Urban Schools Teachers Enacting Project-Based Science

Revital Tal¹, Joseph Krajcik² and Phyllis Blumenfeld²

¹Technion, Israel Institute of Technology ²University of Michigan

What teaching practices foster inquiry and promote students' learning in urban schools? In this paper, we describe the characteristics of inquiry teaching practices that promote student learning in urban schools. Inquiry-based instruction and successful inquiry learning and teaching in project-based science were described in previous papers (Blumenfeld et al., 1994; Brown & Campione, 1990; Crawford, 1999; Krajcik et al, 1994; Krajcik et al., 1998; Ladewski et al., 1994; Marx et al., 1994; Minstrell & van Zee, 2000). Teaching is a major factor that affects both achievement and attitude of students towards learning science. Our involvement in reform in a large urban district includes the development of suitable learning materials and providing continuous professional development for teachers. Urban schools face particular challenges when enacting inquiry-based teaching practices like those espoused in PBS. In this paper, we describe two case studies of teachers whose students achieved high gains on pre and posttests and who demonstrated a great deal of preparedness and commitment to their students. Teachers' attempts to help their students to perform well are described and analyzed. The teachers described here work in a system, which is attempting to bring about systemic reform in science and mathematics.

The Center for Learning Technologies in Urban Schools (LeTUS) has collaborated with the Detroit Public Schools to bring about systemic reform. Through this collaboration, diverse populations of urban school students learn science through inquiryoriented projects and the use of various educational learning technologies. In order for inquiry-based science to succeed in urban schools, teachers must play an important role in enacting the curriculum, while addressing unique needs of the students. The aim of this paper was to describe patterns of good science teaching in urban school. The contribution of the paper is in describing how teachers in urban schools manage to mediate inquirybased science classrooms. Two case studies of teachers who succeed in enacting projectbased science helping their students to perform well are described and analyzed.

BACKGROUND

Urban schools

Urban American public schools face a variety of challenges while they struggle to provide positive and encouraging learning environments. These challenges include over crowded classrooms, old buildings, lack of resources, constant need for attracting qualified teachers, low student achievement scores on standardized tests, and students' attendance problems (Lynch, 2000). Systemic reform in urban schools addresses the issue of creating learning environments that promote all students acquiring positive attitudes, knowledge and skills. Professional development targeted at improving the content knowledge and pedagogical skills of teachers, coupled with understanding science education reform and what it means for urban population are necessary components for good teaching in urban schools (Lynch, 2000). Currently, textbooks and related materials

serve as a major device for student to learn science, but these materials can contribute very little to students learning in general and to students who have learning difficulties in particular (AAAS, 2000; Stern & Roseman, 2000).

Haberman (1991) describes good teaching practice for urban schools, which he claims, should promote learning for all students. Good teaching occurs if students:

- solve problems that are of interest to them;
- explain human differences, see major concepts, big ideas, and general principles, rather than accumulate isolated facts;
- plan what they will be doing;
- apply ideals such as fairness, equity, or justice;
- do experiments and construct things;
- reflect on real life experiences;
- work in heterogeneous groups;
- think about an idea in a way that questions common sense or widely accepted assumption;
- relate new ideas to ones learned previously or that apply an idea to the problems of living;
- redo, polish, or perfect their own works;
- access information through technology; and
- reflect on their own lives and how they come to believe and feel as they do.

Lynch and colleagues (1996) called for systematic development of science curricula with accompanying technology to support learning and eliminate inequities in science classrooms. Atwater (2000) supports this position. She describes the 'real life experiences' of urban children, and claims that they have already formed ideas about natural phenomena and developed cognitive structures on which to hang new science ideas. Therefore, she suggests that using engaging curriculum, computers and internet access along with standards-based curriculum materials may help African American students to narrow the achievement and attitude gaps.

Curriculum

The Center for Learning Technologies in Urban Schools (LeTUS), accepted that challenge put forth by Atwater, Lynch and Huberman to develop engaging curricula based on principles of social constructivism (active construction, situated cognition, community and discourse) and the use of technology. This curriculum materials address everyday life, deal with real life settings, and promote technology through experience, inquiry and collaborative work in project-based science. As part of our development efforts we address Huberman's and Atwater's concerns by developing our curricula according to specific design principles (Blumenfeld et al., 1998; Krajcik et al., 1998; Singer, Marx, Krajcik & Clay Chambers, 2000) such as contextualization, collaborating in doing inquiry and using learning technologies, and creating artifacts that address national and district standards. Scaffolds are designed to help guide learning as students are introduced to science concepts and processes.

Teaching and teachers

Educational reform depends on teachers' ability to lead the ambitious learning processes. Although many reform efforts envision much more thoughtful and demanding

instruction, most instructional practice in the US is traditional with lecture like, formal recitation as the common teaching strategy (Cohen & Spillane, 1993). Lynch (2000) argues that "schools with high number of students of color and low SES students are taught by less qualified teachers" (p. 138). Based on NSF and U.S Department of Education reports she claims that the poorer the school, the higher concentration of inexperienced teachers. This situation is partially explained high turnover rate of teachers. Lynch also claims that teachers in urban schools are less qualified and that occasionally they lack the positive attitude towards their students or what she calls: "rapport and trust" (pp. 197-198). Teachers' content knowledge and pedagogical skills are necessary, but not sufficient for science education reform. According to Putnam and Borko (1998), teachers require changes in their knowledge, beliefs and practice in order to achieve goals such as teachers as helping students to construct understanding, develop expertise and encourage the use of high cognitive skills. This effort is not just a case of learning new strategies or techniques. Various reform efforts (Blumenfeld et al., 1998; Krajcik et al., 1998; O'Day & Smith, 1993) present programs, that include both curriculum development and teacher professional development. This might cause an increase in students' achievements.

In order for students to achieve, they must have appropriate opportunities to learn. Opportunity to learn (OTL) was first introduced several decades ago and was defined by a narrow set of instructional components. Since then, educators and policy makers have incorporated additional criteria into the OTL concept (Schwartz, 1995; Tamir, 1998). According to Tamir, one of the major reasons for unsuccessful curriculum innovations is the failure of implementing the innovations in a manner that matches what was intended.

Teachers often teach in their traditional manner, but with new text. Teachers play a major role in implementing the intended curriculum and adopting the centrality of inquiry and active construction of knowledge. They assign the time students spend on task, present the ideas and build relationships. Teachers press students for understanding, foster students' reasoning, and use misconceptions for diagnosis and teaching (Blumenfeld, 1992). Teachers' content knowledge and pedagogical content knowledge play a major role in the way any curriculum and especially an innovative reform based curriculum is implemented (Lynch, 2000; Putnam & Borko, 1998).

Stevens (1996) presented the following opportunity to learn variables as important for successful innovations.

- *Content coverage* whether or not students cover the core curriculum and whether or not there is a match between the content of the curriculum taught and the content of the tests or assessment.
- *Content exposure-* the time allocated to students to learn (time on task) and the depth of teaching the subject.
- *Content emphasis* which topics within the curriculum teachers emphasize, and whether teachers choose to teach for low or high order skills.
- *Quality of instructional delivery* reveals how teaching practices have an impact on students' academic achievement.

Schwartz (1995) adds measures relate to time on task and teachers' competence.

According to Schwartz:

Time –

- Whether or not teachers spend adequate time covering the content in class
- Do students should have time to learn content on their own?
- Do schools emphasize more important curricula by assigning more class time for

it

- Teacher competence -Lead to mastery of course content and techniques to teach it meaningfully, with particular attention to the material in the content standards.
- Include strategies for reaching diverse students with different learning styles.

Measures of good teaching

Putnam and Borko (1998) argue that reform efforts depend on teachers' ability to depart significantly from much of the practice that is based on views of teaching as presenting and explaining content and learning as a rehearsal and retention of presented information and skills. They claim that both curriculum and teaching have to help students build nascent understanding. Teachers, like students interpret experiences through the filters of their existing knowledge and beliefs, which can be presented as: Pedagogical knowledge and beliefs; Subject matter knowledge and beliefs; and Pedagogical content knowledge and beliefs. The pedagogical knowledge includes teacher's knowledge and beliefs about teaching, learning, and learners not specific to particular subject matter (Putnam & Borko, 1998). Conceptions of learning such as active construction, learning in social context, teachers as mediators (Blumenfeld et al., 1998) are all aspects of pedagogical knowledge and beliefs. Content or subject matter knowledge affect the learning experiences that teachers provide their students with. Teachers with deeper understanding of subject matter tend to emphasize conceptual, problem solving, and inquiry aspects of their subjects whereas less knowledgeable teachers tend to emphasize facts and procedures (Ball, 1990a, 1990b; Cochran & Jones, 1998; Putnam & Borko, 1998; Tobin et al., 1994). Pedagogical content knowledge (PCK) refers to the "ways of representing and formulating the subject that make it comprehensible to others" and "an understanding of what makes the learning of specific topics easy or difficult: the conceptions and the preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons" (Shulman, 1986 p.9). In more recent works PCK is described as an integrated understanding different from either content knowledge or pedagogical knowledge and more constructivist oriented. PCK is described as consisting of four components: knowledge of pedagogy, knowledge of content, knowledge of the learning and knowledge of students (Cochran & Jones, 1998).

Another important measure, especially in urban schools is the level of commitment and involvement of the teacher in the reform objectives and efforts, which are expressed in his/her attitude towards the students. A teacher who feels committed, and wants the students to succeed would have a larger effect on students' achievements (Lynch, 2000).

In a systemic reform, there are complex relationships among design of curriculum materials, teaching, learning and professional development programs. Given the fact that project-based science is a continuing design effort, our goal was to describe various

measures of teaching, which can explain students' achievements. Defining these criteria and checking them against achievements allows us to describe patterns of teaching and highlight the domains, which should be the focus of our future professional development.

A set of several studies describing middle school teachers involved in inquiry based science (Krajcik et al, 1994; Ladewski et al, 1994; Marx et al., 1994; & Blumenfeld et al., 1994) show a strong connection between good implementation and understanding of the basic ideas of the reform in science education. Devoted teachers enact inquiry-based curriculum and struggle with various issues such as technology and collaboration. However, these teachers do not meet the same challenges teachers in urban school meet.

In this paper we present two teachers who succeeded in enacting project based science curriculum in urban middle schools in a large school district. The students of these teachers showed higher gains on posttest assessments compared to other students that were using this curriculum.

SETTINGS AND METHODS

University of Michigan (UM) scientists and educational researchers and Detroit Public Schools (DPS) are working together in the last few years to reform science education for middle school students. The collaborative work between DPS and UM takes place within curriculum projects funded by the National Science Foundation: the Detroit Urban Systemic Program and the Center for Learning Technologies in Urban Schools (LeTUS). This collaboration takes as its core challenge the infusion of technology to support learning into urban classrooms, and to provide a rich professional

development program, which includes summer institutes, Saturday workshops, afterschool sessions and work-groups.

The teachers described in this paper taught the seventh grade air quality project or an eighth grade force and motion project, each encompassing 8-12 weeks of instruction.

The air quality project centered on the driving question "What is the quality of the air in my community?" and included the concepts of the particulate nature of matter, states of matter, and chemical change. During the project, students performed group inquiry activities such as measuring and calculating the percent of oxygen in the air and determining the effects of acid rain on the environment. Students used modeling software as a learning technology to create air quality models that could be tested and evaluated. The project concluded with students in small groups making an extensive presentation comparing air pollution in two US cities. Presentations provided students with the opportunity to demonstrate their knowledge on relating sources and effects of pollutants, the chemistry of air quality, and the nature of states of matter.

The driving question for the physics project was "Why do I need to wear a helmet when I ride my bike?" to explore the concepts of motion, force, velocity and acceleration. Students planned and designed experiments, collected and analyzed data, using motion sensors with a computer interface to examine velocity and acceleration and to support their inquiry into the driving question. The anchor for the project was a series of eggand-cart demonstrations in which the egg represented a student and the cart represented a bike. In these demonstrations, Newton's first laws of motion, force, mass, velocity, and acceleration could be related. The project concluded with students working together to design helmets for their eggs and crash-testing them, using motion sensors, to

demonstrate the importance of wearing a helmet when they ride their bikes. Their helmet artifact was part of a final presentation in which groups of students presented data they collected, and interpreted and shared with their classmates. The projects were enacted in the 1998-1999 and 1999-2000 academic years to over 700 students in 1998, and about 1500 students in 1999. Almost all the participant students were African American.

Method

This study focused on two teachers: Laura and Barbara, from the Center of Learning Technologies in Urban Schools (LeTUS) in Detroit Michigan.

The cases of Laura and Barbara were selected from the work of approximately 25 teachers who participated in the projects during 1998-1999 and 1999-2000 school years. We had detailed video data of 10 teachers; however, we selected the two teachers to represent exemplary cases of teaching practices, various idiosyncratic challenges teachers in urban school meet, and common practices used by the teachers that led their students to succeed. University staff that followed all the teachers had nominated these two to represent the higher range of teacher performance. Both teachers presented good management skills and they covered the major parts of the curriculum.

Laura enacted the "*What affects the Air quality in my community*?" project in fall 1998 and in fall 1999, and the "*What is the water like in our river*?" project in spring 1999 and in spring 2000. Barbara enacted the "*Why do I have to wear a helmet when I ride my bicycle*?" project in fall 1998, and the "*What is the water like in our river*?" in spring 1999.

Data collection

University staff videotaped the classrooms across the projects, approximately three times a week. Pre- and posttests were administered in all the participating classrooms at the beginning and at the end of each project. Based on Taines, Schnider and Blumenfeld (2000) we selected tapes from three continuous events in each curriculum: investigations, technology use, and artifact creation. The lessons selected varied so that whole group, small group and individual interactions were represented and they occurred at different parts of the unit (Blumenfeld, 1992; Krajcik et al., 1994; Taines, Schnider & Blumenfeld, 2000). Approximately 15 lesson periods of videotapes per teacher were analyzed for this study.

Data analysis

Based on Blumenfeld (1992), Schwartz (1995), Stevens (1996), Krajcik and colleagues (1998), Putnam and Borko (1998) and Lynch (2000), the analysis units we chose for this study were:

- curriculum coverage;
- time on task;
- accuracy (content knowledge);
- curriculum emphasis and thoughtfulness (pedagogical content knowledge);
- use of technology;
- collaboration; and
- attitude towards the students.

Table 1 presents these analysis criteria and short descriptions. Data were analyzed in several stages. A detailed summary of each videotape was prepared. This summary included description of teacher and students actions and conversations. Then instances of teacher initiating lessons, whole class discussion, summarizing and concluding lessons were coded for: curriculum coverage, scientific accuracy, curriculum emphasis, collaboration and attitude towards the students.

Analysis criteria	Description
Curriculum	The extent at which the curriculum events were covered. Whether the
coverage	main activities were enacted and the main concepts were discussed in
	class.
Time on task	The time allocated to students to learn the main concepts and be
	engaged in the investigations in class.
Accuracy	Whether the teacher is accurate in the use of scientific ideas and
(content	concepts. The way the teacher presents scientific ideas.
knowledge)	
Curriculum	The depth of teaching the subject, and teacher's press for
emphasis	understanding by questioning to help students undercover the mean
(pedagogical	of concepts. Teacher's use of analogies and metaphors. Whether the
content	teacher instructs for low or high order skills, builds relationships,
knowledge)	analyzes and critiques. Whether the teacher deals with student
	misconception and uses them to improve learning. The way the
	teacher enacts the investigations, does inquiry and integrates the
	scientific concepts to everyday experience.
Technology use	The level of comfort the teacher shows with using technology in the
	classroom. How the teacher enacts the technology activities, and
	makes meaning by connecting the technology activity to the main
	ideas in the project.
Collaboration	Whether the teacher allows the students to work in small groups,
	encourages them to discuss and share their ideas and present group
	work.
Attitude towards	The level of respect and empathy the teacher shows towards the
the students	students. The level of desire for the students' success the teacher
	presents, the efforts the teacher shows in encouraging the students to
	do their best. Whether the teacher promotes independence and
	supports self-regulation.

Table 1. Analysis scheme for coding the videotapes

The analysis was synthesized across classrooms and teachers in order to form a general coherent description of good teaching in urban schools.

In order to describe the range of performances we used the terms *thorough*, *skillful* and *excellent* to describe the highest performance. The terms *sufficient* and *adequate* were used when the performance was good enough. In describing *fair* performance we mean that it was mediocrity.

FINDINGS

Background. Laura is Hispanic teacher who has six years of teaching experience, all in science. She has a BA in Education and Social Science. She has minors in Science and Language arts. Her certification is K-5 (all subjects) and 6-8 (social science, science, and language arts). She teaches in a typical neighborhood middle school in Detroit. The data described here are from her second year on the project.

Laura's class is very neat and well organized. She has excellent management skills. She never raises her voice, and she always addresses her students with respect. She is very structured, always well prepared for her classes, her overheads are ready to use, the title of the lesson or the driving question is presented on the board and a few questions are written on the board or a slide for bell-work. When the students enter the room they immediately grab their journals from marked plastic boxes and start their bellwork. From that moment, until the end of the class period, the students are concentrating on their work, either in groups or as a whole class activity, while Laura walks among the groups and encourages as many students as possible to participate.

Test results. On the air and water curriculum projects of 1999-2000 school year, Laura's students showed the highest gains compared with other teachers. Tables 2 and 3 show Laura's students net gains compared with other teachers' gains.

99-00 Air	Total gain	Stand. Effect
Teacher 1	1.68***	0.69***
Teacher 2	2.15***	0.77***
Teacher 3	3.41***	1.02***
Teacher 4	3.83***	1.07***
Teacher 5	4.40***	2.86***
Teacher 6	4.73***	1.53***
Teacher 8	4.87***	1.59***
Teacher 9	5.35***	1.80***
Laura	5.69***	2.00***

Table 2 Net gains in pre-posttest by teachers in 1999-2000 Air Quality curriculum

Table 3 Net gains in pre-posttest by teachers in 1999-2000 Water Quality curriculum

99-00 water	Total gains	Stand. Effect
Teacher 4	1.73 (0.52)***	0.52***
Teacher 6	2.17 (0.88)***	0.88***
Teacher 3	2.21 (0.84)***	0.84***
Teacher 2	2.31 (0.83)***	0.83***
Teacher 1	2.35 (1.00)***	1.00***
Teacher 7	2.93 (0.92)***	0.92***
Teacher 7	3.78 (1.30)***	1.30***
Teacher 8	3.95 (1.48)***	1.48***
Teacher 9	4.22 (1.40)***	1.40***
Teacher 10	4.27 (3.03)***	1.03***
Laura	4.49 (1.54)***	1.63~

Performance characteristics. Laura's performance, analyzed using videotapes and field observation data, is summarized in Table 4.

Criteria	General description	Evidence
Curriculum coverage	Thorough	Both videos and reports of support people indicate that all the activities according to the suggested sequence were covered. The teacher is observed pacing her students and moves them through the activities.
Time on task	Adequate	Teacher allocates time for all the activities, but many times it seems that students need more time for better understanding.
Content knowledge	Sufficient	Most of our videos indicate that her content knowledge is accurate. However, some inaccuracies were observed.
Pedagogical content knowledge	Adequate	She uses many analogies and repeats them. She monitors students' learning. She enacts investigations and inquiry and integrates scientific concepts to everyday experience. She models phenomena, and creates kinesthetic experiences to link body movements with scientific phenomenon She does not, however, press enough for understanding. We saw no attempt to foster high order thinking. She does not attempt to deal with misconception or use them to improve learning.
Technology	Skillful	She uses technology efficiency and appropriately. She assists the students, and enacts all the technology-based activities.
Collaboration	Fair	Students sit and do some group work, but they hardly discuss ideas, debate or present controversies
Attitude towards the students	Excellent	The teacher demonstrates respect to her students in the way she talks, guide and expects work to be done.

Laura's curriculum coverage was excellent. All the activities including students' presentations, which are time consuming and scheduled at the end of the curriculum were completed. Computer modeling activities, which other teachers avoided in air-curriculum, were enacted as well. In discussions with university staff she always acknowledged the fact that the curriculum's length is appropriate.

Time on task means not only the time the teacher allocates to cover the main ideas, it also means whether the students have enough time to learn things on their own, go over difficult ideas, and exercise skills. We found that Laura tends to give feedback about previous activities and to monitor completion and knowledge at the beginning of each class period. Our video analysis shows that students usually complete work and quietly speak until the teacher calls for attention. However, in regard to technology use, it was clear that due to personal differences, there were students who struggled with using the computers and exercising the mouse and clipboard. These students rarely had enough time to be really engaged with Model-It.

Laura's content knowledge was sufficient but some inaccuracies were observed. It was clear that she knows and understands the main scientific ideas of the curriculum. Occasionally, we observed mis-presented ideas, or attempts to simplify which might cause misconceptions. While discussing polluted air, she implied that polluted air has less O₂ compared to clean air by asking: "does polluted air has the same oxygen like clean air?" and all the class replied "NO". She accepted this answer, which indicates she had a misconception about the percentage of oxygen in polluted air. However, when a university support person was spoke with her about this confusion, she corrected herself in class. In another example she referred to octane as "found in gasoline and it's a toxin", while octane is not a toxin. In another case, the class was role playing CFC's in air. She made students who were playing CFC's molecules, chase and catch the students who were playing O₂ molecules. We know that CFC molecules randomly meet oxygen molecules. Regardless of these inaccuracies, Laura in general demonstrated understanding of the content.

Laura created and used various modeling activities, presenting one aspect of pedagogical content knowledge (PCK). She used a clear box with marbles inside and projected it on the wall, while moving it for better demonstration of the idea of motion of particles. She created hand and fingers kinesthetic experiences, where students demonstrated arrangement and movement of particles in different states of matter. Furthermore, she repeated these experiences over and over again. In order to explain how CFC's react with ozone, the students were acting as various molecules in air. Representations of these types can help young learners big to build models of the particulate nature of matter.

On the other hand, when students had mistakes she rarely prompted them in order to use the mistake for further thought, or as a trigger for class discussion. Here she shows insufficient PCK. Many times votes serve as a means for choosing the right answer. Her common practice was asking many students until she got the correct response. When complex ideas were discussed, quite often she provided generic definitions, or did not go beyond surface level of the content. An example for insufficient content knowledge was when she asked the class about pollutants.

Student: "the hydrogen part of H_2O_2 ".

Teacher: "This is a liquid, so what makes you say it pollutes?"

Student: "the hydrogen."

Teacher: "this is interesting".

At this point the discussion ended. The teacher went on to discuss other ideas and never discussed the difference between hydrogen gas, and hydrogen in a compound or the issue of hydrogen as a pollutant. Another example illustrates the use of generic definition.

Laura asked if in a physical change the original substance could be restored. No one raised hands in class. Then she asked if it couldn't be restored. Several students raised their hand, but Laura noted that many did not have an opinion. She restated her question and took a poll. Some students raised their hand for the wrong answer, but Laura never talked about it again. When doing chemical change activities she asked about getting the flash paper back after it burned and students said "no". Then she provided only this definition: "*Chemical changes produce something new, and you cannot get the original substance back. A physical change it's still the same substance.*" The last example illustrates the teacher avoiding a very important scientific idea, and not pressing her students to understand. When Laura burned paper and steal wool, and weighed the reactants and products, it was obvious that the products gained mass. She implied that when something is burning it uses oxygen. Students did not understand the hint, and she did not add anything and went on until the class ended. Quite often Laura tended to avoid developing complex ideas or verify whether the students really understand the concepts.

With respect to technology use, the computers in Laura's room were always ready to use. Moreover, she connected the technology-based activities to previous activities. When the students were using e-chem, a chemistry modeling software, she linked to their gumdrop models from a previous activity. While using Model-It, she asked the students to refer back to relationships they drew in a prior activity. In several of the videotapes we analyzed, she tended to be procedural to some extent, maybe because of time constrains. She barely checked or asked students to explain the relationships they created while engaged in Model-It. It was also the one of the first time she used Model-It and she may have been trying to determine herself how to best use it in her classroom. Nevertheless,

she was proficient with facilitating technology activities in her class; therefore, we described her as skillful, recognizing that there are areas where she can improve.

Both the videos and interviews with target students indicated that some degree of group work occurred in Laura's class. Students were requested to report to each other and to come to a group agreement. Yet, the students were usually asked to do their own work and only then to *share* their answers. We scarcely observed debates or real discussions in groups. In the interviews, most of the students regarded question and answer pattern as "discussions". In informal talks with Laura, it was clear that she is aware of the need to encourage more collaboration in her class.

Laura is a very devoted teacher. She uses a short poem, about doing the best we can which, she and the students repeat every day when they start class. All our videos and class observations show very calm atmosphere in class. In a few observations she told the students how much they are important to their parents, and how they would like them to succeed. She never shouts, and she calls students to her desk if she discusses personal issues, and it is obvious that the students highly respect her.

Barbara

Barbara is an African American teacher who has taught for 19 years, all in science. She has an undergraduate major in science with a minor in social science. She has an MA in science education, with certificates in elementary and endorsements in all subjects K-8. Barbara's school is a Magnet school. Students must apply for admission; however, they are not accepted according to achievement tests or ability, but rather on the child's and parent's commitment to attend the school. The data described here are from her first year on the project.

Barbara always welcomes her students with a smile. The general atmosphere is informal and sometimes it takes a few moments until the class actually starts. Barbara is always well prepared for class. The planned activities are ready, as well as student worksheets. Barbara's curriculum materials look very worn out. She has dozens of colored stickers between the pages, which indicate she really reads, plans and uses the materials.

Test scores. On the force and motion (physics) curriculum of 1998-1999 her students showed the highest gains. Unfortunately her students did not take the water pre-tests on that year; however, they demonstrated the highest posttest scores, which were significantly higher than all the other teachers in all the test categories. Table 5 shows Barbara's students net gains compared with other teachers' gains.

Table 5 Net gains in pre-posttest by teachers in 1998-1999 Force and Motion curriculum

98-99	Total gains	Effect size
Physics	-	
Teacher 1	2.48 (0.75)**	0.75**
Teacher 2	2.48 (0.75)** 3.00 (0.67)***	0.67***
Barbara	7.55 (2.19)***	2.19

Performance characteristics. Barbara's performance as was analyzed using videotapes and field observation data is summarized in table 6.

Table 6 Summary of Barbara's teaching practices

Criteria	General description	Evidence
Curriculum coverage	Thorough	Both videos and reports of support people indicate that all the activities according to the suggested sequence were covered.
Time on task	Thorough	She allocates time for all the activities. On few occasions, she decided to give more time for students to struggle with activities or making their reports.

Content	Excellent	Our videos indicate that she thoroughly understands the
knowledge		content of the curriculum.
PCK	Excellent	She presses students for understanding throughout the
		curriculum.
Technology	Skillful	She uses technology efficiently and appropriately. She assists the students, and enacts all the technology-based activities.
Collaboration	Excellent	She encourages students to share and develop ideas, and demands that they will discuss everything in groups.
Attitude towards the students	Excellent	The teacher demonstrates respect to her students in the way she talks, guide and expects work to be done.

Barbara, as well as Laura managed to cover the entire curriculum, and to do all the activities. However, on a few occasions Barbara decided to give additional time to students to struggle with activities or to make their reports. While students were engaged in doing investigations, she kept sending them back to write up their reasons, to discuss again in their groups and to come up with conclusions. A few videos show the teacher does not avoid debates and allow students to critique and suggest other ideas. Barbara's content knowledge was excellent. She emphasized important concepts. And we did not observe any misconceptions. Sometimes she was puzzled for a second, and then she organized her thoughts and discussed the ideas again with the students.

It was clear that Barbara pressed her students for understanding. By teacher's press for understanding we mean using questions, activities, analogies and metaphors in order to help the students undercover the meaning of concepts. We observed her press for understanding throughout the curriculum enactment and many examples serve as evidence. She keeps asking students to provide reasons, explanations and evidence. She encourages them to critique each other and herself. She keeps linking the force and motion ideas to real life phenomena. In one example, when the students had difficulty

with understanding a concept, she tells them not to ask her. "I want you to begin to understand the graphs. Look at the meter per seconds on the graph. Read the numbers. It will tell you what the velocity or acceleration was. Then you can compare to the next set of trials". Then she goes and checks on the different groups. She does not mind when students of different groups share their knowledge, and often we observed how she helps one group to understand something on the graph, and then the students went helping their friends in the nearest group. She keeps asking for reasons, evidence and conclusions. She makes them re-write their conclusions, and at the end of many activities, students are reporting to the class.

The force and motion curriculum offers many opportunities to use technology tools and Barbara is skillful with facilitating the investigations. She notices when students are struggling with motion detectors or with understanding the graphs. She moves between the groups and helps the students. The students move efficiently from the computers to class discussion and it seems that all these transitions are easy.

Barbara encourages her students to share and develop ideas; she demands that they will discuss everything in groups. It is obvious that the students feel comfortable in doing group work. The class can get noisy, but it is productive noise of students being cognitively engaged, and it does not bother the teacher. Students tend to ask, critique, help and convince each other. We observed students who do group work for long periods of time. They stayed on task and they were collecting and interpreting data, writing conclusion and suggesting each other ideas and words to use. As in Laura's class the students address the teacher with respect and in a friendly manner. Barbara allows them to speak with their friends and to move around the class. When she goes to recitation she

may wait for a few seconds until they calm down, but she rarely raises her voice and the students always calm down and let her to continue.

SUMMARY AND CONCLUSIONS

We described two successful teachers who managed to achieve high achievement gains. There was a consensus among the university staff and support people that these two teachers present the higher range of teacher performance.

Our study shows that various aspects affect teacher's ability to mediate inquiry in urban school classrooms. Basic management skills are essential. Observations of classrooms with management difficulties indicated that reasonable management is a prerequisite to all kinds of learning. Positive and encouraging attitude of the teacher contributes substantially to the students' tendency to be involved, do excellent work and present high attention in class (Attwater, 2000; Foster, 1997). In both cases, it was clear that the teachers expect much from their students. Both Atwater (2000) and Lynch (2000) addressed the issue of teachers' attitude. They claimed that there is a strong connection between teachers' supportive attitude and devotion to the goal of working in urban schools with diverse student population and students' achievements. Our study supports their claims. The two teachers described here respected their students, demonstrated high expectations and provided relevant and real world examples. Both teachers referred to community needs while teaching the curriculum. Laura kept using the air quality drivingquestion, referring to community health, and Barbara, provided many examples for accidents and hazards of driving in the city. Their enactment is advocated by Banks (1998), who stated that in order to overcome the challenges urban schools face we need

to educate students so that they will have the knowledge, attitudes, and skills needed to help construct a public community, in which all groups can, and will participate. The teachers are the main link between these goals and the young students they teach. Laura and Barbara served as this link in their classes.

Suitable curriculum is a major factor, which enables students to cognitively engage in inquiry. Our group had developed various learning materials that are enacted throughout the district. These learning materials are focused on real-life context, use technologies in order to foster learning and encourage students to collaborate as part of learning in social context (Singer et al., 2000). Both Laura and Barbara managed to teach the complete curriculum and they were always ready for class. We found some differences in their content knowledge; however, pedagogical content knowledge and collaboration in class appear to be more relevant in doing inquiry-based science (Crawford, 1999). Although Laura is monitoring her students' work, paces them, models and uses analogies, she does not appear to take into consideration their prior knowledge or where they might have difficulties. Barbara seems to understand better her students' difficulties. It is clear that she presses them to do thoughtful work, and to develop high order thinking skills by constant request for reasoning. As Ball (1990a, 1990b), Blumenfeld and colleagues (1998) and Putnam and Borko (1998) suggested, this might be the key point for teaching for understanding.

Teachers face many challenges in teaching science and doing inquiry in urban schools. It is clear that providing relevant learning materials, technologies and classroom support is not enough. We believe that exemplary work of teachers described here, which can serve as models for good teaching, reveals some of the major issues about teaching in

urban settings that would allow us to plan our future professional development better to benefit all our teachers.

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