# Mathematics Teaching with the Stars

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**Abstract**

*The mathematics instructional approaches of effective elementary teachers in urban high-poverty schools were investigated. Approximately 99 urban elementary teachers were administered the Star Teacher Selection Interview; a total of 31 were identified as star teachers. These teachers were then administered the Instructional Practices Assessment to identify their mathematical instructional practices and the degree to which they implemented these practices. The findings indicated that the star teachers are using a variety of instructional approaches that are culturally relevant and aligned with the NCTM's Principles and Standards for School Mathematics. The highest mean ratings were associated with principles and practices related to equity and strong adherence to curriculum standards infused with personal creativity.*

## INTRODUCTION

Realizing that traditional approaches to teaching mathematics which emphasize procedural knowledge and memorization of algorithms have fallen short in promoting higher-level mathematics achievement among all students, national efforts have been made to transform mathematics classrooms into engaging learning communities where students participate in inquiry-driven instruction that highlights conceptual understandings of ideas (Hiebert, 2003; Manouchehri, 2004; National Council of Teachers of Mathematics, 2007, 2000). The National Council of Teachers of Mathematics' (NCTM) landmark resource document Principles and Standards for School Mathematics (2000) represents the new vision of what defines a rigorous, high-quality, and ambitious mathematics learning environment. Communicated within this resource guide are six principles--Equity, Teaching, Learning, Curriculum, Assessment, and Technology--that depict specific elements that are imperative for a strong mathematics program. When taken together, these principles provide a framework for mathematics educators to design curriculum and pedagogy so that all students have opportunities to learn important mathematics with conceptual understandings, procedural fluency, and problem solving skills (Hiebert, 2003; NCTM, 2000; U.S. Department of Education, 2008).

Although the NCTM articulates an ambitious vision, actual implementation continues to elude many classrooms, especially those in urban high-poverty school districts (Acker, 1999;

Berry, 2003; NCTM, 1999; Oakes, Franke, Hunter Quartz, & Rogers, 2002). Data from the National Assessment of Educational Progress suggested that the pedagogy of urban teachers was not consistent with the recommendations set forth by the NCTM (Lubienski, 2001). As a result, there continues to be

> …large, persistent disparities in mathematic achievement related to race and income. These disparities are not only devastating for individuals and families, but also project poorly for the nation's future, given the youthfulness and high growth rates of the largest minority populations (U.S. Department of Education, 2008, p. 5).

It is well documented that effective teachers can improve the mathematical achievement of urban students (Berry, 2003; Darling-Hammond & Skyes, 1999; Ladson-Billings, 2002, 1995; Sanders & Rivers, 1996; U.S. Department of Education, 2008). Sanders and Rivers' (1996) study investigated the cumulative and residual effects of teacher quality and mathematics achievement. They found that significant gains in achievement levels were made by students when placed with effective teachers for three consecutive years. Moreover, the U.S. Department of Education (2008) reported that:

> When teachers are ranked according to their ability to produce student achievement gains, there is a 10 percentile point difference across the course of a school year between achievement gains of students of top-quartile teachers versus bottom-quartile teachers (p. 35).

However, the literature shows that defining teacher quality is controversial and differs among scholars and professional organizations (Franke, Kazemi, & Battey, 2007; McKinney, Fuller, Hancock, & Audette, 2006). Because discrepancies in the mathematics achievement levels of students based on ethnic groups, learning abilities, and socioeconomic status continue to emerge in state and national assessments, it is feasible to explore the mathematics instructional practices of teachers who are effective with urban populations. One perspective of effective urban teachers is Haberman's (1995) identification of star teachers.

> Star teachers are outstandingly successful: their students score higher on standardized tests; parents and children think they are great; principals rate them highly; other teachers regard them as outstanding; central office supervisors consider them successful; cooperating universities regard them as superior; and they evaluate themselves as outstanding teachers (p. 1).

He (1995) further contends that "Star teachers conceive that their primary goal is turning kids on to learning - i.e., engaging them into becoming independent learners" (p. 15). This may be particularly challenging in the area of mathematics where many teachers continue to rely on memorization of procedural knowledge (Hiebert, 2003, 1986; Lubienski, McGraw, & Strutchens, 2004).

There is limited sound research focusing on what effective mathematics teachers actually do to produce significant gains in student achievement (U.S. Department of Education, 2008). Examining this issue through the perspective of star teachers will contribute to the limited knowledge base that focuses specifically on the identification of the skills and instructional practices of effective mathematics teachers. Findings from this study can also provide urban elementary teachers information about best practices for teaching mathematics to diverse students in poverty, as well as how to respond to the reform efforts set forth by the NCTM (2000). The following research questions were examined:

What are the instructional practices used by star elementary inservice teachers in urban high-poverty schools?

To what extent are the identified instructional practices used by star elementary inservice teachers in urban high-poverty schools?

## Principles and Standards for School Mathematics

*Principles and Standards for School Mathematics* (PSSM) outlines a new vision for the teaching and learning of mathematics; its intent is to provide comprehensive goals for the improvement of mathematics instructional programs, including the development of curricula, assessments, and instructional materials (NCTM, 2000). Six principles are presented, and a description of the underlying assumptions and values from which each of the principles originated is provided. For example, grounded within the teaching principle is the belief that effective mathematics instruction requires teachers to know and understand the content material, expect their students to be capable learners, and incorporate pedagogical strategies that support a student centered learning environment (NCTM, 2000).

According to the vision for school mathematics articulated in *Principles and Standards,* teachers need to change what is taught and how it is taught. NCTM asserts that teachers must implement learning activities that are worthwhile and engage the students in mathematical thinking and learning. Responding to each of the principles requires teachers to consider culturally relevant pedagogy specific to the mathematics classroom, and that doing so bridges the vision of the PSSM to the learning needs of urban high-poverty students.

## Culturally Responsive Mathematics Teaching

Grounded in critical race theory (Ladson-Billings, 1998, 1995; Tate, 1997, 1995, 1994) culturally responsive teaching draws on the cultural backgrounds, experiences and learning, and performance profiles of diverse populations in order to make learning more relevant, meaningful, and effective (Gay, 2000). Ladson-Billings (1995) characterized its foundation as high academic standards and success, cultural competence, and the ability to challenge social order and justice. Nurturing meaningful relationships with students, developing learning communities, scaffolding instruction, extending students' thinking, and believing in the capabilities of all students further accentuates the theoretical tenets (Ladson-Billings, 1995). Wagner, Cabral-Roy, Ecatoiu, & Rousseau (2000) argued that "If more equitable mathematics achievement is a serious goal of educators, then mathematics instruction must begin to reflect the pedagogies that meaningfully integrate culture into the classroom" (p. 107).

Although there is limited research that examines culture as a means for mathematical learning (Leonard, 2008), several studies have reported the significance of addressing culturally responsive pedagogy during instruction. For example, urban and rural sixth graders served as the subjects for Lipka & Adams' study (as cited in Leonard, 2008) of the effectiveness of a culturally responsive mathematics unit. Results showed significantly better mastery of the mathematical material when instruction was culturally-based.

Several specific teaching approaches have been identified that address urban student's culture and preferences for learning, such as affective interactions, using students' life experiences in instruction, cooperative learning opportunities, active learning, and scaffolding (Leonard, 2008). Malloy (1997) asserts that no new forms of pedagogy need to be developed for urban high-poverty students; instead, existing pedagogy just needs to attend to the cultural and cognitive development of students.

Attending to culturally responsive pedagogy as a means to improve the mathematics achievement of urban students relies on ideology of teachers who contextualize teaching in regards to focusing on the needs and cultural experiences of their students. Star teachers as identified by Haberman (2005, 1995) have the necessary beliefs and expectations to do so. Haberman (2005, 1995) distinguished the belief system and functions carried out by star teachers with those of teachers who fail urban students, or leave urban teaching all together. The distinctive ideology and knowledge base of star teachers are aligned with cultural understandings and responsive pedagogy, and include such functions as: persistence, approach to at-risk students, and gentle teaching in a violent society. Star teachers realize that urban students are faced with multiple challenges, many of which they bring to the classroom. However, they deeply believe in the capabilities of all students and provide them with a variety of experiences so they can realize success. This internal desire and commitment is what drives these teachers to make a difference in the lives of students. They realize that the handicapping conditions many students face don't define their futures.

In the current study we addressed the instructional practices and behaviors of teachers identified to be effective mathematics teachers in urban high-poverty environments. More specifically, we used Haberman's (2004) *Star Selection Interview* to identify these teachers. In the next phase of the study, we administered a questionnaire developed to align with the NCTM's Principles to determine the extent to which these star teachers employed the instructional practices. One potential limitation of this study is our reliance on teacher self-report. As is true with all self-reported data, we cannot rule out the possibility that teacher responses are invalid or subject to social desirability. However, in the current study teacher candor was enhanced by assuring confidentiality to teachers, and only about a third of the teacher participants were identified as star teachers. Furthermore, a recent study investigated the validity of teacher self-report in the context of school restructuring. The findings indicated that teacher perceptions of their pedagogical practices were significantly correlated with observation results obtained by objective observers.

## METHODOLOGY

### Sample and Procedures

The population for this study consisted of approximately 99 urban high-poverty elementary teachers attending local state, regional, or national conferences affiliated with the National Council of Teachers of Mathematics. For the intent of this investigation, urban high-poverty schools were defined as those schools where at least 50% of the students qualify for free or reduced lunch prices. Purposeful sampling was employed; the *Star Teacher Selection Interview* was administered to each of the 99 participants, with 31 identified as star teachers. These identified star teachers served as the subjects for this investigation, and completed the *Instructional Practices Assessment*. Demographic information indicated there were nine Caucasian teachers, 21 African American teachers, and one Hispanic teacher. Subjects' ages ranged from 23-54; 24 were female and 7 were males. Experience levels varied from 7-32 years.

### *Star Teacher Selection Interview*

*The Star Teacher Selection Interview* predicts a teacher's ability to successfully relate to and work with diverse children in poverty and their staying power (Haberman, 2004). It measures seven of the functions that discriminate completely between stars, and those teachers most likely to quit or not meet success with urban populations. The seven functions assessed include: (a) Persistence, (b) Response to Authority, (c) Application of Generalizations, (d) Approach to At-risk Students, (e) Personal/Professional Orientation, (f) Burnout, and (g) Fallibility. These seven mid-range functions are divided into two subcategories, and yield fourteen characteristics, thus allowing the interviewer to develop a profile of the teacher's predispositions and ideology (Haberman, 2005, 2004, 1995). Participating candidates are ranked and categorized (Star, High, Average, Failure) based on their responses to 14 classroom teaching scenarios (Haberman, 2005, 2004, 1995).

The instrument has been periodically tested to validate its level of discrimination. There is a predictive reliability of r = .93 for those being re-interviewed (Haberman, 2003). Additionally, there are no differences in the reliability of the instrument based on respondent's age, sex, or ethnicity.

### Instructional Practices Assessment

A survey instrument which identified 34 mathematics instructional practices was constructed and based on the work of Cathcart, Pothier, Vance, and Bezuk (2006), Malloy, 1997; Van De Walle (2006) and the NCTM (2000). As a means to further validate the survey instrument, a think-aloud, debriefing interview was conducted with three public school math specialists. They agreed that the identified indicators embodied the instructional practices for teaching mathematics. In addition, the items were independently categorized by the research team into the six NCTM principles. During this process, it was discovered that instructional practices characterizing the *Teaching and Learning Principles* were inextricably intertwined and the categories were collapsed. Although some of the other items were related to more than one principal, they were more clearly subsumed under a principle as judged by content area experts. The categorization process reduced the original 43 items to 34 to better align with NCTM principles and minimize overlap among items and principles.

## RESULTS

To provide an overall perspective of the extent to which the star teachers implemented instructional practices by principle, mean ratings across all items per scale were calculated. Table 1 presents the overall means for items comprising each of the principles. Given the fact that these were star teachers chosen for their effective instructional practices in mathematics, it is not surprising that the overall mean values are high. Nevertheless, the highest mean ratings were associated with the Equity and Curriculum scales.

Table 1: *Mean Rating by Category of Mathematical Instructional Principles*

| Category | Number of Items | Average Rating |
|---|---|---|
| Equity | 5 | 4.82 |
| Teaching/Learning | 17 | 4.22 |
| Curriculum | 2 | 4.49 |
| Assessment | 7 | 4.24 |
| Technology | 4 | 4.24 |

*Note: n = 31*

Although we observed some variation in the overall mean scores for the principles, patterns of findings for items within categories better illuminates the specific practices star teachers implement most frequently. We computed means, standard deviations, and the percentage by response option (i.e., Never to Very Frequently) for items within each principle.

## The Equity Principle

The Equity Principle is grounded in the ideology that all students, regardless of gender, socioeconomic status, and special needs are capable of learning mathematics, and deserve every opportunity to do so (NCTM, 2000). It is apparent that the star teachers involved in this investigation are addressing the Equity Principle. For example, the self reported practices indicated that the subjects are demonstrating those behaviors that promote high-expectations. The Equity Principle also calls for meeting the diverse mathematical needs among students, and the vast majority of the subjects are doing this by differentiating instruction. Table 2 provides the descriptive statistics for items indicative of the Equity Principle.

Table 2: *Descriptive Statistics for Equity Items*

| Instructional Practices/Behaviors | Mean | SD | Never | Seldom | Sometimes | Frequently | Very Frequently |
|---|---|---|---|---|---|---|---|
| Higher level questioning | 4.97 | .17 | 0 | 0 | 0 | 3% | 97% |
| Probing and prompting clues | 4.97 | .17 | 0 | 0 | 0 | 3% | 97% |
| Reinforcement techniques | 4.94 | .24 | 0 | 0 | 0 | 6% | 94% |
| Teacher expectations-student achievement behaviors (TESA) | 4.94 | .24 | 0 | 0 | 0 | 6% | 94% |
| Differentiation of instruction | 4.30 | 1.29 | 0 | 0 | 6% | 35% | 58% |

*Note: n = 31*

## The Curriculum Principle

According to the Curriculum Principle, mathematical ideas should be integrated and linked (NCTM, 2000). The subjects were evenly split on adding personal creativity to the curriculum and adhering strictly to the curriculum guide. It is plausible to assume that school district guidelines may either promote or inhibit teachers' personal freedom with the curriculum (see Table 3).

Table 3: *Descriptive Statistics for Curriculum Items*

| Instructional Practices/Behaviors | Mean | SD | Never | Seldom | Sometimes | Frequently | Very Frequently |
|---|---|---|---|---|---|---|---|
| Strictly follows curriculum and pacing guide | 4.49 | .62 | 0 | 0 | 6% | 39% | 55% |
| Adds personal creativity to curriculum | 4.49 | .62 | 0 | 0 | 6% | 39% | 55% |

*Note: n = 31*

## The Teaching and Learning Principles

The Teaching Principle recognizes that teaching mathematics is a complex endeavor and that the teacher plays the central role in promoting mathematical literacy and fluency (NCTM, 2000). The Learning Principle emphasizes conceptual understandings of the different mathematical ideas and process standards, such as reasoning and problem solving (NCTM, 2000). The findings suggest that the subjects are using both traditional and alternative approaches to teaching mathematics (see Table 4). For example, the results indicated that the star teachers are using hands-on and problem based activities and cooperative learning groups. In regards to the more traditional approaches, it appears that star teachers may be complimenting this type of instruction with the use of manipulatives and demonstrations and modeling.

Table 4: *Descriptive Statistics for Teaching/ Learning Items*

| Instructional Practices/Behaviors | Mean | SD | Never | Seldom | Sometimes | Frequently | Very Frequently |
|---|---|---|---|---|---|---|---|
| Teacher directed instruction | 4.90 | .30 | 0 | 0 | 0 | 10% | 90% |
| Connects new to prior learning | 4.87 | .34 | 0 | 0 | 0 | 13% | 87% |
| Demonstrations and modeling | 4.77 | .43 | 0 | 0 | 0 | 23% | 77% |
| Analyzes error patterns | 4.59 | .50 | 0 | 0 | 10% | 26% | 65% |
| Connects to real world experiences | 4.58 | .50 | 0 | 0 | 0 | 42% | 58% |
| Hands-on learning | 4.55 | .46 | 0 | 0 | 3% | 39% | 58% |

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|---|---|---|---|---|---|---|---|
| activities | | | | | | | |
| Cooperative learning groups | 4.51 | .68 | 0 | 0 | 10% | 29% | 61% |
| Critical discourse | 4.42 | .72 | 0 | 0 | 13% | 32% | 55% |
| Utilizes manipulatives | 4.35 | .66 | 0 | 0 | 10% | 45% | 45% |
| Modality based | 4.35 | .71 | 0 | 0 | 13% | 39% | 48% |
| Problem-based learning | 4.23 | .76 | 0 | 0 | 19% | 39% | 42% |
| Writing | 4.13 | .85 | 0 | 0 | 29% | 29% | 29% |
| Interdisciplinary instruction | 3.97 | .79 | 0 | 0 | 32% | 39% | 29% |
| Memorization of algorithms, procedures, rules | 3.47 | 1.31 | 10% | 16% | 6% | 48% | 19% |
| Drill and practice | 3.44 | 1.14 | 3% | 19% | 32% | 23% | 23% |
| Social interactions | 3.30 | 1.24 | 0 | 23% | 35% | 16% | 23% |
| Lecture | 3.28 | .89 | 0 | 16% | 42% | 35% | 6% |

*Note: n = 31*

### The Assessment Principle

According to the NCTM, (2000), assessment should be viewed as a powerful resource in making instructional decisions. It appears that the subjects are moving beyond the traditional methods of testing, and are including more alternative and formative approaches to their assessment practices such as authentic assessments, portfolios, and student self assessments. Table 5 provides the descriptive statistics for items indicative of the Assessment Principle.

Table 5: *Descriptive Statistics for Assessment Items*

| Instructional Practices/Behaviors | Mean | SD | Never | Seldom | Sometimes | Frequently | Very Frequently |
|---|---|---|---|---|---|---|---|
| Teacher made tests | 4.91 | .38 | 0 | 0 | 3% | 3% | 94% |
| Rubrics | 4.87 | .34 | 0 | 0 | 0 | 13% | 87% |
| Authentic | 4.45 | .68 | 0 | 0 | 10% | 35% | 55% |

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|---|---|---|---|---|---|---|---|
| assessments | | | | | | | |
| Student self-assessment | 4.39 | .80 | 0 | 0 | 19% | 23% | 58% |
| Interviews and conferences | 4.07 | .89 | 0 | 0 | 35% | 23% | 42% |
| Student reflection | 3.72 | .86 | 0 | 3% | 45% | 29% | 23% |
| Portfolios | 3.29 | .78 | 0 | 16% | 42% | 39% | 3% |

*Note: n = 31*

**The Technology Principle**

Technology is now considered an essential component in learning mathematics well, and state and local curriculums encourage its use (NCTM, 2000). It can be seen that star teachers are infusing technology within their mathematics curriculum by utilizing websites, software programs, and virtual manipulatives (see Table 6).

Table 6: *Descriptive Statistics for Technology Items*

| Instructional Practices/Behaviors | Mean | SD | Never | Seldom | Sometimes | Frequently | Very Frequently |
|---|---|---|---|---|---|---|---|
| Software | 4.65 | .55 | 0 | 0 | 3% | 29% | 68% |
| Calculators | 4.52 | .77 | 0 | 0 | 16% | 16% | 68% |
| Websites | 4.42 | .68 | 0 | 0 | 10% | 38% | 52% |
| National Library of Virtual Manipulatives | 3.36 | .70 | 0 | 6% | 48% | 45% | 0 |

*Note: n = 31*

**DISCUSSION AND IMPLICATIONS**

This study focused on 31 star teacher's instructional practices for teaching mathematics. While the literature reports that many teachers in urban high-poverty schools are using more traditional approaches to teaching mathematics, this is not the case for star teachers. As seen by the results, a variety of approaches and practices that are culturally relevant and support NCTM's principles (2000) are being utilized. It's worth calling attention to some of the practices that are utilized regularly, as well as the approaches that appear to be implemented less frequently, and their implications for teaching mathematics in high-poverty elementary schools. A high percentage of teachers are supporting the Equity and Curriculum Principles by asking higher level questions, providing probing and prompting clues, demonstrating reinforcement techniques, and by adding personal creativity to the curriculum. In regards to the Teaching/Learning Principle, star teachers are differentiating instruction, and making use of cooperative groups, manipulatives, hands-on, and problem-based learning activities, all culturally responsive practices. The results also revealed that these teachers are not excluding the more traditional approaches. Although many teachers may implement an either- or method, existing research does not support an all-encompassing approach for the teaching of mathematics (U.S. Department of Education, 2008). It appears that the star teachers may be trying to address a balance of each.

It can also be seen that the star teachers are implementing more alternative and formative approaches to assessment, such as interviews and conferences, authentic assessments, student assessments and portfolios. Again, this is of particular interest since these types of assessment approaches focus on individual students' mathematical achievements and diagnosis (Cathcart, Pothier, Vance, & Bezuk, 2006; Van de Walle, 2006). The participating teachers are not using student reflections and portfolios as frequently as the other identified assessments. Both approaches hold merit in assisting students' understandings of mathematical ideas (Cathcart, Pothier, Vance, & Bezuk, 2006; Van de Walle, 2006). One plausible explanation is that the star teachers are infusing these approaches within student self-assessments or authentic assessments. Further justification from the star teachers is needed.

Star teachers are undoubtedly demonstrating those practices supported by the NCTM (2000). Demonstrating and believing in best practices is at the core of star teachers. Haberman (2005) explains:

> The way stars think cannot be separated from their observable behaviors. Their actions reflect their ideology and vice versa. This ideology includes their beliefs about the role of the school in serving diverse students in poverty, the nature of learning and the nature of teaching. . . To do what stars do requires sharing the beliefs and values they use as guidelines for making the countless decisions they make daily. To try to imitate what stars do, without believing as they do, leads to merely going through the motions of teaching and having little influence on students' learning (p. 131).

Clearly, star teachers can play an instrumental role in improving the mathematics education program within individual schools and districts since they are implementing the ideals set forth by the NCTM (NCTM, 2007). For example, these teachers can serve as teacher leaders or mathematics specialists and assist other teachers through collective planning, coaching, and modeling best practices. Cavanagh (2008) reported that the potential benefits of using mathematics specialists in elementary schools are great. He further stated, "Using specialists could be a practical alternative to attempting to raise the math skills of all elementary teachers (p. 15).

School districts might explore the use of selection instruments, such as Haberman's (2005, 2004) Star Teacher Selection Interview to best identify those teachers who will not only embrace NCTM's Principles and Standards (2000), but will also be effective with urban populations. This investment also holds promise in increasing the mathematics achievement levels of all students and attracting and retaining mathematics educators.

In this study, we used star teachers as the perspective of defining effective urban teachers. Other scholars have identified additional characteristics, dispositions, and profiles of effective urban teachers as well (Baron, Rusnack, Brookhart, Burrett, Whordley, 1992; Ladson-Billings, 1994; McDermott & Rothenberg, 2000). School districts use other interpretations of defining effective teachers, such as teaching credentials, teaching awards, and administrative evaluations. Because of the different interpretations of what defines an effective urban teacher, future research is needed to identify the mathematics instructional practices from these different viewpoints. Such evidence can contribute to the knowledge base of what effective mathematics educators actually do to impact student achievement.

While this study has identified the mathematics pedagogical practices of star teachers in elementary urban high-poverty schools, many questions remain. These include (a) how individual schools or districts can utilize star teachers to significantly improve the culturally responsive pedagogical practices of all mathematics teachers, (b) how best to nurture mathematics teachers so that they develop into stars, and (c) how best to attract star teachers for the urban high-poverty mathematics classroom as pressing issues in mathematics education. Focusing on these issues can better equip urban school districts to provide all students with rich opportunities that enhance their mathematical literacy and fluency.

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