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Urban Elementary Teachers' Perspectives on Teaching Science to English Language Learners

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Abstract

This descriptive study examined urban elementary school teachers' perceptions of their science content knowledge, science teaching practices, and support for language development of English language learners. Also examined were teachers' perceptions of organizational supports and barriers associated with teaching science to nonmainstream students. The study involved 221 third through fifth grade teachers from 15 urban elementary schools in a large school district. The teachers completed a survey in the spring of 2005. The internal consistency reliability estimates, Cronbach α , for scales created from the survey items were within an acceptable range. The teachers reported that they were generally knowledgeable about science topics at their grade level and that they taught science to promote students' understanding and inquiry. In contrast, the teachers reported rarely discussing student diversity in their own teaching or with other teachers at their schools. The teachers identified specific organizational supports and barriers in teaching science with diverse student groups at both the school and classroom levels.

Urban Elementary Teachers' Perspectives on Teaching Science to English Language Learners

As the school-aged population of the United States continues to grow more racially/ethnically and linguistically diverse, teachers face the challenge of making science content and processes accessible and meaningful for students from a broad range of backgrounds. Despite this urgent need, most elementary teachers are not prepared to teach science effectively in terms of content knowledge and teaching practices (Kennedy, 1998; Loucks-Horsley, Hewson, Love, & Stiles, 1998). Additionally, most teachers are inadequately equipped to meet the learning needs of culturally and linguistically diverse students (National Center for Education Statistics [NCES], 1999). Adding to the challenge, elementary classrooms often lack appropriate science instructional materials and supplies. This state of affairs is exacerbated in urban schools, in which nonmainstream students tend to be concentrated, because of a more generalized lack of resources and funding (Hewson, Kahle, Scantlebury, & Davies, 2001; Knapp & Plecki, 2001; Spillane, Diamond, Walker, Halverson, & Jita, 2001). Science instructional time in low-performing urban elementary schools is often limited and tightly regulated due to the urgency of developing basic literacy and numeracy in the context of high-stakes assessment and accountability policies that do not include science (Lee & Luykx, 2005; Settlage & Meadows, 2002; Shaver et al., in press). Furthermore, urban elementary school teachers often do not receive sufficient support from school administrators or colleagues for teaching science to nonmainstream students (Knapp & Plecki, 2000; Spillane et al., 2001).

Unlike the existing literature that has addressed science education and student diversity separately, this study examined urban elementary school teachers' perceptions of their knowledge of science content, science teaching practices, and support for language development of English language learners or ELL students simultaneously. Furthermore, unlike the existing

literature that has addressed school organization and student diversity separately, this study examined teachers' perceptions of organizational supports and barriers associated with their classroom practices in science. While teachers' perceptions may distort their actual teaching practices, their perceptions need still be taken into account when designing interventions as teachers are more likely to enact changes when those changes reflect their beliefs. Additionally, while it is not possible to produce a fixed list of recommendations for professional development, understanding current science teaching practices in the context of organizational supports or barriers is important for designing and implementing professional development aimed at promoting reform-oriented practices. The results of this study hold particular significance, given that the high-stakes testing policy in science will start nationally in 2007 under the *No Child Left Behind [NCLB] Act*.

Literature Review

Teaching practices are influenced by teachers' knowledge of academic content and strategies to teach this content with diverse student groups. Beyond factors residing with individual teachers, features of school organization, such as the interactions between school administrators and teachers, also influence teaching practices.

Teachers' Perceived Knowledge and Practices in Science Instruction with ELL Students

Teachers' knowledge of science content. It seems self-evident that teachers must know the subject matter they are required to teach (Kennedy, 1998). Teachers should have deep and complex understandings of science concepts, be able to make connections among science concepts or topics, and be able to apply science concepts to explain natural phenomena or real world situations. In addition, teachers should be able to engage in inquiry related to the practice of science, as they generate questions, design and carry out investigations, analyze and draw

conclusions, and communicate findings using multiple formats (National Research Council, 2000). Furthermore, teachers should be able to develop arguments and justify their ideas or solutions based on evidence (Lemke, 1990).

Teachers' knowledge of subject matter is a particularly important issue in science education, as many science teachers have only limited preparation in the science disciplines. They often have the same misconceptions or alternative frameworks about science as do their students (Abd-El-Khalick, Bell, & Lederman, 1998; Lonergan, 2000; Smith & Neale, 1989). Teachers who possess subject matter expertise and the ability to represent the subject matter to their students are more likely to engage in conceptually rich, inquiry based activities that facilitate student learning, whereas teachers with weak subject matter knowledge are more likely to rely heavily on the textbook as the primary source of subject matter content (Carlsen, 1991; Tobin & Fraser, 1990). This is problematic for student learning, since science textbooks generally fail to address students' misconceptions and teachers with weak science knowledge are unable to clarify students' confusions (Donovan, 1997).

Teaching science and English language development of ELL students. Many elementary school teachers have difficulty adopting reform-oriented practices because they have insufficient knowledge of science content and content specific teaching strategies (Garet, Porter, Desimone, Birman, & Yoon, 2001; Kennedy, 1998; Loucks-Horsley et al., 1998). Cohen and Hill (2000) and Knapp (1997) found that teachers who had engaged in large-scale professional development often blended reform-oriented practices with traditional practices. For example, teachers might engage students in hands-on activities or ask them to pose their own questions, but fail to help students make sense of the data they collected or ask the students for evidence-based explanations.

Many elementary school teachers have additional difficulties teaching science to ELL students (Bryan & Atwater, 2002; Rodriguez & Kitchen, 2005). They assume that ELL students must acquire English before learning science, are unaware of cultural/linguistic and cultural influences on science learning, do not consider “teaching for diversity” as their responsibility, or overlook linguistic differences and accept inequities as a given condition.

With ELL students, English language and literacy development should be seen as integral to subject area instruction (August & Hakuta, 1997; Chamot & O’Malley, 1994; Lee & Fradd, 1998). ELL students confront the demands of academic learning through a yet unmastered language. Subject area instruction provides a meaningful context for English language and literacy development, while language processes provide the medium for understanding academic content (Casteel & Isom, 1994; Stoddart, Pinal, Latzke, & Canaday, 2002). Hands-on, inquiry-based science is particularly effective for ELL students, as it bridges contextualized exploration of natural phenomena, authentic language activities, and communication of ideas in a variety of formats, including written, oral, gestural, and graphic (Lee, Deaktor, Hart, Cuevas, & Enders, 2005; Rosebery, Warren, & Conant, 1992). Doing so fosters the creation of classroom environments that promote ELL students’ development of general and content-specific academic language (August & Hakuta, 1997; Wong-Fillmore & Snow, 2002).

Organizational Supports and Barriers in Teaching Science for Student Diversity

Organizational supports. School leadership is one source of organizational support for the teaching of science, particularly in a context in which other subjects (i.e., reading, writing, and mathematics) command the bulk of the resources by virtue of tradition and formal policy. Spillane et al. (2001) examined how the school leadership (i.e., administrators and lead teachers in science) at one urban elementary school successfully identified and activated resources for

promoting change in science education. The researchers argue that promoting change in science education involves the identification and activation of: (a) physical resources (i.e., money and other material assets); (b) human capital of teachers and school leaders (i.e., the individual knowledge, skills, and expertise that form the stock of resources available in an organization); and (c) social capital (i.e., the relations among individuals in a group or organization, and such norms as trust, collaboration, and a sense of obligation). The researchers emphasize the importance of “distributed leadership,” in which administrators and teacher leaders support and sustain the professional community.

Collaboration among teachers within a school is another source of organizational support for the teaching of science. Gamoran and his colleagues (2003) argued that successful efforts to enable students to learn mathematics and science with understanding entailed the strategic use of human, social, and physical resources to promote change among teachers, including those teachers who would otherwise resist change. Challenges to such strategic use of resources are more formidable in urban schools where funding tends to be limited (Hewson et al., 2001; Knapp & Plecki, 2001; Spillane et al., 2001).

In secondary schools that maintained a strong academic focus on student achievement and provided students with strong supportive learning environments, compared to schools that lacked either or both, mathematics and science achievement was significantly higher (i.e., schools were more effective) and achievement gaps among students from different socioeconomic status (SES) backgrounds were reduced (i.e., schools were more equitable) (V. Lee & Smith, 1995). In these schools, teachers had strong professional communities that focused on the quality of the content of instruction, and all students took a highly academic curriculum with limited tracking options (V. Lee, Smith, Croninger, & Robert, 1997). These professional

communities were characterized by strong working relationships among teachers in their respective departments and a shared sense of purpose focused on student learning of mathematics and science (V. Lee & Smith, 2001).

Studies involving schools that enroll large numbers of ELL students have produced findings that are consistent with those of school restructuring, although science is seldom the focus in the literature (as exceptions, see Fradd & Lee, 1995; Garcia & Lee, in press; Minicucci, 1996; Secada & Lee, 2003). Effective schools for ELL students highlight language development both in students' home languages and in English as a key feature of the school's instructional program. Minicucci (1996) reported that four middle schools offering exemplary science and mathematics programs to ELL students gave them access to challenging and stimulating science and mathematics curricula by teaching them either in their home languages or via sheltered English instruction. In their study contrasting mathematics and science instruction between highly effective and typical elementary schools with high student diversity, Secada and Lee (2003) found that teachers in highly effective schools relied on their similar ethnic and linguistic backgrounds to encourage students' engagement in classroom tasks.

Organizational barriers. In addition to organizational supports, schools present organizational barriers to the teaching of science. Typically, barriers are more than simply the absence of supports. Some barriers are internal characteristics residing in the school with regard to students (e.g., poor academic skills in reading, writing, and math), personnel (e.g., administrator turnover, teacher turnover, low morale among teachers), and other school-level constraints (e.g., shortage of science supplies, large class size, lack of time to teach science, pullout programs during science). In their review of literature on schools as social organizations, Gamoran, Secada, and Marrett (2000) argued that teachers would sometimes resist, if not work

directly against, programmatic changes that are supported by other teachers in their school, thereby revealing organizational divides within the school. Such tension is felt more acutely in urban schools due to limited resources and funding (Hewson et al., 2001; Knapp & Plecki, 2001; Spillane et al., 2001).

Barriers also include external forces that impinge on school functioning. In the current policy environment, accountability measures influence instructional practices both in subject areas that are tested and in those that are not tested. When science is not part of accountability, it may be taught only minimally in the elementary grades (Knapp & Plecki, 2001; Spillane et al., 2001). When science is part of accountability, this may force schools to introduce the teaching of science in ways that take away from other subject areas. In other words, school subjects end up competing against one another for time, resources, and quality. This tension may be experienced more acutely in low-performing urban schools due to the urgency of developing basic literacy and numeracy. Furthermore, urban school teachers face added challenges, as sanctions against poor academic performance are disproportionately leveled against them, their students, and their schools (Secada & Lee, 2003; Settlage & Meadows, 2002; Wideen, O'Shea, Pye, & Ivany, 1997).

Barriers from parents, family, and community also impinge on school functioning. In their review of literature on science teachers' beliefs about student diversity, Bryan and Atwater (2002) report that teachers tend to ascribe problems associated with nonmainstream students' learning to the students' lives outside of school involving parents, family, and community, rather than to teachers' beliefs and actions toward students in the classroom. Such perceptions conflict with the "funds of knowledge" possessed by parents, family, and community that have the potential to serve as valuable resources for school science (Gonzalez & Moll, 2002; Moll, 1992).

Thus, a challenge facing urban schools is to build connections between schools and nonmainstream students' lives outside school.

Research Purpose and Questions

The existing literature indicates that elementary teachers experience a range of difficulties in teaching science to ELL students and other nonmainstream students in urban schools. These difficulties can be traced in part to their insufficient knowledge of science content and inadequate skills in using content-specific teaching strategies and addressing the academic language needs of ELL students. Beyond these factors and others residing at the level of individual teachers, organizational supports and barriers within and outside the school influence teaching practices with nonmainstream students.

This study is part of a five-year research project designed to simultaneously promote urban elementary school teachers' knowledge of science content, practices in teaching science, and practices for supporting English language development of ELL students in a large urban school district. As initial efforts to design effective professional development interventions, this study presents descriptive results about urban elementary school teachers' perceptions with regard to (1) their own knowledge of science content and their practices in teaching science and English language development of ELL students and (2) organizational supports and barriers to teaching science for student diversity.

This study contributes to the existing literature by examining how urban elementary teachers perceive challenges at both the school and classroom levels in teaching science and English language development to nonmainstream students, especially ELL students. The results establish a baseline for our own interventions using a longitudinal design and help others

consider the role of teacher perceptions in their efforts to develop professional development interventions in elementary science instruction with diverse student groups.

Method

Research Setting and Teacher Participants

The research was conducted in a large urban school district in the southeast U.S. with a student population displaying a high level of linguistic and cultural diversity. During the 2004-2005 school year, the ethnic makeup of the student population in the school district was 60% Hispanic, 28% Black (including 7% Haitian according to the district data on students' home language), 10% White Non-Hispanic, and 2% Asian or Native American. Across the school district, 72% of elementary students participated in free or reduced price lunch programs, and 24% were designated as limited English proficient (LEP), the state's term for ELL students in English to Speakers of Other Languages (ESOL) programs.

In late May 2004, elementary schools were selected based on three criteria: (a) percentage of ELL students (predominantly Spanish or Haitian Creole-speaking students) above the district average, (b) percentage of students on free and reduced price lunch programs above the district average, and (c) a minimum of four years getting school grades of C or D according to the state's accountability plan. This plan, which started in the 1998-1999 school year, assigns grades of A, B, C, D, and F to each school. In other words, we wanted to work with schools that were above the district average in concentration of poverty and ELL students and academically low performing. We avoided working with so-called failing (or F) schools because the district was focusing many resources and programs on those schools.

Of the 206 elementary schools in the district, 33 schools met these criteria. Our letter of invitation was sent to the principals of these schools to ascertain their own and their faculty's

interest in and commitment to a five-year professional development intervention project. Of the 33 schools, 17 volunteered to participate. Shortly after the project commenced, two schools withdrew, for a total of 15 schools participating in the larger project.

For our school-wide initiative, we invited every third through fifth grade teacher in each of the 15 participating schools. Table 1 presents the demographic makeup of the third through fifth grade students in these 15 schools. The students were predominantly Hispanic and Black (including many Haitian) from low SES backgrounds. Close to 40% of the students were currently in ESOL programs or had exited from ESOL programs within the previous two years.

Table 1

Student Demographics in the 15 Participating Schools (n = 5,577)

Variables	Demographic Groups	%
Ethnicity	Hispanic	52.4
	Black (including Haitian and Caribbean immigrants)	43.5
	White Non-Hispanic	3.0
	Asian	.2
	Other	.9
Socioeconomic status (SES)	Free and reduced price lunch programs	91.7
English language learners (ELL)	ESOL levels 1 through 4	15.8
	Exited from ESOL within 2 years	22.5
	Exited from ESOL over 2 years or never in ESOL	61.7
Exceptional student education (ESE)	Exceptional students (not including gifted students)	12.9

Table 2 presents the demographic makeup of the third through fifth grade teachers in the 15 participating schools. The majority of the teachers identified themselves as being from racial/ethnic nonmainstream backgrounds, which reflected the overall teacher demographics of the school district. The nearly 40,000 teachers in the district consisted of 41% Hispanic, 34% Black, 24% White Non-Hispanic, and 1% Asian/Pacific Islander. Approximately one third of the teachers in the research reported languages other than English as their native language. Almost

half of the teachers reported graduate degrees beyond a bachelor's degree. Their teaching experience ranged from 1 to 40 years, with an average of 12.5 years. They had been teaching at their current schools for an average of 9.1 years.

Table 2

Teacher Demographics in the 15 Participating Schools (n = 221)

Variables	Demographic Groups	%
Grade	Third	39.4
	Fourth	29.9
	Fifth	23.5
	Mixed	5.8
	Missing response	1.4
Gender	Male	14.0
	Female	83.3
	Missing response	2.7
Ethnicity	Hispanic	43.9
	Black Non-Hispanic	33.9
	White Non-Hispanic	13.1
	Haitian	3.2
	Asian	1.8
	Other	1.4
	Missing response	2.7
Native Language(s)*	English	64.7
	Spanish	30.8
	Haitian Creole	2.7
	French	1.8
	Missing response	5.4
Degrees	Bachelor's	55.2
	Master's	38.5
	Specialist	4.5
	Doctorate	.5
	Other	.5
	Missing response	.9

* Multiple native languages could be selected.

Data Collection and Analysis

Instrument. A survey instrument was developed based on relevant literature, our previous research (Hart & Lee, 2003; Lee, Hart, Cuevas, & Enders, 2004), and extensive field-testing to develop scales during fall 2004. The instrument is unique in that: (a) it includes scales to

measure latent constructs (see Appendix and the results section) rather than individual items, (b) it considers science instruction and student diversity simultaneously, (c) it examines both classroom-level and school-level variables, and (d) it addresses issues pertinent to nonmainstream students in urban schools.

In addition to the items about teachers' demographic and professional history, the survey included background questions about professional development during the 2004-2005 school year. The majority of the survey items were categorized according to the following sections: (1) teachers' knowledge of science topics according to the state science content standards, (2) teaching practices to promote science learning, (3) teaching practices to support English language development, (4) organizational supports in teaching science among the school administrators and teachers, and (5) organizational barriers in teaching science for student diversity. To help teachers think about their actual classroom practices and guard against their responding impressionistically, items inquiring into teacher "practices" were framed in terms of specific time periods (such as "in the last month") and were focused on practices that teachers engaged in for sustained periods of time (such as "for at least 10 minutes.") The survey items relevant to this study are presented in the Appendix.

Data collection. Data collection occurred in two ways. First, as a part of a professional development intervention, 45 third grade teachers from the seven treatment schools started their participation in the intervention in the fall of 2004. These teachers completed the questionnaire during the final workshop of the school year in May 2005. The remaining 176 teachers in the study completed the questionnaire at their school sites in May 2005. Administration varied at each of the 15 school sites. At most of the schools the questionnaire was administered to teachers in a separate session for each grade. At some schools the questionnaire was administered to all

third, fourth, and fifth grade teachers at the same time. Of the 230 teachers in the pool, 221 teachers (96%) completed the questionnaire. The questionnaire took 30 – 45 minutes to complete. A small compensation was offered to participating teachers.

Data analysis. The questionnaire consisted of items that were grouped together to form a total of 15 scales. The scales used a four-point rating system for each item. The score for each scale was computed using the average of the responses to the items that comprised the scale. Use of the average item response, as opposed to the summated score, ensured that missing responses would not lead to a systematic negative bias of the scale scores. A scale score was computed only for those respondents who had valid responses for at least 75% of the items in the scale. If someone answered fewer than 75% of a scale's items, the respondent's scale score was set to be missing and omitted from that particular scale. The reliability of the obtained scale scores was estimated using Cronbach alpha (α).

Results

The results are reported with regard to three domains: (a) background information about teacher preparation and professional development in science, science education, ESOL, and student diversity, (b) teacher knowledge of science content, science teaching, and English language development of ELL students, and (c) organizational supports and barriers in teaching science to nonmainstream students in urban schools.

Teacher Preparation and Professional Development in Science and Student Diversity

Table 3 presents the average number of science courses that the teachers reported taking at the undergraduate and/or graduate level. This question was asked to get an idea of the science background of the teachers. On average, they took two elementary science methods courses and one course each of physical, earth/space, and life science.

Table 3

Number of Science Courses Taken at Undergraduate and/or Graduate Level (n = 221)

Topic	<i>M</i>	<i>SD</i>
Methods of teaching science in elementary school	1.95	1.47
Methods of teaching science in secondary school	.30	.74
Physical science	1.02	1.22
Earth/space science	1.05	1.22
Life science	1.46	1.35

The teachers' training in ESOL is presented in Table 4. Over 50% of the teachers had ESOL training through college courses, including degree-bearing coursework at the undergraduate or graduate level. Additionally, close to 50% completed ESOL training offered by the school district. Slightly over 10% of the teachers did not have any ESOL training.

Table 4

ESOL Training (n = 182)

	<i>%</i>
Bachelor's degree in ESOL	4.9
Master's degree in ESOL	7.1
ESOL endorsement through college coursework	41.2
ESOL endorsement through school district	48.4
Grandfathered in through teaching limited English proficient students	8.8
No preparation for ESOL	11.5

Note. Teachers could check more than one response, and thus the percentages add up to more than 100%.

Teachers were asked to report their participation in professional development activities (aside from our intervention from the larger project) related to (a) science or science education and (b) student diversity. The results are presented in Table 5. The majority of the teachers never

or rarely participated in professional development activities in either science/science education or student diversity during the school year.

Table 5

Teacher Professional Development (Percentage of Teachers Based on n = 221)

	Science or Science Education (%)	Student Diversity (%)
Frequency During Past Twelve Month		
Never	39.8	48.9
Once	25.8	26.2
Twice	15.4	13.6
3-4 Times	10.4	6.3
More than 4 times	8.6	3.6
Missing Response	0	1.4
Total Hours During Past Twelve Months		
N/A	34.8	44.8
1-6 hours	27.6	26.7
7-15 hours	10.0	11.3
16-35 hours	11.8	5.9
More than 35 hours	6.3	3.6
Missing Response	9.5	7.7

Teachers' Perceived Knowledge and Practices in Science Instruction with ELL Students

The items for this scale asked teachers to rate their level of knowledge in teaching the eight science topics according to the state science content standards (see Table 6). Cronbach α for the score of this scale was .95, indicating strong reliability. The mean for this scale was 2.81, indicating that teachers reported they were generally knowledgeable about science topics at their grade level. Teachers' responses were largely consistent across the science topics, ranging from the mean of 2.74 for the topic of force and motion to the mean of 2.92 for the topic of processes of life.

Table 6

Teachers' Knowledge of Science Content

Science Topics	Cronbach α	<i>M</i>	<i>SD</i>	<i>n</i>
All science topics	.95	2.81	.64	219
Nature of matter		2.86	.78	218
Energy		2.75	.73	216
Force and motion		2.74	.72	218
Processes that shape the earth (earth science)		2.76	.74	217
Earth and space		2.80	.75	218
Processes of life		2.92	.73	217
Environment (environmental science)		2.88	.74	219
Nature of science		2.78	.78	218

Note. The responses are based on a four-point rating system (1 = not knowledgeable; 2 = somewhat knowledgeable; 3 = knowledgeable; 4 = very knowledgeable).

Teachers' self-reported practices for teaching science while supporting English language development of ELL students are presented in Table 7. These scales had a smaller number of respondents because only those teachers teaching science when the survey was administered were asked to answer these items. Faculty departmentalization at certain grade levels and in certain schools meant that some teachers were not asked to teach science during some academic years. As a result, we included only those teachers teaching science during this particular school year for this analysis. The scales included scientific understanding, scientific inquiry, traditional/conventional practices in teaching science, use of ESOL strategies, and use of ELL students' home language. Cronbach α for the scores of these scales ranged from .71 (acceptable but fairly low) to .86 (strong). The mean for the scale of teaching science for understanding was 2.90 and the mean for inquiry was 2.86, indicating that teachers claimed that they taught science to promote students' understanding and inquiry in most science lessons. In some lessons, they

taught science using traditional/conventional approaches ($M = 2.32$). They reported that they used ESOL strategies to promote English language development in only some of the science lessons, ($M = 2.04$) and used ELL students' home languages in few lessons ($M = 1.85$).

Table 7

Teaching Science and English Language Development of ELL Students

Scales	Cronbach α	M	SD	n
Scientific understanding	.77	2.90	.59	183
Scientific inquiry	.86	2.86	.65	180
Traditional/conventional practices in science	.71	2.32	.50	179
ESOL strategy use	.84	2.04	.84	166
Home language use	.83	1.85	.81	164

Note. The responses are based on a four-point rating system (1 = never or almost never; 2 = some lessons; 3 = most lessons; 4 = every lesson).

Organizational Supports and Barriers in Teaching Science for Student Diversity

Teachers' perceptions of organizational supports for teaching science are presented in Table 8. The scales included principal support for science, teacher collaboration in science practices, teacher collaboration in science tasks, and teacher discussion of how to address student diversity. Cronbach α for the scores of these scales ranged from .74 to .89, indicating moderate to strong reliability. Teachers generally agreed that their principals supported science instruction ($M = 2.90$) and that teachers at their schools collaborated for teaching science ($M = 2.93$). However, teachers infrequently shared teaching materials and activities, assessment tasks, students' work, or stories about teaching experiences in science ($M = 1.60$). Furthermore, teachers rarely discussed inclusion of girls, ESE students, ELL students, or culturally diverse students in teaching science ($M = .86$).

Table 8

Organizational Supports in Teaching Science for Student Diversity

Scales	Cronbach α	<i>M</i>	<i>SD</i>	<i>n</i>
Principal support of science ^a	.84	2.90	.73	212
Teacher collaboration in science practices ^a	.74	2.93	.61	215
Teacher collaboration in science tasks ^b	.85	1.60	1.02	213
Teacher discussion of student diversity ^b	.89	.86	1.03	211

^a The responses are based on a four-point rating system (1 = strongly disagree; 2 = somewhat disagree; 3 = somewhat agree; 4 = strongly agree).

^b The responses are based on a five-point rating system (“for at least 15 minutes during the last month,” 0 = never; 1 = 1 time; 2 = 2 – 3 times; 3 = 4 – 8 times; 4 = more than 8 times).

As a counterpart to the organizational supports, teachers reported their perceptions of organizational barriers to teaching science (see Table 9). The scales included barriers due to internal characteristics including (a) school-level constraints, (b) school personnel, and (c) students’ poor academic skills. The scales also included barriers due to external forces including (a) statewide assessments and (b) parents, family, and community. Cronbach α for the scores of these scales ranged from .74 to .92, indicating moderate to strong reliability. Teachers reported that emphasis on statewide assessments in reading, writing, and mathematics was a moderate barrier to teaching science ($M = 3.06$). Similarly, they reported the following as moderate barriers—students’ poor academic skills in reading, writing, and mathematics ($M = 2.92$); school-level constraints ($M = 2.75$); and parents, family, and community ($M = 2.75$). In contrast, teachers reported school personnel as a minor barrier ($M = 1.91$).

Table 9

Barriers to Teaching Science for Student Diversity

Scales	Cronbach α	<i>M</i>	<i>SD</i>	<i>n</i>
School-level constraints	.77	2.75	.69	210
School personnel	.74	1.91	.79	198
Students' poor academic skills in reading, writing, and math	.92	2.92	.85	214
Statewide assessments in reading, writing, and math	.90	3.06	.96	214
Parents, family, and community	.80	2.75	.88	211

Note. The responses are based on a four-point rating system (1 = not a barrier; 2 = minor barrier; 3 = moderate barrier; 4 = major barrier).

Discussion and Implications

Our nation's teachers are called upon to teach academic subjects to a student population that is becoming (ever) more culturally and linguistically diverse. This presents multiple challenges for elementary school teachers teaching science to nonmainstream students in urban schools. The literature indicates a multitude of difficulties facing these teachers. This study examined how the teachers themselves perceived the challenges, at both the classroom and school levels, of teaching science to diverse student groups. Specifically, as part of a larger research project, the study involved all third through fifth grade teachers from 15 urban elementary schools with high proportions of cultural and linguistic student diversity in a large urban school district. The majority of the teachers in these schools were from racial/ethnic and linguistic minority backgrounds, and many reported languages other than English as their native language. While these teacher demographics approximate the teacher demographics of the school district as a whole, both present a stark contrast to the science teaching force nationally which is close to 90% White (Smith, Banlilower, McMahon, & Weiss, 2002, p. 3).

Discussion

The teachers in the study took, on average, two elementary science methods courses and one course in physical, earth/space, and life science, respectively. This preparation is basically in line with the recommendation by the National Science Teachers Association (1998) for elementary teachers—to be adequately prepared to teach science, elementary teachers should have taken a course in science education teaching methods and one course each in the life sciences, earth/space sciences, physical sciences, and environmental sciences. Over the course of the school year during this study, however, a majority of the teachers never or rarely participated in professional development activities in science or science education. This finding is consistent with a national survey involving elementary school teachers (Smith et al., 2002, p. 24) as well as the literature indicating inadequate professional development of elementary school teachers in science content knowledge and science teaching (Garet et al., 2001; Kennedy, 1998; Loucks-Horsley et al., 1998). We believe that ongoing professional development in science content and pedagogy is at least as important for teachers as university courses, which were often taken many years in the past and which rarely address the science content or the pedagogy relevant to elementary science teaching.

Most teachers in this study had ESOL endorsement through college coursework or through the school district. This was to be expected, given a state mandate that teachers working with ELL students be endorsed in ESOL. After achieving ESOL endorsement, however, half of the teachers reported never having participated in professional development activities concerning student diversity in the last 12 months. This finding is consistent with the national survey of full-time public school teachers—about half of the teachers working at schools with more than 50% of minority enrollment did not participate in professional development activities addressing the

needs of ELL students or cultural diversity in the last 12 months (NCES, 1999, pp. 22-24). Given the cultural and linguistic diversity of the teachers in our study, our work could be seen as taking place in a best case environment for teaching diverse student groups. If the teachers in this study are not engaged in ongoing efforts to learn to better meet the learning needs of their nonmainstream students, it seems unlikely that teachers in more mainstream educational environments will do so.

The teachers reported that they were generally knowledgeable about science topics at their grade level. They reported teaching science to promote students' understanding and inquiry in most science lessons, while also using traditional/conventional approaches in some lessons. Furthermore, the teachers generally agreed that their principals supported science instruction and that teachers at their schools collaborated for teaching science. In contrast, the teachers reported infrequently using ESOL strategies or ELL students' home languages to promote English language development. Additionally, they rarely discussed student diversity (i.e., inclusion of girls, ESE students, ELL students, or culturally diverse students) in teaching science with other teachers at their schools. The teachers' lack of attention to student diversity is a concern, considering that the majority of both the teachers themselves and their students were from nonmainstream backgrounds.

The teachers in the study generally felt supported by their school administrators and other teachers regarding teaching science. However, they reported that school-level constraints (e.g., shortage of science supplies, large class size, lack of time to teach science, pullout programs during science) were moderate barriers to teaching science. They also reported the emphasis on statewide assessments in reading, writing, and mathematics, accompanied by students' poor academic skills in these subjects, as moderate barriers to teaching science. Furthermore, they

reported parents, family, and community as moderate barriers. These results are consistent with the literature on elementary science instruction in urban schools, indicating a lack of science instructional materials and supplies (Knapp & Plecki, 2001; Spillane et al., 2001), limited science instructional time due to the urgency of developing basic literacy and numeracy within the context of high-stakes assessment and accountability policies (Settlage & Meadows, 2002; Shaver et al., in press), and teachers' tendency to ascribe problems associated with nonmainstream students' learning to the students' lives outside of school involving parents, family, and community (Bryan & Atwater, 2002).

Implications for Further Research

The results of this study need to be interpreted with caution. Self-reports are subject to social desirability response tendency. Since the sample was not randomly selected, there is a limitation in the generalizability of the results. Additionally, this study presents only descriptive results of teacher perceptions. Despite these limitations, there are significant reasons why these results are worth reflecting upon. This exploratory study provides baseline results for further longitudinal investigations within our own research and in other similar studies. The results of our longitudinal research will contribute to the emerging knowledge base on teacher professional development for science instruction with diverse student groups, including ELL students, in urban elementary schools.

A major contribution of the study is the construction of the survey instrument. Unlike most of the existing survey instruments for large-scale research, we developed scales, rather than individual items, to measure latent constructs, for example, what constitutes "teaching science for understanding" or "ESOL strategy use." Our survey instrument also considers science instruction and student diversity simultaneously, while examining both classroom-level and

school-level variables. Additionally, it addresses issues pertinent to nonmainstream students, including ELL students, in urban schools.

Because we surveyed all third through fifth grade teachers in the participating schools (rather than just volunteer teachers) and because of the very high response rate to the survey (96%), we can be confident that the teacher perceptions speak to the pressing issues in the culturally and linguistically diverse urban schools in which we are situating our work. Extending the descriptive results of teachers' responses in this exploratory study, our further research will establish a theoretical model of relationships among the constructs in terms of teaching practices and organizational supports and barriers. This research will offer insights into what how these variables are related to one another and what key variables shape teachers' perceptions.

Most teachers in the study felt generally knowledgeable about science topics at their grade level, taught science for understanding and inquiry in most lessons, and collaborated with other teachers for teaching science. In contrast, they reported infrequent use of ESOL strategies or ESOL students' home languages and infrequent discussion with other teachers about nonmainstream students in science instruction. These self-report results will be compared with classroom observation results for the subset of participating teachers who will carry out our professional development intervention during the five-year period of the project. Our further research will examine whether teachers' perceptions reflect their actual teaching practices in their classrooms and actual collaboration with administrators and other teachers in their schools.

Using a longitudinal research design, further research may examine the impact of our professional development intervention on changes in teachers' perceptions over the years of their participation in the intervention. Further research may also examine the impact of our intervention on the relationship between teachers' perceptions and classroom practices over the

years. Additionally, further research may examine the relationship between changes in teachers' perceptions and practices, on one hand, and students' achievement outcomes, on the other.

A particularly promising line of research involves how the forthcoming high-stakes testing environment influences teachers' perceptions. In this study, teachers' perceptions of barriers to teaching science are telling—they identified the emphasis on statewide assessments in reading, writing, and mathematics, accompanied by students' poor academic skills in these subjects, as moderate barriers. Teachers' perceptions may change as science becomes part of school accountability in 2006 in the state in which this research takes place and in 2007 nationally as part of the *NCLB* Act.

We conclude that the results indicate both strengths and limitations in teachers' responses. As year-one baseline results, this study indicates that elementary school teachers entered our professional development intervention with a set of practices which, while problematic, showed promise. Even as they managed the multiple pressures of high-stakes testing and accountability in reading, writing, and mathematics, they perceived organizational supports to draw upon when it came to teaching science to nonmainstream students, including ELL students. Our hope through our ongoing intervention is to lower what the teachers see as barriers, to strengthen their organizational supports, and to enhance their teaching practices, so that the impacts of our intervention are sustained in the long term.

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Appendix

Teacher Survey Instrument

Section I: Teacher Knowledge and Practices in Science Instruction with ELL Students

Science Knowledge Scale

Please indicate how knowledgeable you feel in teaching each of the following science topics at your grade level.

Question	<i>Not knowledgeable</i>	<i>Somewhat knowledgeable</i>	<i>Knowledgeable</i>	<i>Very Knowledgeable</i>
1 Nature of Matter	1	2	3	4
2 Energy	1	2	3	4
3 Force and Motion	1	2	3	4
4 Processes that Shape the Earth (Earth Science)	1	2	3	4
5 Earth and Space	1	2	3	4
6 Processes of Life	1	2	3	4
7 Environment (Environmental Science)	1	2	3	4
8 Nature of Science	1	2	3	4

Teaching Science for Understanding Scale

- (Item 1) During the last month, how often did **YOU** do the following **in your science lessons**?
- (Items 2, 3, and 4) During the last month, how often did you **ASK STUDENTS** to do following **in your science lessons**?
- (Item 5) During the last month, how often did you **ASK STUDENTS** to do the following **in your science lessons for at least 10 minutes**?

Question	<i>Never or almost never</i>	<i>Some lessons</i>	<i>Most lessons</i>	<i>Every lesson</i>
1 Use students' mistakes to generate class discussion	1	2	3	4
2 Explain the reasoning behind an idea	1	2	3	4
3 Apply science concepts to explain natural events or real world situations	1	2	3	4
4 Talk about things they do at home that are similar to what we do in science class (e.g., measuring, boiling water, freezing water)	1	2	3	4
5 Discuss their prior knowledge or experience related to the science topic or concept	1	2	3	4

Teaching Science for Inquiry Scale

(Items 1, 2, 3) During the last month, how often did you **ASK STUDENTS** to do following **in your science lessons**?

(Items 4, 5) During the last month, how often did you **ASK STUDENTS** to do the following **in your science lessons for at least 10 minutes**?

Question		<i>Never or almost never</i>	<i>Some lessons</i>	<i>Most lessons</i>	<i>Every lesson</i>
1	Use science process skills (e.g., hypothesize, organize, infer, analyze, evaluate, describe patterns, make models or simulations)	1	2	3	4
2	Use basic measurement tools (e.g., ruler, thermometer, scale/balance, timer, graduated cylinder)	1	2	3	4
3	Use everyday, household items (e.g., plastic cups or containers, food coloring, light bulbs, batteries)	1	2	3	4
4	Analyze relationships using tables, charts, or graphs	1	2	3	4
5	Write about what was observed and why it happened	1	2	3	4

Traditional/Conventional Practices in Teaching Science Scale

(Items 1 through 6) During the last month, how often did you **ASK STUDENTS** to do following **in your science lessons**?

(Item 7) During the last month, how often did you **ASK STUDENTS** to do the following **in your science lessons for at least ten minutes**?

Question		<i>Never or almost never</i>	<i>Some lessons</i>	<i>Most lessons</i>	<i>Every lesson</i>
1	Lecture to explain science concepts	1	2	3	4
2	Conduct an experiment and have students watch rather than do it	1	2	3	4
3	End an experiment early (for reasons such as classroom management or time running out)	1	2	3	4
4	Strictly follow district guidelines for pacing of benchmarks	1	2	3	4
5	Use worksheets to reinforce basic skills	1	2	3	4
6	Present science facts quickly and efficiently	1	2	3	4
7	Memorize science vocabulary	1	2	3	4

ESOL Strategy Use Scale

During the last month, how often did **YOU** do the following **in your science lessons**?

	Question	<i>Never or almost never</i>	<i>Some lessons</i>	<i>Most lessons</i>	<i>Every lesson</i>
1	Revise science materials in English to make them accessible to ESOL students	1	2	3	4
2	Reduce difficult language to key science vocabulary in English with ESOL students	1	2	3	4
3	Talk with an ESOL student one-on-one in English to assess his or her communication of science ideas	1	2	3	4
4	Purposefully create small groups of English proficient and ESOL students to work together in science class	1	2	3	4

Home Language Use Scale

During the last month, how often did **YOU** do the following **in your science lessons**?

	Question	<i>Never or almost never</i>	<i>Some lessons</i>	<i>Most lessons</i>	<i>Every lesson</i>
1	Use science vocabulary in ESOL students' home language	1	2	3	4
2	Allow ESOL students to discuss science using their home language	1	2	3	4
3	Encourage small groups of bilingual and ESOL students to use their home language in science class	1	2	3	4
4	Allow ESOL students to write about science ideas or experiments in their home language	1	2	3	4

Section II: Organizational Supports and Barriers in Teaching Science for Student Diversity

Principal Support of Science Scale

We would like to know how you feel about **teaching science in your school**. Please indicate how strongly you agree or disagree by circling one response for each statement.

	Question	<i>Strongly disagree</i>	<i>Somewhat disagree</i>	<i>Somewhat agree</i>	<i>Strongly agree</i>
1	The principal actively supports finding time for science instruction	1	2	3	4
2	The principal allocates enough funding for science supplies	1	2	3	4
3	The principal clearly communicates the importance of teaching science	1	2	3	4
4	The principal encourages faculty to do planning for science instruction together	1	2	3	4

Teacher Collaboration in Science Practice Scale

We would like to know how you feel about **teaching science in your school**. Please indicate how strongly you agree or disagree by circling one response for each statement.

	Question	<i>Strongly disagree</i>	<i>Somewhat disagree</i>	<i>Somewhat agree</i>	<i>Strongly agree</i>
1	Most teachers in this school agree about how to teach science	1	2	3	4
2	When I have questions about teaching science, I can get good advice from other teachers in this school	1	2	3	4
3	I can rely on other teachers in this school to help me try out new teaching techniques in science	1	2	3	4
4	There is a lot of disagreement among teachers in this school about how to teach science	1	2	3	4

Teacher Collaboration in Science Tasks Scale

During the last month, how often did **YOU** do the following with other teachers in your school **for at least 15 minutes**? Please circle one response for each statement.

	Question	<i>Never</i>	<i>1 time</i>	<i>2-3 times</i>	<i>4-8 times</i>	<i>More than 8 times</i>
1	Share teaching materials and activities for science	0	1	2	3	4
2	Share stories about teaching experiences in science	0	1	2	3	4
3	Analyze a specific student's work in science	0	1	2	3	4

4	Work together to develop the goals or objectives for science instruction	0	1	2	3	4
5	Share assessment tasks that reveal how students understand science	0	1	2	3	4

Teacher Discussion of Student Diversity Scale

During the last month, how often did **YOU** do the following with other teachers in your school for at least 15 minutes? Please circle one response for each statement.

Question		<i>Never</i>	<i>1 time</i>	<i>2-3 times</i>	<i>4-8 times</i>	<i>More than 8 times</i>
1	Discuss inclusion of girls in teaching science	0	1	2	3	4
2	Discuss inclusion of ESE students in teaching science	0	1	2	3	4
3	Discuss inclusion of ESOL students in teaching science	0	1	2	3	4
4	Discuss inclusion of culturally diverse students in teaching science	0	1	2	3	4

School-Level Constraints as Barrier to Teaching Science Scale

How much of a **barrier** is each of the following factors to your **teaching science**?

Question		<i>Not a barrier</i>	<i>Minor barrier</i>	<i>Moderate barrier</i>	<i>Major barrier</i>
Policies and Practices					
1	Shortage of science supplies	1	2	3	4
2	Too many science topics to cover	1	2	3	4
3	Science topics too difficult	1	2	3	4
4	Large class size	1	2	3	4
5	Lack of time to teach science	1	2	3	4
6	Pullout programs during science	1	2	3	4

School Personnel as Barrier to Teaching Science Scale

How much of a **barrier** is each of the following factors to your **teaching science**?

Question		<i>Not a barrier</i>	<i>Minor barrier</i>	<i>Moderate barrier</i>	<i>Major barrier</i>
Policies and Practices					
1	Administrator turnover	1	2	3	4
2	Teacher turnover	1	2	3	4
3	Low morale among teachers	1	2	3	4

Students' Poor Academic Skills as Barrier to Teaching Science Scale

How much of a **barrier** is each of the following factors to your **teaching science**?

Question		<i>Not a barrier</i>	<i>Minor barrier</i>	<i>Moderate barrier</i>	<i>Major barrier</i>
1	Poor math skills	1	2	3	4
2	Poor reading skills	1	2	3	4
3	Poor writing skills	1	2	3	4

Statewide Assessment as Barrier to Teaching Science Scale

How much of a **barrier** is each of the following factors to your **teaching science**?

Question		<i>Not a barrier</i>	<i>Minor barrier</i>	<i>Moderate barrier</i>	<i>Major barrier</i>
Policies and Practices					
1	Emphasis on [statewide assessment] in reading	1	2	3	4
2	Emphasis on [statewide assessment] in math	1	2	3	4
3	Emphasis on [statewide assessment] in writing	1	2	3	4

Parents, Family, and Community as Barrier to Teaching Science Scale

How much of a **barrier** is each of the following factors to your **teaching science**?

Question		<i>Not a barrier</i>	<i>Minor barrier</i>	<i>Moderate barrier</i>	<i>Major barrier</i>
1	Lack of participation in school activities (e.g., parent-teacher conferences, returning phone calls)	1	2	3	4
2	Parents' (or guardians') limited English proficiency	1	2	3	4
3	Lack of supervision and support for homework	1	2	3	4