[1]Urban students' beliefs about science in an inquiry-based classrooms

Tali Tal, Robert Geier, Joseph Krajcik

School of Education
University of Michigan

The Center for Learning Technologies in Urban Schools (LeTUS) has worked in collaboration with the Detroit Public Schools to bring about systemic reform. Through our collaboration, a diverse population of urban school students learn science through inquiry-oriented projects and the use of various educational learning technologies. For these projects to address the country's most critical science education needs, their design must benefit all learners regardless of culture, race, or gender. Professional development opportunities are provided to help address the needs of participating teachers.

The aim of this paper is to describe urban school students' beliefs about science, and their attitudes towards learning science in a real-life context, using technology and working collaboratively.

BACKGROUND

Urban schools

Urban American public schools face a variety of challenges while they struggle to provide positive learning environments. These challenges include over crowded classrooms, old buildings, lack of resources, constant need for qualified teachers, low student achievement scores on standardized tests, and students' attendance problems (Lynch, 2000). Banks (1998) states that in order to overcome these challenges 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. Systemic reform in urban schools addresses the issue of creating learning environments that promote acquiring these attitudes, knowledge and skills. Professional development

[1] Paper presented at AERA conference April 2000 New Orleans

targeted at improving the content knowledge and pedagogical skills of the 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 aid for learning science, but these materials can contribute very little to students in learning general and to students who have learning difficulties in particular (AAAS, 2000).

George Nelson in his article *Science Literacy for All in the 21st Century* states that today's science textbooks and methods of instruction, far from helping, often impede progress toward science literacy. Current methods of instruction emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, and bits of information instead of understandings in context. These textbooks fail to encourage students or to use technology to extend students' intellectual capabilities. These materials often prevent students from developing an appreciation for why science and technology are important.

Haberman (1991) describes good teaching for urban students, which he claims, is true for all students. Good teaching occurs if students are:

- solving problems which are of interest to them;
- explaining human differences, seeing major concepts, big ideas, and general principles, rather than accumulating isolated facts;
- planning what they will be doing;
- applying ideals such as fairness, equity, or justice;
- doing experiments and constructing things;
- reflecting on real life experiences;
- working in heterogeneous groups;
- thinking about an idea in a way that questions common sense or widely accepted assumption, that relates new ideas to ones learned previously, or that applies an idea to the problems of living;

- redoing, polishing, or perfecting their own works;
- accessing information through technology;
- reflecting on their own lives and how they come to believe and feel as they do.

Lynch and colleagues (1996) call 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 learning may help ‘Black American’ students to narrow the achievement and attitude gaps.

Curriculum

The Center for Learning Technologies in Urban Schools (LeTUS) also supports the position expressed by Atwater, Lynch and Huberman. Based on principles of social constructivism (active construction, situated cognition, community and discourse) we developed engaging curricula which address everyday life, deal with real life settings, promote technology through experience, inquiry and collaborative work in project-based science. As part of our development efforts we address Hubermans’ and Atwaters’ concerns and design our curricula according to the following principles (Blumenfeld et al., 1998; Krajcik et al., 1998; Singer, Marx, Krajcik & Clay Chambers, 2000):

- **Context** is created through the use of a driving question based on real world experience, and the use of anchoring events which expose students to phenomena being studied.
- **National standards** (AAAS, 1993; NRC, 1996) specify the sequence and substance of science concepts, specialized language, and practices and methods for asking

questions, solving problems and analyzing data. Standards also suggest how to help learners understand the nature of science, advocating a pedagogical approach that promotes the active construction of knowledge.

- **Inquiry** encourages students to ask questions, plan experiments, collect, analyze and share information. Inquiry also allows students to experience scientific phenomena, participate in the scientific processes and to create new understanding.

- **Collaboration** and student discourse is fostered within the learning community. Students are encouraged to work in groups, discuss their investigations, share their knowledge and create group presentations.

- **Learning tools** are used by students to support various aspects of inquiry. Learning technologies within the projects mirror those used by scientists, but are designed with learners in mind (Jackson, Krajcik, & Soloway, 1999; Krajcik, Blumenfeld, Marx, & Soloway, 1998).
- **Artifacts** are created as students conduct investigations. Students create a variety of artifacts that can be shared, critiqued, and revised to further enhance understanding and serve as means for assessment.

- **Scaffolds** are designed to help guide learning as students are introduced to science concepts and processes. Teachers sequence, model, coach, and give feedback as a scaffold for students' learning. Learning materials reduce complexity, highlight concepts and inquiry strategies.

  Technology provides multiple representations, hides complexity, and helps guide the scientific iquiry processes.

Learning environment research

Learning environment research has undergone remarkable development through studying different schools and classrooms during the past three decades. This field of research has helped us understand science learning differences between countries, schools and classrooms. It has also highlighted differences between subject matters. Through learning

environment research we confirmed the advantage of using laboratories compared to recitation teaching (Fraser, Giddings & McRobbie ,1995) and the advantages of using technology in the classrooms (Maor & Fraser, 1996; Tobin, 1998).
Quantitative instruments for measuring learning environments such as Learning Environment Inventory (LEI) (Walberg & Anderson, 1968) and Classroom Environment Scale (CES) (Moos & Trickett, 1987), which were widely used and are effective when applied to large scale studies. The administration and scoring of these instruments is manageable and cost effective and they tend to have few problems of reliability. Qualitative studies, which use ethnographic approaches to describe classroom environments help provide in-depth analysis of these classrooms. Since the nineties there have been many studies which combine the use of constructed scales with qualitative in-depth studies (Fraser and Tobin, 1991; Tobin, Kahle and Fraser, 1990; Tobin and Fraser, 1998).

In our work, we applied both quantitative and qualitative approachs to describe students' beliefs and attitudes about science and science learning in urban middle schools.

SETTINGS AND METHODS

University of Michigan (UM) scientists and educational researchers and Detroit Public Schools (DPS) are working together to reform science education for middle school students. The collaborative work between DPS and UM takes place within three 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, after-school sessions and work-groups.

Students in this study were participants in a sixth grade mechanical advantage project, a seventh grade air quality project or an eighth grade force and motion project, each encompassing 8-12 weeks of instruction.

The driving question for the mechanical advantage project was “How Do Machines Help Me Build Big Things?” During this project students learn about the concepts of balanced and unbalanced forces, motion, and the mechanical advantage provided by simple machines. The project is set in the context of designing a new machine to use to construct new buildings. Throughout the project students are asked to relate the concepts they are learning back to their ideas for their new machine design. Students explore the concepts of balanced and unbalanced forces and their relation to motion using force probes. Students work in groups to investigate the principle of mechanical advantage in the case of three different simple machines. Each group member designs and conducts an extended investigation into one of the simple machines, and brings his/her expertise back to the group for the development the group’s new machine design. The project culminates with the students’ creation of a drawing or a working model of their machine, which uses at least three simple machines. Each group develops a class presentation of their machine and their understanding of the science concepts behind how their new machine will function.

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 were involved in 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. The presentation provided students 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 probes 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 egg-and-cart demonstrations in which the egg represented a student and the cart represented a bike. In these demonstrations, Newton's first law 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, again using motion sensors, to demonstrate the importance of wearing a helmet when they ride their bikes in terms of the physics principles of motion. 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.

Population

The projects were enacted in the 1998-99 and 1999-2000 academic years to over 700 students in 1998, and about 1500 students in 14 Detroit middle schools classrooms taught by 20 teachers in 1999. Almost all the students were African American. Since our paper deals mostly with 1999 data the following numbers describe fall 1999, Two sixth grade teachers taught the module “Building Big Things” in 6 classrooms for the first time. Nine seventh grade teachers taught the module “What affects the Air Quality in Our Community?” in 28 classrooms, and 8 eighth grade teachers taught the module “Why do I Have to Wear a Helmet When I Ride my Bicycle?” in 24 classrooms. Some of the teachers taught these two curricula two years in a row, while others were new to the project.

Instruments

We combined qualitative and quantitative methods as recommended by Fraser and Tobin (1991) and Tobin and Fraser (1998). Self-report motivation surveys were adapted from work by Midgley and her colleagues (1998) and a scale measuring student perception of support for inquiry was adapted from the work of Taylor, Fraser, & Fisher (1997). The format for all items was a 5-point scale, ranging from 1 = "not at all true" through 5 = "very true". The survey was administered to students at the conclusion of each curriculum. Student responses to the item pool were factor analyzed and combined into distinct scales measuring science motivation, technology interest, thoughtfulness in inquiry, real-world connections and perception of the classroom (student collaboration and teacher press for understanding). The reliability of the constructs was examined after the first year of the study, and minor modifications were made to the question pool to enhance the utility of the instrument. Student-Newmann-Keuls post-hoc contrasts were run along with a general ANOVA model on teacher-related differences for each scale.

In addition, we conducted semi-structured, in-depth interviews with 30 target students in order to investigate their attitudes, beliefs, and perceptions about science and about their experiences during the science curriculum. Trained interviewers followed a protocol of questions but let the participants answer the questions in an open-ended manner and encouraged the students to give examples as illustration. The questions assessed student perceptions of how science relates to the real world, the authenticity of the driving question, their attitudes towards science, to technology, and to group work, and their perceptions of inquiry and thoughtful activities in their science classroom.

The interviews were transcribed, and then analyzed according to the main categories used for the quantitative analysis. For each category we counted the valid responses and grouped them under sub-categories expressing the actual opinions and arguments the students used. The over all positive and negative responses related to each question were tallied and recorded along with the illustrative responses

FINDINGS

Our work explored a subset of the data, focused on students' self-described motivation, their approach to scientific inquiry, and their attitudes toward science, using technology and working collaboratively. This paper does not attempt to describe actual classroom dynamics (see Krajick et al., 2000; Taines et al., 2000; Patrick et al., 2000), achievement, or instructional issues, but rather explores student self-perceptions about their classroom and approach to science learning.

Student perceptions

Five of the six composite scales relate to student perceptions of their motivation, classroom environment and the project curricula:

Motivation: student interest and motivation in science. This measure is sub-scaled into general science interest and motivation related to a desire for mastery.

Technology Interest: student attitudes about learning and using technology in the classroom.

Thoughtfulness in Inquiry: student responses to how they think about inquiry in the course of doing science in their classroom.

Collaboration: student perception of how they work with other students on science questions and investigations.

Real World Connection: student attitudes on how their science classroom learning relates to their outside-of-school life and experience.

Table 1 lists sample items and descriptive statistics for these survey measures, along with the reliabilities for the construct scales. Improvements in reliability between years were the result of question additions to strengthen construct scales where the question pool had been small.

Table 1: Student self-report academic beliefs and behavior measures

	1998 N=734			1999 N=1501		
	(α)	Mean	SD	(α)	Mean	SD
Science Motivation (12 items) I do my science work because I'm interested in it. I enjoy what we do in science class	.91	3.57	.94	.90	3.42	.89
Technology Interest (4 items) I like learning to use technology. I think learning about technology is useful.	.76	4.10	.89	.75	4.11	.88
Thoughtfulness in inquiry (10 items) When I design investigations, I try to think about how I can get the most information. When I am learning science, I try to make the ideas fit together.	.80	3.71	.71	.83	3.67	.69
Collaboration (6 items) I learn from other students in science class. When I work in groups in science class, there is teamwork.	.57	3.47	.86	.69	3.41	.83
Real world connection In science class I learn about the world outside the school. The ideas we learn about in science class are related to what's happening in our city.	.62	3.91	1.04	.71	3.67	.91

Although it is difficult to offer any reliable interpretation of such raw scale data, a few points are worth emphasizing. Both technology interest and real-world connection are high on the scale, suggesting that urban youth may be motivated by and benefit from technology rich curricula, and are seeing connections between curriculum projects and their everyday life.

Student Attitudes and Curriculum

Student reported perceptions of their science learning experience varied according to the curriculum unit they had just completed. There was no significant difference between the curricula on the technology interest measure, though a slight upward trend is seen from grade 6 to 8, this increase may be a product of increased integration of computer technology in the Air Quality and the Force & Motion units.

In contrast, the differences in students' sense that their science learning connects to their experiential world are great between the curricula. In urban Detroit, an industrial city, the issues of air quality and the related chemistry are strongly connected to the students' everyday life. Sixth grade students find good connections between the use of simple machines and their use for urban construction. Though still quite positive, the abstract concepts of force and motion related to bicycle collisions do not draw as strong a connection between classroom science and students' lives.

We found a significant decline in student reports of thoughtful inquiry, collaboration, and general science motivation from the 6th grade to the 8th grade. In the years considered, curriculum and grade level/student age are confounded, so it is impossible for us to separate curricular issues from what we believe may be a general decline in science motivation and classroom engagement through the middle school years. There is also evidence from student reports of teacher press for understanding and our survey data that teacher effects may also contribute (see figure 1). The grade level decline in these areas is a matter for future study.

Table 2: Survey scales by curriculum (***=p<.001)

1999	Mechanical advantage (6th)	Air Chemistry (7th)	Force & Motion (8th)
Motivation***	3.63	3.53	3.27
Thoughtfulness in inquiry***	3.84	3.72	3.57
Collaboration***	3.53	3.50	3.31
Technology Interest	4.02	4.11	4.14
Real World Connections***	3.61	4.00	3.40

Gender Effects

In urban classrooms, we found gender influences on student self-reported attitudes and practices in science (Table 3). One interesting result is the marginally significant difference between girls and boys in science motivation, with girls showing slightly higher motivation.

Although both genders reported an equal level of perceived connection between their work in science class and their life outside of class, they differed significantly in the other attitude scales. Though both girls and boys reported a high level of interest and enthusiasm for learning technology and using technology in learning science, boys interest was greater. In contrast, girls report higher levels of peer collaboration in their science work than boys, and a greater degree of thoughtfulness as they engage in scientific inquiry.

Table 3: Survey scales by gender (*** = p<.001, ~=p<.10)

1999	Boys	Girls
Motivation	3.35	3.45~
Thoughtfulness in inquiry	3.58	3.73***
Collaboration	3.28	3.54***
Technology Interest	4.24***	3.99
Real World Connections	3.63	3.69

The effect of gender on student responses also varied according to the curriculum project in which the students were engaged (Table 4). Higher reporting of peer collaboration by girls was consistent across all of the curricula, as was the higher level of technology interest reported by boys (statistical power was limited for the 6th grade curriculum because of a much smaller sample during the pilot year). The air chemistry curriculum, however, captured the attention of the girls. They reported a stronger sense of connection to the real-world environment of the urban area in which they lived, a greater willingness to engage in thoughtful inquiry on the topic, and a stronger motivation reflected in both science interest and mastery orientation. The aspects of the air chemistry curriculum that appeal to girls but fail to produce the same strength of effect in boys merits further study.

Table 4: Survey scales by gender and curriculum (***=p<.001, **=p<.01, *=p<.05, ~=p<.10)

1999	Mechanical advantage	Air Chemistry	Force & Motion
Motivation			

Boys	3.46	3.40	3.28
Girls	3.51	3.71***	3.26
Thoughtfulness in inquiry			
Boys	3.81	3.58	3.52
Girls	3.76	3.89***	3.61
Collaboration			
Boys	3.29	3.35	3.21
Girls	3.56~	3.70***	3.43**
Technology Interest			
Boys	4.10	4.20*	4.3***
Girls	3.80	4.02	4.00
Real World Connections			
Boys	3.64	3.87	3.41
Girls		4.14***	3.40

Note: statistical power was reduced because of small sample size for the Simple Machines curriculum.

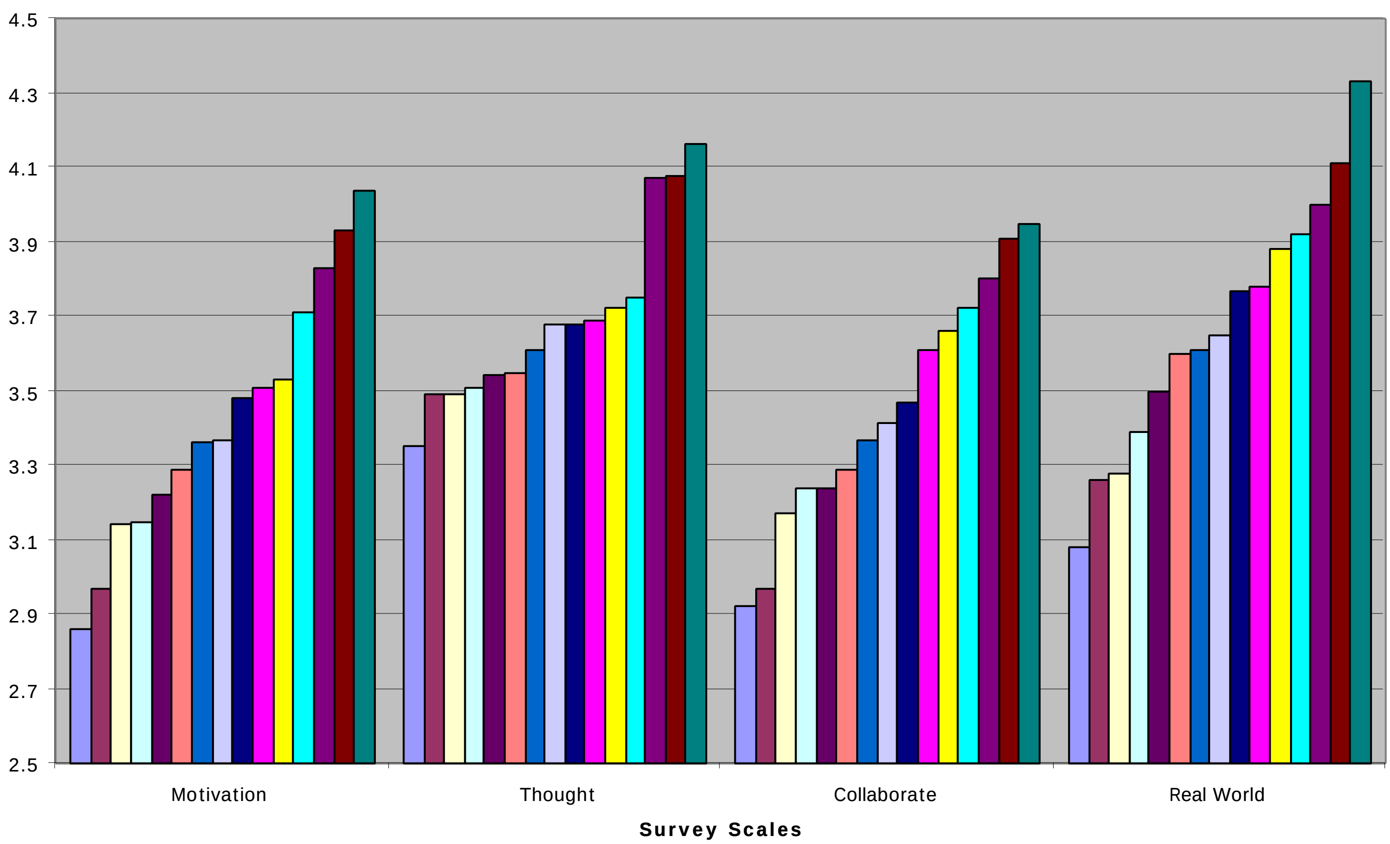
Teacher Effects

The student perception and attitude scales presented in figure 1 showed substantial effects related to the teacher, most likely arising from variations in individual instructors' approach to the classroom and implementation of the curriculum. With the exception of the technology interest scale, all of our student attitude scales showed significant ($p<.001$) and substantive variations across our participating instructors. The technology interest scale variation was also statistically significant, but the effects were notably smaller.

Student-Newmann-Keuls post-hoc contrasts were run along with a general ANOVA model on teacher-related differences for each scale. The data presented in figure 1 generally suggest that significant contrast differences (measured from the lowest scoring teacher) begin to show up after the first third of the teachers, and the top teachers show significant difference from the bottom two thirds. Most of the teachers tend to hold their position across the scales, with the top scoring teacher appearing at or near the top for all the scales except technology interest.

subject to “halo” effect related to general student enjoyment of the classroom. Our

Figure 1 Teacher effects on scales



teacher data are also confounded by school environment.

The survey findings do, however, provide a general picture, which allows us to include classroom-specific qualitative data in our analysis to provide some explanations for the general phenomena observed. The quantitative data suggest that our participating instructors tend to fall into three groups: several who consistently receive high student attitude for science reports, several who consistently score low, and a broad middle. Care should be taken in drawing conclusions from the numerical student reports in this way, as student ratings may be general trend observed.

Qualitative findings

The aim of the qualitative phase of the study was to provide further evidence to support the quantitative data. The main interview questions, which also served as analysis categories were:

1. Do you like science, and if so, why (science motivation)?

2. Does science learning involve thinking rather than memorizing? (what are the perceived features of science class?)

3. Are there group/class discussions in your classroom while learning science? Is there group collaboration in your science class? (collaboration)?

4. Do kids think about science after school, do they bring additional materials to the class?

5. Is technology important for learning science? And do you like using technology?

6. Is contextualized learning important? Does it improve the level of interest and commitment?

Table 5 presents the interview main categories, the description of the category, which includes students' opinions and some illustrative responses.

Table 5: Categories, trends and illustrative responses for the target students' interviews

Categories	Trend	Illustrative responses
Thoughtfulness in inquiry	Most students state that both thinking and memorizing are needed. Many addressed the fact that science is "more difficult" than other subjects. They have more homework, and they are expected to do things such as projects and presentations.	"You have to memorize and think a lot, you have to know math and lots of things. You need both because sometimes you do have to memorize stuff, especially when we did our formulas."
Discussing ideas	Most kids acknowledge discussions in science class, although sometimes they mention discussions as teacher led activity, or as a question-answer pattern, and not as group discussion.	"When we did the presentations, we had to discuss it and to go to other tables. They gave us grades and stuff like that, then we went up for the real presentations."
Collaboration in science class	Vast majority of the students prefers to have group work. Most of them stated that it is easier and that friends help each other to understand. They would like to have more group discussion in the future. A few number of students do not like group work, and do not want to have it in the future.	"More heads is better than one. When I don't understand something my friends help me to understand." "I learn better on my own"
Thinking about science after school, or bringing additional materials to the class?	Almost all the students responses were negative. They neither bring things nor think about or involved in science activities after school. Very few students stated they think about science or do science after school.	"I made picture frames from recycled paper."
Technology	Technology is the fun part of science class, technology is important nowadays, and it helps the students deal with science ideas. Vast majority of the students would like to use it more. Very few students would not like to use more technology, because it is boring.	"You have models and you get to connect them and tell what their pair group (variables) are. Computers are fun." Yes, because in my home we don't have a computer, so when we come to school it's like we do lab experiments we can really get to know a computer and do stuff with it."
Importance of contextualized learning,	All the students gave reasons for using a driving question in order to promote interest, but many of the examples given presented wrong or insufficient content knowledge. Most of the physics students stated helmets are important, but they would not wear them.	"In my neighborhood I see a lot of cars and pollution, so that let's us know that our air quality is not as good as you might find in the suburbs." "A lot of people ride their bikes and they need to know what could happen and how it could happen. I care about it a lot

	because I ride my bike a lot and I don't want to get hurt."

In the following section we elaborate each domain and provide illustrative responses, representing of the average and common responses.

Thoughtfulness in inquiry

This construct can be called "doing science" as "thoughtfulness in inquiry". When we asked students about their science class, we expected responses demonstrating inquiry activities. All the students stated they liked the experiments in science class the best. Other activities, which were mentioned as favorite ones were building models and doing presentations are components of inquiry as well. One of the students compared his different experiences:

> *"I like all the 'hands-on stuff' like e-chem [computerized visualizing tool]. We had the chance to do our own stuff, unlike 6th grade, when they do things for you and you just observe. In [our] science class we have to do a journal entry every day and it's a fine class."*

All these activities are considered to promote thoughtfulness and inquiry-based science education. When asked about what thing they would like to do more, all the responses included more building of physical and computerized models, more experiments, and more presentations. A common response was

> *"I'd like to do more presentations, where we got the chance to do our own research and make graphs from our data.*"

We can summarize that the main perception of science class for these students includes the use of investigations, collecting and interpreting data and presenting the acquired knowledge.

When asked about the ratio between thinking and memorizing in science class most of the students mentioned both as examples for learning science. One of the students explained:

> *"(We have to do) both, because sometimes you have to memorize stuff. Especially when doing (learning) formulas… but science is not hard because you get to do a lot of hands-on experiments and think*
>
> *and do stuff with it. "*

Collaboration and discourse

Classroom and group discussions are considered to be activities that encourage thinking in science. When asked whether they have many discussions in class and whether discussions are important, all the students stated that discussions are important in learning science but at the same time other provided a generic answer, of *"discussions are important because you get to hear other opinions."* When asked about discussion in their classrooms not all of them agreed they had enough discussions. One of the students described the process in her class.

> "*Discussing is important because when we did the presentations, we had to discuss and to go to other tables, and they gave us grades. When we went up for the real presentation, the whole class had to give us a grade. We were* (discussing) *about how the air met the national standards and we had to (see) if it goes over the national* (air quality) *standards…*"

There were also a few hesitating or negative responses of students who expected more discussions in their classes. One of them states she knows discussions are important, but are not done enough, and others saw discussion as the teachers' introduction or the question-answer pattern *"We talk about the lesson, what we're going to do today, that's what we discuss about."*

Collaboration, group work and discussions are very central in our curricula. The process of adjusting to learn though collaboration is difficult for both students and teachers. A main effort of our professional development is to encourage the teachers to apply as much group work as possible. Almost all the interviewees enjoyed working in groups, and believe that group work is helping them. They all explain how group work is easier, because each individual contribute to the whole group. Many used the metaphor of ‘two heads/minds are better than one. Many implied the fact that it’s less work. One of the student concluded the positive experience:

> *We did group experiments as a group and it is fun to do as a group instead of by yourself because if you are wrong or if you right or if you want to know something you can get it from your other classmates. Their opinion on that or whether why they agree or disagree with you…I liked group work because you get a chance to hear what they think about the experiment and it’s better than working by yourself because then you have more work or more help with the experiment…If I did not know how to explain the graph then they would show me how you could save your graph and stuff, and then we would go back to the graph we did before and then I’ll see if I can explain it to them and if I get it wrong then they can help me say well this is wrong you do it this way…*

A few students stated they’d rather work alone, because they do better when they are working alone. One of them had the feeling that she was *doing all the work* for her group mates, and she preferred to do it for herself. The overall response was very positive and the vast majority of the students would like to have more group work in the future.

Technology

Almost all the students were very enthusiastic about using technology in their classes. They provided many direct examples for how technology was used or how it helped them to learn. Following are a few examples.

- *With the computer we could see how molecules "move around"*
- *Using e-chem helped me because I was mixing molecules and atoms. if I'm making a chain (relationship – using model-builder), it gives us the source and what would be affected.*
- *It was pretty fun to build the models and to put the pH probes in the water.*
- *Kids go on computer now and they are more interested in computers, so when you build stuff, they think it's cool. Computers are like the up-to-date thing now. I like to build models and stuff.*
- *I liked it because most of the computers do not do that, you just type and print. On these computers you can angle it (examine molecules) the way you want, you see how to make lines that go up and down, back and forth fast and slow.*
- *Using the motion probes helps you get better understanding.*
- *I liked it, setting it and looking on the graphs. Getting information, it shows us more about acceleration.*

Only one student hesitated about using technology, then she defined the different activities and concluded that she liked some activities, where others were boring.

When asked about difficulties in using technology, most of the kids responded that the activities were easy. When asked about future use of technology all students but two expressed their wish to use more technology. There were students who responded in regard to their learning with technology, while others explained how technology would help them in their future lives. The following quotes emphasize the potential use of technology.

- *yes, it shows us technology that we can learn, and how to use it, and if you wanted to make technology, you would see how technology companies make things and you would see how fun and useful it is.*
- *yes, because it helps you understand better*
- *yes, I like technology because with the computers it help you a lot. Sometimes you have to do by yourself but it does give a helpful hand. I learned more about velocity by using the computer, like at first I didn't understand, but then I went into the computer and I began to learn it better…acceleration can change the velocity so when I stop that was acceleration.*
- *yes, because in my home we don't have a computer, so when we come to school it's like we do lab experiments we can really get to know a computer*

Real-world connection

The driving question we used for each curriculum was the main contextualizing method. Students would discuss the driving question in various stages of their learning. All the interviewees remembered the driving question for their curriculum, and all of them explained that it was related to the real world and how it was related, but the nature of the responses was very general. For example, all the physics students explained that they now understand the importance of wearing a helmet when they ride their bike, but no one provided the scientific explanation as to why it was important. When asked about themselves, most of them replied they wouldn't wear a helmet, because the way they look, or because they are very careful when they rode their bike. The air students explained quite nicely that our air quality is important to our health, but they mentioned air pollution and pollutants in a general way, and many times with inaccuracies.

"What affects it like smoke, when they burn trees and cut them down, that affects the air. That question can affect everything in life by the trains burning air, the engines coming out of the smoke, when the planes crash, the oil and the gas come out into the ocean."

These inaccuracies may be due to the great affect of the anchoring events we use for this unit, which encourage the social involvement, but in turn may interfere with acquiring the accurate content knowledgeknowledge.

A few of the students gave a good social rationale for using driving question as a real-world connection.

" I see a lot of ways (this question is important to me*), because in my neighborhood, we have a lot of cars and pollution…so that lets us know that our air quality is not as good as you might find in the suburbs. They* (in the suburbs*) make sure that their areas are clean, and they not really pollute the air."*

"The question was interesting because we got to figure out what our air is like. Some people say it's good, other people say it's bad. It's basically just knowing that you get to find out for yourself."

"It is fun and interesting because I would like to know why we have to wear a helmet and like the consequences of wearing one and the consequences of not wearing one. If some kids don't wear helmets that would tell them why they need to wear helmets. Some kids do not wear them because the way they look."

Science motivation

The science set of questions dealt with 'thinking about science after school', or 'doing science after school', or 'bringing additional things such as books and articles to school' and finally with future interest in learning science. This group of questions provided us with mixed responses. In general, these students are not thinking about science after school and are not involved in any kind of science activities after school. They rarely bring additional items to school, unless they are getting credit for it. Although this picture may look not very encouraging, about half of the interviewees would like to study more science in the future. The human body was mentioned as the most interesting topic, when describing the kind of science they want to learn. One of the students even suggested the driving question/s for the unit

> *"…yes, I likes to learn on why do you have to wash your hands before you eat, or like what different germs you can get, how to get through food so it won't get moldy and stuff."*

And another student described the way he wants to learn science

> *"…yes, I rather work in small groups. Everybody knows different things."*

DISCUSSION

Reviewing the learning environment of diverse urban classrooms, involved in project-based science allowed us to provide the students' perception of their classroom environment and of the curriculum they used. This is the first attempt to bring these students' perception to the fore. There is a large body of literature describing students' learning science and using inquiry (Krajcik et. al, 1998; Krajcik et. al, 2000; Lee & Anderson, 1993; Lunetta, 1998; 1998; Roth, 1995; Scardamelia and Bereiter, 1992). However, while this literature is focused on main stream schools, and provided much less information about urban school students.

We found that urban school students' perceptions about inquiry are similar to non-urban students' perceptions as addressed by Taines and colleagues (2000). The age of the students plays a major role in some measures such as collaboration and thoughtfulness in inquiry. Patrick et al (2000) have found that these measures are correlated with motivation towards learning science. In addition previous studies showed that the more

years our students are enrolled in science courses, the less they like it (Lazarowitz, Baird & Allman, 1985; Yager and Penick, 1986). These studies suggested that both teaching methods and curricular decisions may be the reason for the decrease in science interest in the secondary school level.
However, this tendency did not appear in the more curriculum dependent measures of real world connection and technology in our study. The air quality curriculum was positive for real world, and the physics was high for student interest in technology. These findings are in accord the nature of these curricula. The air quality curriculum addresses many real life issues such as pollution in the cities, and the physics curriculum is focused on technology (probes)-based investigations.

Gender differences in attitudes towards science are known and well documented. Many studies showed that at these ages boys' attitudes toward science are more positive than girls' attitudes (Kahle & Meece, 1994). Interestingly, our study shows a greater interest in science by girls when compared to boys, which is encouraging. However, the literature says that boys prefer physics while girls prefer learning about the human body and other 'softer' science topics (Baird et al., 1984; Kahle & Meece, 1994; Lazarowitz et al., 1985). Our study shows that girls preferred air quality and boys preferred physics. Our current development efforts are in accordance with these findings as well as the with the literature. A curriculum unit about sexual transmitted diseases for eighth grade is focused on the driving question "Can good friends make me sick?" is now pilot-implemented, and is aimed to address both the age and the gender related issues.

Science educators, researchers and policy makers agree that inquiry-based science is a key element in science education. Although there is a wide consensus about the basic nature of classroom inquiry many studies highlight difficulties and barriers in implementing inquiry. Our involvement in systemic reform in an urban school district had added another view on project-based science. The students' diverse cultural background suggests that their perceptions and beliefs about science and learning project-based science may be different from what we already know from other settings. Although most of the kids liked science because of the inquiry involved, and although many had advocated the use of technology, only about half of the students expressed positive responses towards learning science in the future. We believe that our project-based curricula and the teachers' professional development had contributed to the moderate positive attitudes.

Lee (1999) states that diverse groups of students may incorporate emotion and personal beliefs, where they are expected to use arguments based on critical scientific inquiry. They may involve a complex interaction of personal and supernatural beliefs with science understanding. She also claims that poverty and social class present a serious challenge in making science meaningful and relevant. Lee's claim may explain the mixed attitude towards future science and the negative response to the question about bringing books, articles or other materials to class. However, as Atwaters' (1994; 2000) and Lynchs' (2000) suggest, we use relevant experiences as triggers for learning, apply real-world situation to present scientific concepts and methods and provide technology tools to encourage and improve science learning. Doing all these in our projects and incorporating intensive professional development allowed urban middle school students to experience inquiry-based science. Our interviews with these students reinforced our belief that urban students appreciate inquiry, use technology and enjoy advanced learning methods such as class-discussions, group-work and creating artifacts. The data show that they enjoy learning science in the context of the real-world. We know as well that learning in a social context may be more appealing to these students than the traditional science context. This supports Lee's (2000) position, which highlighted the interaction of personal events with traditional western science. As suggested by Atwater (2000), Haberman (1991) and Lynch (1994; 2000), technology use may have a key role in encouraging urban school students to be engaged in science. Almost all the students who participated in the interviews enjoyed using technology and thought that this use may help them to understand science better. There were students who emphasized that school provides them the only opportunity to use technology, and others who addressed the importance of using technology in today's world.

Collaboration is another construct which is discussed a lot in the science education literature (Lazarowitz & Hertz-Lazarowitz, 1998). Many studies have emphasized the relationship between motivation and collaboration in the classroom, between collaboration and achievements and between collaboration and positive classroom environment (Fraser 1998a,1998b). Atwater (1996) suggests social constructivism as a framework where teachers and students negotiate contextualized concepts. The sociocultural context allows to evaluate scientific knowledge and actions. Students' cultural realities, including concepts of self and social roles, are constructed through social interactions. The data we obtained in our interviews supports Atwater's position. The students preferred learning in collaborative environment, they enjoyed their science learning more, and they believed collaborating with their classmates has contributed to their understanding.

Teaching is the last component of attitudes toward science. Our findings show significant differences among the teachers who participated in the project. Although we provide a comprehensive professional development program, and classroom support, factors such as teacher participation and attendance, involvement, preparation and commitment play an important role in the level of our curriculum implementation. This is also supported by Krajcik et al.(2000), who highlighted the influence of teachers on students' outcomes. There is also a consistency within the sub-scales which allows us to state that the more involved and committed teachers are the ones who contribute more to a positive learning environment, and are the ones that help their students to develop positive attitudes toward learning science.

Project-based science provides students with opportunities to learn science in real world context, to conduct investigations supported by technology in social settings, to discuss various science contents and develop positive attitudes about science. Our study shows that although there are many factors influencing and even interfering with these goals, the general trend is positive and promises further improvement. We are aware that the efforts we put in curriculum development and in professional development are long term endeavors and provide us with gradual change. Therefore we continue to improve existing curriculum units, develop new ones, and continue and improve with our professional development programs. All these efforts may contribute to improve our urban school students' attitudes toward learning science.

REFERENCES

American Association for the Advancement of Science (AAAS) (2000). Middle Grades Science Textbooks Report**,** http://www.project2061.org/newsinfo/press/rl092899.htm

Atwater, M.M. (1994). Research on Cultural Diversity in the Classroom. In: D.L. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning*. New York: MacMillan.

Atwater, M.M. (1996). Social constructvism: Infusion into the multicultural science education research agenda. *Journal of Research in Science Teaching*, 33, 821-837.

Atwater, M.M. (2000). Equity for Black Americans in Precollege Science. Science Education, 84, 154-179.

Baird, J.H., Lazarowitz, R. & Allman, V. (1984). Science choices and preferences of middle and secondary school students in Utah. *Journal of Research in Science Teaching*, 21, 45-54.

Banks, J.A. (1998). The Lives and Values of Researchers: Implications for Educating Citizens in a Multicultural Society. *Educational Researcher*, 27,4-17.

Blumenfeld, P.C., Marx, R.W.,Patrick, H. & Krajcik, J.S. (1998). Teaching for understanding. In: B.J. Biddle, T.l. Good & I.F. Goodson (eds.), *International handbook of teachers and teaching* (pp 819-878*)*. Dordrecht, The Netherlands: Kluwer.

Fraser, B.J. (1998a). Science learning environments: assessment, effects and determinants. In B.J Fraser & K.G Tobin (eds.), *International handbook of science education* (pp. 527-564). Dordrecht, The Netherlands: Kluwer.

Fraser, B.J. (1998b). Classroom environment instruments: development, validity and applications. *Learning Environment Research*, 1,7-33.

Fraser, B.J. & Tobin, K. (1991). Combining qualitative and quantitative methods in classroom environment research. In: B.J. Fraser & H.J. Walberg (eds.), *Educational Environments: evaluation, Antecedents and Consequences*, London: Pergamon (pp. 271-292).

Fraser, B.J., Giddings, J.G. & McRobbie, C.J. (1995). Evolution and validation of a personal form of an instrument for assessing science laboratory classroom environments. *Journal of Research in Science Teaching*, 32, 399-422.

Goe S.C & Tobin, K. (1998). Student and Teacher Perspectives in Computer Mediated Learning Environments in Teacher Education, *Learning Environment Research*, 2, 169-190.

Haberman, M. (1991). The pedagogy of poverty versus good teaching. *Phi Delta Kappan*, 73, 290-294.

Jackson. S., Stratford, S., Krajcik, J. & Soloway, E. (1996). Making system dynamics modeling accessible to pre-college science students. *Interactive Learning Environments*, 4, 233-257.

Kahle, J.B. & Meece, J. (1994). Research on gender issues in the classroom. In: D.L Gabel (ed.). *Handbook of research on science teaching and learning*, (pp.542-557). New York: Macmillan.

Krajcik, J., Blumenfeld, P.C., Marx, R.W., Bass, K.M. & Fredricks, J. (1998). Inquiry in project-based science classrooms: initial attempts by middle school students. *The Journal of the Learning Sciences*, 7, 313-350.

Krajcik, J., Blumenfeld, P., Marx, R. & Soloway, E. (2000). Instructional, curricular and technological supports for inquiry in science classrooms. In: J. Minstrell (ed.). *Inquiring into inquiry learning and teaching in science* (pp.283-315).

Lazarowitz, R. & Hetz-Lazarowitz, R. (1998). Cooperative learning in the science curriculum. In B.J Fraser & K.G Tobin (eds.), *International handbook of science education* (pp. 449-470). Dordrecht, The Netherlands: Kluwer.

Lazarowitz, R., Baird, J.H., & Allman, V. (1985). Reasons why elementary and secondary students in Utah do and do not like science. *School Science and Mathematics*, 85, 663-673.

Lee, O. (1999). Equity implications based on the conceptions of science achievement in major reform documents. Review of Educational Research, 69,83-

Lee, O. & Anderson, C.W. (1993). Task engagement and conceptual change in middle school science classrooms. American Educational research journal, 30, 585-610.

Lynch S.J. (1994). Ability grouping and science education reform: Policy and research base. *Journal of Research in Science Teaching*, 31, 105–128.

Lynch, S.J. (2000). *Equity and Science Education Reform*, Mahwah, New-Jersey; Lawrence Erlbaum Associates.

Lunetta, V. N. (1998). The school science laboratory: historical perspectives and contexts for contemporary teaching. In: In K. Tobin, & B. J. Fraser (Eds.), *International handbook of science education*. (pp. 249-262). Dordrecht, The Netherlands: Kluwer.

Lynch (1996)

Maor, D. & Fraser, B.J. (1996). Use of classroom environment perceptions in evaluating inquiry-based compute assisted learning. *International Journal of Science Education*, 18, 401-421.

Middleton M (2000). Can classrooms be both motivating and demanding? The role of academic press. Unpublished dissertation, University of Michigan.

Midgley, C., Kaplan, A., Middleton, M.J., Maehr, M.L., Urdan, T., Anderman, L.H., Anderman, E., & Roeser, R. (1998). The development and validation of scales assessing students' achievement goal orientations. *Contemporary Educational Psychology*, *23*, 113-131.Moos R.H. & Trickett, E.J. (1987*). Classroom environment scale manual* (second edition). Palo Alto, CA: Consulting Psychology Press.

National Research Council (1996). *National Science Education Standards*. Washington DC: National Academy Press.

Nelson, G.D. (1999). Science literacy for all in the 21st century, *Educational Leadership; Alexandria*, 57,2,131-142.

Roth, W. M. (1995). *Authentic school science.* Dordrecht: Kluwer.

Scardamelia, M. & Bereiter, C. (1992).Text-basrd and knowledge-based questioning by children. *Cognition and Instruction*, 9, 177-199.

Singer, J., Marx, R.W., Krajcik, J. & Clay Chambers, J. (2000). Constructing extended inquiry projects: curriculum materials, for science education reform. *Educational Psychology*, in press. Taines, C. Schneider, R, Patrickk, H. & Middleton, M. (2000). Observations of urban middle school students engaged in technology-supported inquiry. Paper presented at the AERA conference, New Orleans, April, 2000.Taylor, T. C., Fraser, B.J., & Fisher, D.L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research,* 27, 293-302.

Tobin, K. (1998). Qualitative perceptions of learning environments on the World Wide Web. Learning Environment Research, 1, 139-162.

Tobin K. & Fraser, B.J. (1998). Qualitative and quantitative landscapes of classroom learning environment. In B.J Fraser & K.G Tobin (eds.), *International handbook of science education* (pp. 623-640). Dordrecht, The Netherlands: Kluwer.

Tobin, K. Kahle & Fraser, B.J. (1990). Windows into science classes: problem associated with higher-level cognitive learning, London: Falmer Press.

Walberg, H.J. & Anderson, G.T. (1968). Classroom climate and individual learning. *Journal of Educational Psychology*, 59, 414-419.

Yager, R.E. & Penick. J.E. (1986). Perceptions of four age groups toward science classes, teachers, and the value of science. *Science Education*, 70, 355-363.