type of instruction, some include the following: giving information and directions, monitoring seat work, reviewing assignments, and giving tests (Haberman, 1991, 2005). Although there is no single teaching methodology or instructional practice that can be viewed as the foremost factor for empowering the urban mathematics learner, practices that give prominence to hands-on and inquiry-driven lessons have been shown to be successful in helping urban students to achieve (Ensign, 2003; Haberman, 1995, 2005; NCTM).

Method

Approximately 176 in-service elementary mathematics teachers who attended a local, state, regional, or national conference sponsored by the NCTM served as the participants for the present study. We used purposeful sampling to include only the participants who were teaching mathematics in urban high-poverty elementary schools. Therefore, 99 subjects identified agreed to volunteer to complete

the Mathematics Instructional Practices and Assessment. For the intention of this investigation, urban high-poverty schools are defined as those schools in which at least 50% of the students qualify for free or reduced lunch prices (Olson & Jerald, 1998). All participants (78 women, 21 men) were teachers, 47 of them reported that they were Caucasian, 39 reported African American, 8 reported Hispanic, and 5 reported their ethnicity as other. Participants' ages ranged from 23 to 54 years, and experience levels ranging from 1 to 32 years. The Mathematics Instructional Practices and Assessment Instrument was administered during the registration, or evaluation period, of each local, state, regional, or national conference.

Mathematics Instructional Practices and Assessment Instrument

A survey instrument comprising traditional and alterative instructional practices for teaching mathematics was developed based on the literature of leading scholars in mathematics education—Cathcart, Pothier, Vance, and Bezuk (2006) and Van De Walle (2006)—and the PSSM (NCTM, 2000). The survey identified 43 instructional practices and allowed participants to write in other practices not addressed. Participants were instructed to identify the degree to which each of the instructional practices was used in their mathematics classroom on a 5-point Likert-type scale ranging from 1 (*never*) to 5 (*very frequently*). As a means of validating the survey instrument, a think-aloud debriefing interview was conducted with three public school mathematics specialists. They agreed that the identified indicators embodied the instructional practices for teaching mathematics. Creswell (1998) and Lincoln and Guba (1985) reported that debriefing sessions are an accepted practice in the research process. As shown in Table 1, each instructional practice identified on the assessment instrument also indicates the mathematical principles it addressed. This was to serve the research team in distinguishing the practices and was not included on the instrument during the actual assessment.

Descriptive statistics were used to identify the pedagogical and instructional practices used by the teachers involved in this investigation, as well as the extent to which the identified practices were used. Identification of the PSSM (NCTM, 2000)—in which the instructional practices addressed—are also presented. Table 1 reports the percentages of the extent to which each indicator was used.

Results

To present the data succinctly, we introduce the pedagogical and instructional practices according to the PSSM (NCTM, 2000). As mentioned earlier, many of the pedagogical and instructional practices included in the instrument address more than one principle. We agreed that it was not viable to compartmentalize each practice according to one set principle because the six principles are interconnected. Therefore, all principles need to be in practice to provide a rigorous mathematics program.

Equity Principle

The equity principle is based on the belief that all students are capable of meeting success with mathematics and must be provided with the necessary support and accommodations to meet their individual needs. The Mathematics Instructional Practices Assessment Instrument addresses five practices that are indicative of the equity principle (Indicator 1, 2, 3, 4, and 6). The results indicated that the subjects demonstrate those behaviors that promote high expectations (*very frequently*, 46%; *frequently*, 40%) and include higher level questions (*very frequently*, 83%) and reinforcement techniques (*very frequently*, 93%) during their mathematics instructional program. Especially alarming is the small percentage of participants who reported they differentiate mathematics instruction (*very frequently*, 27%; *frequently*, 21%) and use cooperative learning groups (*very frequently*, 30%; *frequently*, 37%). Because the equity principle brings attention to the urgency of increased equity in the mathematics classroom, all teachers should strive to address students' learning profiles, learning preferences, readiness levels, and cultural differences so as to tap into all students' capabilities and unique strengths that they bring to mathematics understandings (Berry, 2003; NCTM, 2000; Tomlison, 1999).

Curriculum Principle

The curriculum principle articulates the need for a focused and coherent curriculum that connects the different mathematical ideas and concepts (NCTM, 2000). NCTM further communicates that the mathematics curriculum should be a resource or tool to guide teachers in focusing on important mathematics (Huetinck & Munshin, 2008; NCTM). The assessment instrument contained three practices that pertained to the curriculum principle (Indicators 10, 20, and 42). A high percentage of the participants reported that they connect new learning to previous learning (*very frequently*, 92%). However, a larger percentage of the participants indicated that they adhere strictly to the curriculum and pacing guides (*very frequently*, 68%) instead of adding personal creativity to the curriculum (*very frequently*, 13%).

Teaching and Learning Principles

It is clear that teaching mathematics is a complex undertaking that centers on many factors such as the teacher's understanding of the different mathematical content areas, his or her ability and confidence in teaching this content with conceptual understanding, and his or her ability to be cognizant of how children come to learn and make sense of different mathematical knowledge structures (Cathcart et al., 2006; NCTM, 2000). These percepts serve as the foundation for the

TABLE 1. Mathematics Instructional Practices Percentages and Distributions

Mathematics instructional practices and behaviors item	Very frequently (%)	Frequently (%)	Sometimes (%)	Seldom (%)	Never (%)
1. Teacher expectations—Student achievement behaviors (equity, learning)	46	40	14	0	0
2. Higher level questioning (equity, teaching, learning)	83	9	8	0	0
3. Probing and prompting clues (equity, teaching, learning)	69	16	15	0	0
4. Differentiation of instruction (equity, teaching, learning)	27	21	18	19	15
5. Cooperative learning groups (teaching, learning)	30	27	26	17	0
6. Reinforcement techniques (equity, teaching, learning)	93	7	0	0	0
7. Critical discourse (teaching, learning)	36	24	27	13	0
8. Lecture (teaching, learning)	62	21	3	3	11
9. Drill and practice (teaching, learning)	64	8	14	11	3
10. Adds personal creativity to curriculum (curriculum, teaching, learning)	13	14	46	27	0
11. Independent work (learning)	100	0	0	0	0
12. Teacher-directed instruction (teaching, learning)	83	17	0	0	0
13. Hands-on learning activities (teaching, learning)	46	20	22	12	0
14. Address concrete, transition, and abstract levels (teaching, learning)	29	26	25	15	5
15. Connect mathematics to real-world experiences (teaching, learning)	55	40	5	0	0
16. Problem-based learning (teaching, learning)	35	27	25	13	0
17. Thematic units (teaching, learning)	35	29	17	19	0
18. Modality based (teaching, learning)	30	29	36	5	0
29. Interdisciplinary instruction (teaching, learning)	18	34	38	10	0
20. Connect prior learning to new learning (curriculum, teaching, learning)	92	8	0	0	0
21. Use manipulatives (teaching, learning)	22	29	39	10	0
22. Process standards integration (teaching, learning)	34	35	25	6	0
23. Demonstrations and modeling (teaching, learning)	81	19	0	0	0
24. Memorization of algorithms, procedures, and rules (teaching, learning)	38	36	7	1	18
25. Dramatizations (teaching, learning)	17	10	25	30	18
26. Games, puzzles, and riddles (teaching, learning)	74	20	6	0	0
27. Student reflection (learning, assessment)	17	19	46	17	3
28. Social interactions (teaching, learning)	19	13	4	56	8
29. Interviews and conferences (learning, assessment)	16	12	38	26	8
30. Writing (teaching, learning, assessment)	33	23	18	26	0
31. Diagnostic assessments (assessment)	0	14	80	6	0
32. Rubrics (teaching, learning, assessment)	48	20	10	21	1
33. Authentic assessments (learning, assessment)	29	24	30	15	2
34. Portfolios (learning, assessment)	5	14	40	32	9
35. Student self-assessment (learning, assessment)	27	25	20	13	15
36. Teacher-made tests (assessment)	79	21	0	0	0
37. Use assessments to make instructional decisions (teaching, learning, assessment)	89	11	0	0	0
38. Web sites (technology, teaching, learning)	27	20	21	17	15
39. Software (technology, teaching, learning)	55	22	12	7	4
40. Calculators (technology, teaching, learning)	41	31	19	9	0
41. National library of virtual manipulatives (technology, teaching, learning)	0	15	30	44	11
42. Strictly follows curriculum and pacing guide (learning, teaching, curriculum)	68	25	7	0	0
43. Analyzes error patterns (teaching, learning)	29	25	30	12	4
44. Other: Music	0	18	0	0	0

teaching and learning principles. Because these principles are inherently related, the results would be presented collectively and their unity would be apparent. The teaching and learning principles addressed 41 instructional practices and behaviors (Indicators 1–30, 33–35, and 37–43). The data indicate some encouraging and disappointing results.

On a positive note, the results indicate that the participants connect mathematics instruction to their real-world experiences (*very frequently*, 55%; *frequently*, 40%) and provide demonstrations and modeling of the different mathematical concepts (*very frequently*, 81%; *frequently*, 19%). However, these results may be tempered by the fact that many of the instructional approaches advocated by NCTM (2000) are not prevalent in many of the participating subjects' classrooms on a frequent basis. For example, lectures (*very frequently*, 53%), drill and practice (*very frequently*, 64%), and teacher-directed instruction (*very frequently*, 83%) appear to be more dominate in the mathematics classrooms when compared with more alternative approaches, such as using manipulatives (*very frequently*, 22%; *frequently*, 29%); addressing the concrete, transition, and abstract levels of mathematics thinking (*very frequently*, 29%; *frequently*, 26%); and providing hands-on (*very frequently*, 46%) and problem-based learning activities (*very frequently*, 35%).

Assessment Principle

The assessment principle recognizes that assessment is fundamental to the teaching and learning of mathematics (NCTM, 2000). The NCTM also acknowledges that multiple assessment techniques should be used depending on the purpose of assessment and how it would be used to enhance students' learning. The assessment instrument contained 10 indicators that addressed the assessment principle (Indicators 27, 29, and 30–37). The data revealed that the participants tend to use the traditional method of assessing mathematics learning, such as teacher-made tests (*very frequently*, 79%; *frequently*, 21%). Although alternative assessment strategies—which include the following: student reflections (*very frequently*, 17%; *frequently*, 18%), interviews and conferences (*very frequently*, 16%), authentic assessments (*very frequently*, 29%), and portfolios (*very frequently*, 5%)—are encouraged by the NCTM, only a small percentage of teachers implement these assessment approaches.

Technology Principle

NCTM (2000) accentuated the role that technology can play in facilitating student engagement in mathematics learning and how its effective use can promote process skills such as problem solving and reasoning. Technology can also lead teachers in providing a more dynamic classroom environment that adopts the vision set forth by the NCTM (Huetinck & Munshin, 2008; NCTM). Four practices attend to the technology principle (Indicators 38–41). The participants indicated that software programs (*very frequently*, 55%) and calculators (*very frequently*, 41%; *frequently*, 31%) are readily used during instruction. However, only a small percentage of participants used virtual manipulatives (*very frequently*, 0%; *frequently*, 15%) or Web sites (*very frequently*, 27%) to enhance their mathematics instruction.

Discussion and Recommendations

Mathematics literacy can no longer be considered for a select few students, nor can educators continue to accept the ideology of "I'm just not good at math" (NCTM, 2000). If the United States is to compete internationally, teachers need to facilitate all students' learning of important mathematics to promote construction of mathematical meaning (Ball & Bass, 2003; NCTM; Siegler, 2003). This can only be achieved if mathematics teachers use pedagogical and instructional approaches that are supported by the PSSM (NCTM).

The results reveal that many pedagogical practices endorsed by NCTM's PSSM (2000) are used to foster students' learning. Attention needs to be given to a few of the approaches that are used frequently and those that are used infrequently, and the implications of such in creating a classroom environment that emphasizes mathematics fluency.

Data revealed a strict adherence by teachers to the mathematics curriculum and pacing guides (*very frequently*, 68%; *frequently*, 25%), with a small population infusing personal creativity in the curricula focus (*very frequently*, 13%; *frequently*, 14%). In an era of high-stakes testing and accountability, prescribed curricula often limits instructional decisions and teachers' preferences (Crocco & Costigan, 2007). Current research reports that because of diminished opportunities to create and personalize curricula, teachers are seeking school settings that offer more autonomy (Crocco & Costigan; Ingersoll, 2001). This can be especially troubling for urban high-poverty schools because they suffer from higher teacher attrition rates when compared to more affluent districts (Haberman, 1995, 2005; Kozol, 1991; Olson & Jerald, 1998; Smith & Ingersoll, 2004; Steinberg & Kincheloe, 2004). Because urban high-poverty school districts tend to make use of scripted lessons (Crocco & Costigan), additional research is warranted to explore the possibilities of allowing teachers more curricula freedom when teaching mathematics and the effect of such on students' mathematics achievement.

Planning and delivering quality mathematics lessons that are inquiry driven and focus on the concrete-transitional-abstract learning model is key to creating a results-oriented classroom environment (NCTM, 2000). However, the results indicate that teachers continue to implement traditional mathematics methodology more frequently than student-centered approaches. For example, teachers appear to use lecture (*very frequently*, 53%; *frequently*, 21%); drill and practice (*very frequently*, 64%); teacher-directed instruction (*very frequently*, 83%); and memorization of algorithms, procedures,

and rules (*very frequently*, 38%; *frequently*, 36%) than more alternative approaches such as hands-on learning activities (*very frequently*, 46%), problem-based learning (*very frequently*, 35%; *frequently*, 27%), and using manipulatives (*very frequently*, 22%; frequently, 29%). The literature suggests that alternative approaches to teaching mathematics that are student and inquiry centered and concentrate on problem-solving and reasoning skills allow students to develop a deeper understanding of mathematics when compared with more traditional approaches (Hiebert, 1986; Hiebert & Carpenter, 1992; NCTM, 1989, 1991, 1995, 2000; Owens, 1993; Spillane & Zeuli, 1999; Wenglinsky, 2002). However, high-quality research does not support an all-encompassing instructional approach for the teaching of mathematics (U.S. Department of Education, 2008). The research literature confirms that when teachers embrace the PSSM (NCTM, 2000) through their instructional methodology, their students perform better on standardized assessments when compared with teachers whose practices are not so aligned (Gimbert, Bol, & Wallace, 2007; Spillane & Zeuli).

A limited number of teachers use alternative approaches to assessment. Students' self-assessment (*very frequently*, 27%; *frequently*, 25%), portfolios (*very frequently*, 5%; *frequently*, 14%), interviews and conferences (*very frequently*, 16%), analysis of error patterns (*very frequently*, 29%), and writing (*very frequently*, 33%)—all examples of alternative assessment approaches—can yield student data that provide teachers with an in-depth understanding of students' thinking and their capabilities. The same holds true with technology. Although the teachers indicated that calculators and software programs are used regularly, the mathematics community conveys that technology can lend itself to more innovative learning activities (Jensen & Williams, 1993; NCTM, 2000). Although coordinating the use of technology into the mathematics classroom can be overwhelming in regards to classroom management and monitoring student progress, teachers must be willing to capitalize on its possibilities (Jensen & Williams; NCTM).

It is feasible to suggest that more professional development experiences that stress the NCTM's principles are needed for urban high-poverty school elementary teachers. If teachers are to move forward in providing mathematics instruction uniform to the principles, opportunities for new learning need to occur. Without such, teachers would most likely continue their current mathematics teaching practices regardless of whether the practices align with NCTM principles (Hiebert, 2003). In addition, mathematics specialists can be used to guide teachers in not only providing quality instruction, but also improving their instructional practices and methodology.

PSSM conveyed that all students are capable of attaining high levels of mathematical understanding (NCTM, 2000). Gilbert and Gay (1985) avowed that to improve the mathematics success of urban high-poverty students, a modification of the methods to achieve the intended learning outcomes is needed. Furthermore, Walker and Chappell (1997) reported, "Mathematics teachers in urban classrooms should develop and implement teaching strategies that would enhance their students' learning capabilities, dispelling the myth that urban schools are at risk of failure" (p. 1). If schools are to achieve world-class status in mathematics, widespread efforts are needed to advance the mathematics opportunities of urban high-poverty students. However, implementing the instructional practices and pedagogy recommended by the NCTM is reliant on teachers' willingness and direction to do so (Palacios, 2005).

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