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Urban Students and School Science: Out-of-School Inquiry as Access

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Abstract

Students, especially students not represented in the culture of power such as many students in urban settings, need opportunities to find their voices in science and then have these unique voices heard by those in the culture of power, most notably, teachers. Science enrichment programs housed outside of traditional school settings can offer valuable opportunities for students from traditionally under-resourced schools to access authentic tools and practices, giving them unique opportunities to be recognized as competent participants in science. This study contributes to our understanding of this potential and how it can best be realized through an analysis of insiders' (science teachers' and students') perspectives of the outcomes of a specific enrichment program. Extensive data were collected on sixteen urban secondary science classrooms' participation in a one-day, hands-on laboratory experience offered at a university-sponsored education center. Building on the valuable perspectives of these participants, this study demonstrated that carefully designed out-of-school inquiry programs, in collaboration with teachers' work in science classrooms, have the potential to both broaden students' experiences as well as bridge them to this academic culture of power.

Introduction

Urban students have been shown to experience distinctly different science education experiences than their suburban counterparts due, in part, to poorly funded and under-equipped schools. Unfortunately, many times this different science is less accessible, less motivating, and less welcoming. Urban science education has developed as a distinct subfield of study in science education with a primary purpose of “documenting, describing, and transforming the landscape of science education in schools and community settings where resources are sometimes inequitably distributed, student bodies are diverse, and a sense of place is sometimes hard to understand amidst the bustle of buildings, roadways, communities, and sanitary and environmental concerns,” (Barton, 2002, p.32).

Previous research has highlighted the reality that access to resources, though important, is only part of the story (Spillane, Diamond, Walker, Halverson, & Jita, 2001). These researchers first point out that studying the impact of resources on science education requires extending our definition of resources beyond the school context, to the multiple contexts and resource available in the community. This study explores and thus presents one model of (a) how classroom resources can be extended to include access to authentic resources in the context of the school’s community through out-of-school enrichment programs, and (b) how interaction with these authentic tools and experiences were perceived by one group of urban students and their teachers. More specifically, this paper reports on a specific partnership between eight classroom teachers and a university-based science outreach program, focusing on participating students’ perceptions of the experience and comparing these perspectives with those of their teachers as well as to

benefits identified in the literature. The research questions that focus this work include, “What learning needs of urban science students can out-of-school inquiry experiences address?” and “What conditions contribute to the realization of these benefits?”

Reconceived Goals and Recommended Practices for School Science

Grounded in a theoretical framework of learning referred to as situated cognition (Brown, Collins & Duguid, 1989; Greeno, 1989, 1998; Lave & Wenger, 1991), current science education reform urges that every student should be frequently and actively involved in exploring the natural world in ways that resemble how scientists work in order to develop meaningful and applicable understandings of scientific phenomena (AAAS, 2001, NRC, 1996, 2000). This calls for learning activities that involve scientific practices focused on meaningful questions, using authentic tools, and offering opportunities for collaborative discourse. The National Science Education Standards (NRC, 1996) and the American Association for the Advancement of Science’s Project 2061 *Benchmarks for Science Literacy* (AAAS, 1993) place significant importance on a student’s understanding of and skills with the process of scientific inquiry. Learning science through inquiry-based methods challenges students to actively develop their understanding of scientific concepts, principles, laws and theories by combining scientific knowledge with manipulation skills and scientific reasoning (NRC, 1996). In addition, student access to modern scientific equipment provides them with data collection and analysis experiences that emulate those used by the scientific community and thus facilitate these new members’ participation in a unique community of practice, namely that of scientific knowledge construction.

Additional Needs and Challenges of Urban Science Students

While the goals identified earlier such as those set by the National Research Council (1996) present significant challenges to all science teachers, these challenges are exacerbated in most urban settings. Research has shown that urban science students can lose interest and develop negative attitudes toward science by the time they *enter* high school (Atwater, Wiggins, & Gardner, 1995; Hill, Atwater & Wiggins, 1995), which is not surprising when one considers that research (Oakes, 1990; Polakow, 2000) has shown to be accurate of urban school science: “They [urban students] experience a school science that focuses on behaviour skills, static conceptions of knowledge, and disciplining students through humiliation, stripping them of their cultural identities, their rights to learn, and their dignity as human beings,”(as cited by Barton, 2001 p.2). Students (and their teachers) in these settings and circumstances are in desperate need of learning contexts which offer access to and opportunity for meaningful engagement with the culture and community of science in equitable ways.

Barton and Yang (2000) describe the “culture of power” that is present in many existing science classrooms. As described by these authors, a “culture of power” exists when a particular set of values, beliefs, ways of acting and interacting unfairly and unevenly elevate one group of people over others (Delpit, 1988). Specific practices that perpetuate this culture of power in typical science classrooms include the predominance of “one right answer” for most activities, exercises, or investigations, the focus on memorization and recitation which runs counter to common scientific practices, and the treatment of science as a collection of facts separate from its rich cultural context and history. These practices keep science distant from student participants, making the

processes invisible from the products, which, in turn, perpetuates stereotypes that only very smart people somewhere out there (usually white and wealthy) can do science.

Offering urban students access to *authentic* scientific tools and processes in a supportive environment may lead to more inclusive and welcoming science education, education that invites and recognizes competent participation by these students.

However, simply providing urban students access to authentic resources and experiences is likely insufficient to foster equitable and motivating science learning opportunities. Therefore, meaningful and productive engagement with these tools and practices will likely require culturally-relevant, context-specific support (Spillane et al, 2001). For example, simply giving teachers and students access to tools such as computers is insufficient and will not alone lead support student learning (c.f. Cuban, 1986). Similarly, it would be unwise to assume that simply exposing students to an enrichment program (however strong its design) would result in optimal experiences for the individual students coming from uniquely diverse backgrounds and contexts. Instead, as Lee and Songer (2003) found, “real-world” situations used to support learning should map closely to students’ unique content understanding and curricular activities for inquiry to garner its full potential. As researchers suggest (e.g. Blumenfeld, Fishman, Krajcik, & Marx, 2000), an introduction and effective implementation of innovative tools and practices requires collaboration among the stakeholders. Stakeholders must first develop an understanding of the specifics of what the resource or innovation entails and how it maps within a given curriculum they must provide sufficient social and intellectual support for the implementation of these instructional tools in their practice.

Students, especially students who are not represented in the culture of power, need opportunities to find their voices in science and then have these unique voices heard by teachers, those in the culture of power. Out-of-school inquiry programs, in collaboration with teachers' work in science classrooms, have the potential to both broaden students' experiences as well as bridge them to this academic culture of power.

However, we know little about the specific ways such a partnership with community resources can offer science students different ways to participate in school science as well as ways in which this participation can be recognized by teachers and others.

Out-of-School Science Enrichment Programs

Science enrichment programs situated outside of typical school settings have been developed as a way to offer students access to authentic scientific tools and experiences, such as laboratory-based investigations, as a way to enhance students' achievement in science, attitudes towards science, and understanding of the nature of science (Freedman, 1997; Gibson & Chase, 2002; Bell, Blair, Crawford, Lederman, 2003; Knox, Moynihan & Markowitz, 2003; Markowitz, 2004). Examples include museum learning, university-outreach programs, summer science camps and apprenticeships, and outdoor adventure learning. These experiences offer science educators one powerful way to extend science learning resources outside the classroom.

Research has documented a number of important benefits of these out-of-school programs. Some specific programs have been shown to have a positive effect on improving science content knowledge of students in the general student population (Houtz, 1995; Freedman, 1997), girls (Houtz, 1995; Freedman, 1997) and gifted students (Tassel-Baska & Kulieke, 1987). Others have been shown to have a positive impact on

students' understanding of the nature of science and scientific inquiry (Bell et al, 2003; Kimbrough, 1995) as well as scientific reasoning (Gerber, 2001). These types of programs can offer venues to encourage a student's interest in science, help them develop a sense of scientific appreciation and literacy, and the many possible career opportunities in science (Atwater, Colson, and Simpson, 1999; Gibson and Chase, 2002; Helm, Parker & Russell, 1999; Richmond and Kurth, 1999). Bringing students into the community of scientific research and experimentation offers them the opportunity to experience first-hand the culture of scientific practice including the use of scientific methods, concepts and reasoning that are used by practicing scientists (Bleicher, 1996; Knox, Moynihan & Markowitz, 2003; Markowitz, 2004). In addition, numerous studies indicate that there is a positive relationship between the use of laboratory instruction in science class and students' achievement in science knowledge, their acquisition of science process skills, and their attitudes towards science (Freedman, 1997; Glasson, 1989; Goh, Toh, & Chia, 1989; Harty and Al-Faleh, 1983; Hofstein & Lunetta 2004).

A critical review of Resnick's (1987) comparison of out-of-school to in-school learning suggests that, considering typical challenges faced by urban science education, the benefits of out-of-school learning may be even more amplified for urban students such as those participating in this study. Out-of-school inquiry experiences have the potential to offer urban students much needed access to authentic science tools (e.g. microscopes, pipettes), practices (e.g. collaborative activity structure) and contexts (well-equipped laboratories).

Previous research on science education initiatives in out-of-school contexts has primarily investigated its impact with respect to one particular dimension of student

experience. Some researchers questioned the impact of the experience on student achievement; others on student attitudes; some on the number of students later pursuing scientifically-related careers; and still others on students' understanding of the nature of science and scientific inquiry. Though certainly valuable to the field, research narrowed by the research question to explore only one particular aspect of the resulting impact of such unique and diverse experiences and partnerships inevitably narrows the scope and richness of the findings. As the findings are limited to one particular outcome, it is impossible to explore the relative importance or impact of various results in comparison with each other.

In addition, Erickson (1986) argues that interpretive research should be stereoscopic in nature with a quest to understand the experience from both the insiders' perspective as well as a more detached outsiders' perspective. As it was the goal of this partnership to engage students in authentic and meaningful science experiences, we wanted to understand the benefits from the students' and teachers' vantage point (insiders') as well as from an analyst's (outsiders') perspective. Few research studies offer an open-ended exploration of the perceived benefits and limitations of these learning experiences from the insiders' perspectives, allowing for the emergence of good *and* bad, expected *and* surprising, as well as the perceived impact of these in relation to each other. In addition, no studies were found that explored the unique perceptions of such an experience from the perspective of students from a typical under-resourced urban setting.

The “Partners” and the Partnership

The partnership explored in this study was a joint project between a university’s outreach program and eight science teachers and their students from an urban school district. Understanding what each brings to the table is essential first step in beginning to understand the potential impact of such a collaboration.

The Life Sciences Learning Center. The University of Rochester’s Life Sciences Learning Centre (LSLC) is a hands-on science education and outreach centre offering programs for students in grades 6-12. The LSLC facility is housed in the University of Rochester School of Medicine and Dentistry and includes two teaching laboratories, fully equipped with items such as micropipetors, microcentrifuges, incubators, waterbaths, microscopes, DNA electrophoresis equipment, and networked computers. LSLC programs include student field trips (for laboratory-based investigations) for middle and high school science classes (grades 6-12), a Saturday morning program for middle school students and summer science camps for middle and high school students. The LSLC also hosts a variety of science teacher professional development workshops for in-service and pre-service teachers. The LSLC inquiry-based curriculum units introduce both science content and hands-on laboratory skills and cover a wide variety of topics in the life sciences including recombinant DNA, genetics, microbiology, cell biology, biochemistry, toxicology, and environmental health.

Rochester City School District. The Rochester City School District (RCSD) is one of the largest school districts in New York State, with 35,000 K-12 students in 39 elementary and 17 secondary schools. Thirty-five different languages are spoken within the student population, and 8% (2,900) of RCSD students are English language learners.

Though this diversity brings with it strengths, it also creates challenges for teachers to meet each student's very unique needs.

Schools in the RCSD face a number of challenges with high student needs relative to district resource capacity. According to the Children's Defense Fund (<http://www.childrensdefense.org/data/census00/pov/city.txt>), Rochester is 11th in the nation in per capita poverty of persons under 18 out of 245 US cities with populations of 100,000 persons or more. Eighty percent of RCSD students qualify for Title I services, provided to students whose family income is below the federal poverty level. Students with special education needs make up 15% of the student population (5,500 students). Given these demographics of being primarily under-resourced while serving a diverse population with respect to race and ethnicity, RCSD science teachers and their students face challenges common to those described in the urban science education literature.

Student Participants. Two hundred ninety-two grade 6-12 students from eight classes in the RCSD participated in this study. Teachers who had previously participated in LSLC student field trips or professional development workshops were recruited to participate via a formal letter and project application form that was mailed to Rochester City teachers and to their school principals. The eight teachers were selected to participate in this outreach program on a "first come, first serve" basis once they and their principal completed the application form that described the program goals and mechanics.

Table 1: Overview of study participants

Teacher*	School Type	# of Participating Classes	# of Participating Students**	# Years Teaching Experience	Lab-based Investigation
Ms. ES	High	2	34	2	What's in our water?
Ms. MB	High	2	29	4	What's in our water?
Ms. DB	High	2	49	9	Bacterial Transformation
Mr. DS	High	2	44	2.5	Bacterial Transformation
Mr. JV	Middle	2	40	16	Molecular Size
Ms. CS	Middle	2	41	7	Molecular Size
Ms. SM	Middle	2	22	3	Environmental Hazards
Ms. BB	Middle	2	33	22	Environmental Hazards

* Pseudonyms are used in place of teachers' formal names to protect the privacy of these participants.

**Note: This number refers to the number of participating students who attended the class at the LSLC. The in-school class consisted of more students. Not all students from each class were able to visit the LSLC, due to lack of permission slips, being absent on the day of the trip, or behavioural issues.

Approximately 44% of the participating students were African American, 25% Hispanic, 14% European American, and the remainder were small percentages of Asian American, American Indian, Arab American, mixed, other, or non-respondents.

Approximately 45% of students spoke a home language other than English.

Approximately 58% of the students were female. This trip to the LSLC was the first such visit for approximately 88% of the students.

The Partnership.

The eight RCSD science teacher participants in this study worked with the facilitators of the Life Sciences Learning Center (LSLC) to choose, develop, and cater a mini-curricular unit for each class of science students. Collaborative work between the

teachers and the university facilitators centered around the choosing and modifying of one of four inquiry-based units (which included pre-activities in school classroom, half-day lab experience on the university campus, and post-activities in school classroom) to cater to the interests and learning needs of each class of students, scheduling, and determining the classroom teacher's role. These decisions were made both in large group discussions between all eight teachers and university facilitators as well as in one-on-one meetings between the teacher and a facilitator.

The LSLC Laboratory Investigation Program. Participating classroom science teachers selected one of four available curricular units, two designed for middle school students and two designed for high school students. These curricular units focused on supporting students' understanding of concepts and investigative skills related to recombinant DNA, genetics, cell biology and environmental health. Each on-site visit included an introduction to the lab activity followed by a group activity or computer simulation, review of lab procedures and safety issues, construction of an experimental design and completion of lab activities, discussion of results, and final group wrap-up activity.

In addition to conceptual understanding, these inquiry-based LSLC activities were developed to teach students to use scientific research methods to design and carry out an investigation and in so doing, to familiarize students with laboratory equipment and techniques used in authentic science research. LSLC visits addressed basic science laboratory skills such as using the microscope and measuring liquid volume with pipettes, as well as more advanced techniques such as bioassays and agarose gel electrophoresis of DNA. Focused time was made for small- and whole-group discussion of laboratory

results, during which time students were encouraged to draw conclusions from the collected data and share ideas for follow-up investigations. The LSLC curricula were correlated with the New York State Math, Science and Technology Standards (<http://www.emsc.nysed.gov/ciai/mst.html>) .

Two middle school teachers and four of their classes (grades 6-8) participated in a two and one half-hour laboratory-based investigation called *Environmental Hazards: Find the Toxic Dose*. Students learned about measuring in parts per million, they investigated water for various contaminants, and they designed their own bioassay experiments to assess the impact of various chemicals on plant seeds. In a similar unit, two high school teachers and four of their classes (grades 9-12) participated in a four-hour laboratory-based investigation called *What's in Our Water?* These students had the opportunity to spend more time learning about measuring in parts per million, investigating water for various contaminants, and designing their own bioassay experiments to assess the impact of various chemicals on plant seeds. The class discussions for these two units focused on the nature of toxic chemicals in general, and in particular those found in water, and also what sorts of water-borne contaminants might be found in the urban environment.

Two middle school teachers and four of their classes (grades 6-8) participated in a two and one half-hour laboratory-based investigation called *Molecular Size*. Students learned about separating molecules according to size and charge, and they performed molecular separation of dyes using agarose gel electrophoresis and paper chromatography. Discussions focused on the real-world applications of these molecular separation techniques. Two high school teachers and four of their classes (grades 9-12)

participated in the laboratory-based investigation called *Bacterial Transformation*. In this four-hour unit, students used molecular biology techniques to introduce a new gene into bacteria that caused it to glow fluorescent green when exposed to an ultraviolet light. The classes discussed scientists' use of genetic engineering technology to create organisms with new traits, such as genetically modified foods, and antibiotic-resistant strains of microorganisms.

Collaboration and Support. In preparation for the out-of-school university visit, teachers engaged in a number of efforts to maximize the benefit for their students. At the beginning of the school year, the teachers in this study met with the instructors and leadership core of the LSLC to collectively determine priorities and outline strategic steps for the upcoming partnerships. Once the teachers selected the curriculum and lab activities for their students, each teacher worked individually with the LSLC instructors to customize the curriculum to the unique needs and background of each particular participating class. "Customizing" the curricula and instruction included determining the amount of support provided to students for use of laboratory equipment, designing the intentional integration of the LSLC experience with the existing school curricula, and making modifications or adjustments needed due to the unique individuals in each class (e.g., English language learners or students with learning disabilities or behavioural issues).

Suggested preparatory activities were sent to the teacher prior to the class visit to the LSLC, and follow-up activities were given to the teacher after the visit. Preparatory activities focused on reviewing basic science skills, such as measuring, observing and graphing, and also covered vocabulary that would be used during the LSLC lab visit.

Each of the eight teachers had two participating classes in the program. For one class of each teacher, in addition to the class' visit to the LSLC, the LSLC instructor visited the class at their school to co-lead the preparatory and follow-up activities. For the other classes, the teacher alone facilitated the preparatory and follow-up activities.

All teachers participated in at least one workshop to discuss and develop a familiarity with the specifics of the program planned for their particular students. In addition, all teachers had previously participated in at least one other professional development workshop or school field trip at the LSLC during the previous two years, so they were familiar with the LSLC programs and the goals of the centre. Suggested preparatory activities were sent to the teacher prior to the class visit to the LSLC, and follow-up activities were sent back to school with each class after the visit. Each of the eight teachers had two participating classes in this study. For one class, in addition to the class' visit to the LSLC, the LSLC instructor visited the class at their school to co-lead the preparatory and follow-up activities. For the other classes, the teacher alone led the preparatory and follow-up activities.

The selected and customized curriculum was implemented at the LSLC through the leadership of a LSLC instructor and co-taught to varying degrees with the students' classroom science teachers. The RCSD science teachers were encouraged to adopt an active role in the LSLC teaching. However the ultimate decision of how involved and in what ways a classroom teacher wished to engage in the LSLC teaching was left to each individual teacher. These varying arrangements of co-leadership further contributed to the partnership between the science classes and the LSLC through shared ownership of the enacted curricula.

Methods

Data Collection

As part of a larger study, data were collected and analysed from the eight teachers and 292 students over an 8-month period (October 2002 – May 2003) in a variety of contexts. The teachers and students completed an exit survey before leaving the LSLC on the day of the class visit offering feedback on both the strengths and weaknesses as perceived by each participant. Interviews were conducted with classroom teachers and approximately 20% of each class of students following a class visit to the LSLC. Detailed field notes and video recordings were made of the interaction of the classes at the LSLC through the scheduled programming. Also, field notes and video recordings documented teacher-LSLC collaboration at meetings held at the beginning and at the end of the school year.

This study focused on a subset of this data set that collectively offered insight into both teachers' and students' perspectives. Teacher data included teacher comments made at the beginning and end of the partnership during collaboration meetings as well as during interviews that occurred within two days of the university visits. Student data included each participant's written response to each of three exit survey open-ended questions, "What is the most important thing you learned today?" "What was the best part of the lab activity you attended today?" and "What one thing did you find disappointing in the lab activity you attended today?" The first question, "What is the most important thing you learned today?" was added to the exit survey after one class of 20 students had already responded. The unit of analysis was the individual written response made by a participating student.

Data Analysis

Following Glaser and Strauss's (1967) constant-comparative method, each of two researchers independently read through the entire subset of data resources (students' written comments) allowing analytic categories to emerge. These data were analysed in hermeneutic stages in which we examined the data, read relevant research, and discussed and debated resulting categories in light of supporting evidence to determine if each represented a trend, pattern or simply an anomaly. Throughout the analysis, the researchers returned to make a closer examination of the data (Lincoln & Guba, 1986). As we as researchers spent more extensive time analyzing the data, sub-codes and an organizational framework emerged in each category, highlighting perceived outcomes of participation from the students' perspectives. To increase the credibility of the findings, category labels and descriptions were revised until both researchers had agreement on the category labels and descriptions. Disconfirming evidence for categories was sought, and if found, the category was reconceptualized. Some student responses were coded with multiple appropriate codes.

Due to space constraints, findings from the analyses of the teacher data will simply be summarized, while analyses of the student data will be presented in detail. For a detailed account of the analysis of the teacher data, findings, and implications, see Luehmann & Markowitz (in press).

Findings

Teachers' Perceptions

Teachers' perceptions of the impact of the out-of-school LSLC experience for their students can be summarized with three general and inter-related categories: increased

access to learning and science resources, increased student learning, and increased student motivation. Each is summarized briefly; again, for a more detailed account of teachers' perspectives, see Luehmann and Markowitz (in press).

Increased Access to Resources. Bringing students to a fully equipped scientific laboratory on a university campus clearly would offer any student participant increased access to resources. Participating teachers identified various ways this experience offered their students valued and valuable access. First, giving students one larger block of consecutive "class time" for students to participate in their science investigation was valued by teachers as it was perceived to lead to more engaged exploration and learning. Second, the LSCLS facility, with its wealth of laboratory equipment and supplies for students to work with was mentioned by teachers as a way to introduce students to the culture of science and offer them uncommon opportunities to "be real scientists." Third, exposing students to the unique setting of the university medical school was valued by teachers for the motivational impact its "unfamiliarity" and formality offered.

Increased Student Learning. Perceived student learning benefits identified by the teachers included 1) engaging students with core science concepts; 2) complementing (not supplementing) school curricula; and 3) addressing diverse learning needs. First, the content focus of the field trip represented concepts central and important to student learning. Topics such as "DNA Biology" represented "big ideas" for the teachers, those to which many other curricular concepts could be connected. Second, several teachers shared ways the field trip supported what they were trying to do in the classroom. For example, teachers described the value of vocabulary learning which allowed them to progress at a quicker pace in the classroom afterward, repetition and reinforcement of

classroom instruction, and the experience as an “anchor” that teachers and students could refer back to during the remainder of the school year. Third, teachers saw that the LSLC experiences were able to address learning needs of a wide range of students, including those who have been labeled “special education” and those not perceived by students as being interested in science.

Increased Student Motivation. Though not identified as a primary objective at the onset of the partnership, teachers identified the greatest student impact of this out-of-school experience having to do with student motivation. Though certainly related to the previous categories of student impact, teacher comments coded as “motivation” focused on identifying changes in student affect as well as interests and participation. First, many teachers commented both on students’ excitement levels as well as their new-found seriousness and passion for scientific work. Teachers used words such as “enjoyed,” “happy,” “enthralled,” “felt important,” and “flabbergasted” to describe their students’ emotional responses to the opportunities offered in the one-day visit. Teachers told stories of students sharing their enthusiastic impressions with school peers and administrators upon returning to school.

Second, teachers perceived this partnership to have contributed to students’ interest and participation in their classwork. Examples of this new level of commitment included students’ willingness to commit more time and energy to school science, willingness to engage in difficult tasks, and demonstration of piqued interest with respect to the LSLC investigation as well as science more generally. Several teachers commented that their students were more serious and “business-like” in their approach to the new material they were exposed to through this experience. Teachers felt

that this experience raised the expectations and behavior of their students to a higher level. Students' behaviors and their ability to engage in a laboratory investigation in this out-of-school setting were different than what some teachers were used to seeing at school.

Teachers credited a number of factors as contributing to their students' higher motivation including 1) the authenticity of the experience (how it resembled the work of "real" scientists); 2) the novelty of the context, tools and opportunities; 3) support and perceived "do-ability" of the work from students' perspectives; 4) access to available resources; and 5) ownership and roles that were given to the students with respect to their own learning.

While teachers' perceptions offer us insight into what may best support students' achievements with respect to institutional goals, considering how to best support a group of students to successfully engage in school science, student perspectives offer an interesting complement. Student responses report on and give voice to individual's experiences.

Students' Perceptions

Data from the exit survey questions offered insight into the broad range of student perceptions as these data were collected from each participating student. Student responses demonstrated an appreciation for and enjoyment of engaging in authentic science as a way to engage with and learn complex concepts.

"What was the most important thing you learned today?" When asked what aspect of their learning experience they valued most, students primarily differentiated between science concepts, science processes and more general life skills such as

“working with others” (see Appendix A for a summary of the emergent categories). The majority of student responses identified a specific science concept (n = 114) as the most important thing they learned: “I learned about agarose gel electrophoresis,” or “I learned how molecules separate by size and charge.” Some of the identified concepts were more foundational in that they will be useful in other scientific areas or activities: “I learned that molecules separate when you add electricity,” or “...about negative and positive charge.” Answers coded as implications (n = 9) correlate with a social concept and take these scientific concepts a step further: “I learned that proper care and testing of water is important for life safety,” or “...to not pollute.”

Ranked second compared to specific concepts, students identified scientific skills or processes as the most important thing they learned (n=54). These answers fall into two sub-categories: general scientific processes and lab skills, such as “how to test water quality,” or “how to make bacteria grow,” and specific processes and skills such as “how to extract DNA from fruits” and “how to determine temperature of water and the pH chart.” Safety processes were mentioned by four students as the most important learning outcome for the day. It is interesting to note that although many students thought that the best part of the lab activity was being able to design a science experiment (see below), none of the students mentioned that the most important thing they learned was how to design an experiment.

Students also listed aspects of science that were coded as the culture or impact of science (i.e. how scientists do their work) (n=49). These responses fell into four sub-categories:

- Language of science (n=6), e.g. “the most important thing were the words;”

- General processes (n=20), e.g. “I learned that you should always keep on and never give up;”
- Impact of science (n=13), e.g. “that many things can be solved thanks to a scientist;” and
- Scientific tools (n=10), e.g. “...that the agarose gel has little squares and...contain samples of DNA.”

These responses were more general in nature than, for example, those coded as “Processes” and described above. Other examples of comments that were coded as a culture of science, general process are “I learned that safety is really important in the lab,” and “sometimes it’s good to alter an experiment.”

“*What was the best part of the lab activity you attended today?*” A look across the most popular responses to this question highlights these students’ desire to be actively engaged. Of 292 comments, 160 of them highlighted the processes of doing laboratory science (coded as “doing-specific” and “doing-general”) (see Appendix B for a summary of the emergent categories). Looking more in-depth into this subset of comments reveals four types of processes listed by the participants:

- Conducting their own experiment (n=15);
- Doing a particular step of an investigation (n= 82);
- Using a specific scientific tool (n=4); and
- Being physically engaged in general (n=78).

The most frequently described favorite aspect of the day involved engaging in a specific step of a larger protocol. Examples include: “I like testing the pH and dissolved oxygen levels of the different solutions,” or “...cutting paper, wetting it, and putting lettuce seeds

in the bag.” Many students described the best part of the lab activity as scientific engagement in a general sense such as “making your own experiment,” or “when we made our own lab.” Similarly, a large number of students simply listed an activity (A; n=39) without specifying which part of the activity they liked: “the parts per million activity” or “the fruit lab.”

A number of students highlighted the best part of the activity as being able to experience science by watching scientific phenomena take place. Examples of comments coded as “experiencing phenomenon” (EP; n=38) include “seeing all the colors separate in the chromatography” or “watching all the molecules move.” Students were excited about the phenomena they were observing and studying. Beyond simply acting like a scientist they were also experiencing phenomena from a scientific perspective. Students valued the learning of scientific processes (SSP; n = 4) “when we saw how to use or do the gel activity” and how to use the tools of the trade (SST; n = 9) “The best part of the lab activity we did was working with real tools.” Students valued understanding how science works, which is quite different than students just being entertained by the act of doing a lab activity.

“What was one disappointing thing in the lab activity that you attended today?”

The most frequent response students wrote to this survey question was the word “nothing” (n=92). This finding by itself is a powerful response, as from these students who were described by their teachers as being generally uninterested in science. Similar powerful stories are told in the code categories that had smaller numbers of responses (see Appendix C for a summary of these emergent categories). Expectations and requirements for participation in the LSLC lab activities were communicated to all

participants – many of who (according to their teachers) are resistant to following rules and regulations. Despite the high level of expectations set out for the class, only eight of 292 students commented that they were disappointed because they were required to do something, such as being required to wear protective eye goggles or conduct work within small and whole-class groups. Often described as being less scientifically proficient compared to their suburban peers (often using the measurement tool of standardized tests), only five of the 292 participating students listed the “difficulty” of an activity or task, such as “not understanding words that were used” as being disappointing. Likewise, only three students listed amount of “support,” such as wanting the instructor to give them more assistance, as a discouraging factor. Again, of the large number of student participants engaged in authentic laboratory science, only a small number were disappointed because they experienced mistakes or mishaps (n=15) such as broken agarose gels or lacking technical or intellectual proficiency in a given step of the lab. These frustrations are understandable as many of these techniques in the lab investigations are challenging to master.

Many comments that are categorized as perceived missed opportunities (n=42) included students wishing that their experience at the LSLC could be extended. Examples of these comments included: “I found it disappointing that we had to leave,” or “...the time passed too fast.” Other comments in this category included a desire to do more or different types of experiments: “I thought we would have done more than one experiment,” or “we didn’t use any real dangerous things.” Students also did not enjoy being passive or having to listen when the instructor was talking (n=37): “There was too much talking before the experiment,” or “...sitting down for so long.”

Some students' commented that they were disappointed or frustrated in some aspect of their science lab experiment which was coded as "science phenomenon" (n = 21). For example, results that were delayed and therefore took more time than these students would have liked, or perhaps their results turned out different that expected. Finally, some students listed a number of contextual factors as disappointing to them such as the heating of the room, not being able to see the board, seats not being comfortable, lunch not lasting long enough, or problems with a classmate's behaviour. These concerns, coded as "life" (n=30), might have resulted because these open-ended survey questions followed another survey questions asking students to rate such issues as lighting, heat and seating.

The primary message seemingly communicated by the students themselves through the responses to the survey questions was that students valued being actively engaged in their own science learning more than anything else.

Discussion

"Insiders'" Perspectives as Insight to Urban Students' Needs

Teachers' and students' perspectives in this study not only confirmed many of the proposed benefits of out-of-school enrichment experiences in the literature, but also added some new insights. Though science learning is certainly one of the goals for an experience such as the one offered by the LSLC, teachers' commented most on its impact on students' motivation and interest. Students, above all, valued the active "doing" of science – having the opportunity to run authentic scientific procedures, experiencing the awe of scientific phenomena first hand, and designing a unique investigation. Students and teachers alike identified the transformative impact of wearing white lab coats, working in a high-tech laboratory, and being on a research university campus. Both

groups identified this aspect of the experience as giving students the opportunity to be “seen” by self, peers and teachers as “real scientists.” It is clear from this analysis that students have identity needs with respect to school science learning, and partnerships with universities offer one valuable way to give science classrooms access to broadening resources in supported ways so as to address and meet these identity needs.

Lauren Resnick’s (1987) analysis of the value of out-of-school learning experiences referenced earlier offers a framework to explicate the strengths of this particular out-of-school learning opportunity. Compared to in-school experiences, these out-of-school experiences required participation in group work, which mimics authentic scientific inquiry in which scientists collaborate to collect data and discuss research findings, whereas school work is often individual. This out-of-school experiences made extensive use of tools that shape and facilitate the learning activity taking place whereas in-school priorities often center on proving that one can do the work without texts and other tools. Due to a lack of resources, urban science classrooms often do not offer students access to such important authentic tools further emphasizing the need for this access through other means. This out-of-school learning occurred in an authentic and rich context - being housed in the middle of a medical school on a university campus throughout which cutting-edge biomedical research is being conducted. At the LSLC, these urban students experienced working in an authentic science research context, using authentic laboratory equipment, materials and processes. This engagement offered the students the relatively safe, low-risk opportunity to examine their identities as selves-as-scientists (Gee, 2003). In contrast, in-school learning often prioritizes the learning and application of generalized and de-contextualized principles and rules. Students memorize

facts, and teachers “teach to the test”. This de-contextualization of concepts has been shown to be a common approach in urban school science (Oakes, 1990; Polakow, 2000). Finally, this out-of-school experiences focused on the development of situation-specific competencies, whereas school focuses more on developing general skills that are hoped to translate into real life trajectories. A theme running through these various features is the ability and tendency of out-of-school experiences to prioritize authenticity – authentic social dynamics, practices, tools, and contexts. Students’ and teachers’ perspectives of this study revealed that this particular out-of-school experience resulted in these benefits being realized for them as participants. However, the opportunity to participate in authentic science experiences in out-of-school settings is not sufficient to offer urban students access to the existing culture of power of school science.

To highlight this point, we return briefly to Barton and Yang’s (2000) case study on the “culture of power.” In this work, they share the story of Miguel, a science student who “slipped through the cracks.” Currently a homeless, young father of two, “Miguel’s story is one of missed opportunities” (p. 873). Miguel developed a passion for reptiles and amphibians in a brief experience with Boy Scouts that eventually evolved into him becoming an amateur herpetologist, caring for as well as selling both domestic and exotic animals. However “neither his parents nor his teachers drew on this strength and encouraged him to pursue science as a viable school activity or even career” (p. 873). He describes this lack of access to the culture of power in school and school science as one of the reasons he was not successful. Boy Scouts gave Miguel the opportunity to develop his identity and interest in science, but the bridging of this experience with school science did not happen.

Conditions of Success

It is important to take a moment to consider unique aspects of this particular out-of-school experiences that may have led to the benefits reported in this manuscript. Here we will consider three primary factors: 1) opportunity for students to participate in authentic inquiry-based science; 2) the presence of a partnership between the university and classroom teachers; and 3) this learning experience was connected to yet separate from school science.

First, as mentioned earlier, students were offered the opportunity to try their hand at authentic inquiry-based science. The *open-ended structure of inquiry* allowed for student choice and nurtured student ownership. Teachers perceived the authentic tools and contexts to be exceptionally motivating for students to engage in science learning, both on-site and continued back on schoolgrounds.

Second, the *partnership* with the school's science teachers was an essential element for how this authentic inquiry experience gave students access to the culture of power of school science, as it was through this collaboration that students were given the chance to be recognized by their teachers as serious, committed and enthusiastic science learners. Adults (including university facilitators as well as classroom teachers) collaborated to cater the experience to the needs of individual classes. In addition, these adults assumed support roles (instead of directors' roles) for the students' science investigations which offered them uncommon opportunities to view and recognize students' engagement in science.

Third, this out-of-school experience was *connected to but separate from school* science. The activities facilitated by the LSLC were considered to be a part of the school

science curriculum thus expanding what counts as school science. However, because the activities occurred “off-campus” in a field-trip setting, the design of them was freed from constraints typical for classroom-based activities. For example, students were able to commit a larger block of consecutive time to their investigation, university scientists worked with classroom teacher to facilitate student investigations, and accountability through school grades were not emphasized. Teachers and students, as primary stakeholders, bridged the experience from school to university and back.

Conclusions

Thus, the results of this study demonstrated the potential of a carefully designed inquiry enrichment experience to 1) give students and teachers opportunities to participate differently in school science; and, equally importantly, 2) give students and teachers unique vantage points from which to view and recognize students’ participation in school science. First, as an extension to their science class, students were given more time, white lab coats and high-tech equipment, and the challenge of open-ended inquiry. These rich opportunities gave them a safe and supportive, highly motivating context to bring their unique interests and funds of knowledge to the work of developing scientific understandings. Second, this experience gave students and teachers a unique perspective from which to observe students engaged in science learning – thus, it gave students the opportunity to be recognized by self and others, most notably their teachers, as competent, serious and engaged science learners.

The findings of this study offer a valuable, often unexplored look at insiders’ perspectives of the impact of participating in a partnership experience with a resource-

rich local support system within the school's extended context. This study demonstrated that carefully designed out-of-school inquiry programs, in *collaboration* with teachers' work in science classrooms, have the potential to both broaden students' experiences as well as bridge them to this academic culture of power. This study contributes to the growing body of work on out-of-school science learning in important ways. Building on extensive and varied data sources from the insiders' perspectives of eight classroom teachers and 292 secondary science students from an under-resourced urban district, this study explicitly considers the unique benefits of school–university collaborations for urban students. Careful consideration of the unique design features of this year-long collaboration offers the field much needed insight into the specific features of out-of-school inquiry enrichment experiences that hold the most potential for offering students increased access to the culture of power in school science.

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Appendix A: Summary of overarching categories that emerged from students' coded responses to the question, "What was the most important thing you learned today?" in order of frequency of occurrences (total: n=273)

Abbrev.	Code	# Student Comments	Definition	Example*
CON	Concepts of science	114	Developing understanding about a scientific concept; <i>how things work</i>	"I learned that molecules separate when you add electricity"
PRO	Specific scientific process	54	Learning the how-to's of doing various scientific processes	"I learned how to put the colors in the agarose."
BLNK	No answer	33	Item left blank or writing was unreadable	
CP	Culture of science: general processes	20	How, in general scientist do their work	"I learned that you should always keep on and never give up."
CA	Culture of science: appreciation for impact	13	Develop an appreciation for the potential impact of the work of scientists	"That many things can be solved thanks to a scientist"
L	Life skills	13	General life or student skills	"Always pay attention"
CT	Culture of science: tools	10	About scientific tools	"I learned that the agarose gel has little squares and those little squared contain samples of DNA."
I	Implications	9	Implications from scientific investigation	"The most important thing I learned about is to not pollute"
CL	Culture of science: language	6	Language of science	"The most important things were the words."
N	Nothing	1	Student states nothing was important to learn	"Nothing was important to me."
DKN	Don't know	1	Student articulates s/he doesn't know	"I don't know."

* Student responses are indicated as written, with mis-spellings

Appendix B: Summary of overarching categories that emerged from students' coded responses to the question, "What was the best part of the lab activity today?" in order of frequency of occurrences (total: n=293)

Abbrev.	Code	# Student Comments	Definition	Example
DS	Doing specific	82	Student identifies a specific thing they did	"When we put the liquid in the gel"
DG	Doing general	78	Student describes an activity in general terms	"working with the gel"
A	Activity name	39	Student was not specific about whether s/he enjoyed doing the activity or watching the activity	"The best part was the paper chromatography"
EP	Experiencing the phenomenon	38	Students describe the experience of watching, hearing or feeling (messing) with the scientific phenomenon	"Was seeing the colorful colors separate from being next together..."
L	Life	17	Experiences not directly related to lab activity	"Working with a good partner." Or "doing something fun away from school that has to do with science"
E	Everything	12		"Everything"
SST	Science skills tools	9	Students referred to learning how to use a scientific tool	"The best part of the lab activity we did was working with real tools"
TH	Thing	8	Listed a thing	"color water"
SSP	Science skills process	4	Students referred to learning how to do a science related activity	"When we saw how to use or do the gel activity"
T	Tool	4	Student listed a tool but did not specify using it or learning how to use it	"gel"
N	Nothing	2		"Nothing"

Appendix C: Summary of overarching categories that emerged from students' coded responses to the question, "What one thing did you find disappointing in the lab activity you attended today?" in order of frequency of occurrences (total: n=293)

Abbreviation	Code	# Student Comments	Definition	Example
N	Nothing	92	Student said that no aspect of the experience was disappointing.	"Nothing"
MO	Missed opportunity	42	Student didn't get to do something; time was too long or too short	"not able to start the chromatography activity, do to time"
P	Passive	37	The aspects in which the students needed to listen	"All the talking the lady did"
L	Life	30	An aspect not directly related to the curriculum	"I couldn't see the board"
BLNK	Left blank	29	Item left blank or writing was unreadable	
SP	Science phenomenon	21	Things didn't happen as the student hoped or expected	"my plates weren't growing" or "DNA spooling doesn't work with everything"
M	Mistake or mishap	15	Student made mistakes	"We mest up a little bit"
R	Requirement	8	Students were required to do something they didn't like	"I actually found dissapointing that we had to put goggles on but it was just fine after a while."
B	Boring	7	Some aspect was "boring"	"The lab activity was boring"
D	Difficulty	4	Student perceived some aspect of the activity difficult	"not understanding words that were used"

S	Support	3	Missing support	“we did not have professional people besides Donna, Ms. Monk, Jana”
DS	Doing specific	3	Student identifies a specific thing they did	“When we put the liquid in the gel”
DG	Doing general	1	Student describes an activity in general terms	“working with the gel”
I	Implications	1	Implications from scientific investigation	“That we have to drink dirty water and we pollute.”