ACCESS AND ENTRY TO HIGH SCHOOL CHEMISTRY IN NEW YORK CITY

by

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A dissertation submitted to the Graduate Faculty in Urban Education in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

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This manuscript has been read and accepted for the Graduate Faculty in Urban Education in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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Abstract

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Advisor: Professor Nicholas Michelli

The purpose of this study was to determine quantitatively the impact of various school characteristics on access to and enrollment in high school chemistry in New York City and to identify the issues that may contribute to the inequities in high school education, specifically S.T.E.M. education. The context through which this issue is examined is the restructuring and accountability initiatives that have been underway in New York City public schools as well as the accountability of cohort graduation rates. The issue of social justice and accessibility to high school chemistry was the lens through which this study was conducted. Mixed methodology was used in conducting the research so that a holistic view of the issue could be analyzed. Results indicate that the demographic and socioeconomic status of the students in the school district strongly correlate to the access to chemistry in that district.

Acknowledgements

I would like to first thank my dissertation chairman, Dr. Nicholas Michelli for all of the emails, telephone calls, conferences and dinners that have helped to guide the work that is found in these pages. His dedication to social justice in education is contagious and I hope to be able to emulate his work in this area of educational policy. Next I would like to thank Dr. Anthony Picciano for his expertise in data analysis and interpretation. His guidance and critical eye are both respected and very much appreciated. He has helped to strengthen this work and for that I am very grateful. Dr. Stephan Brumberg is the last but not least of my panel of experts in the field of education. Dr. Brumberg is a most fascinating educational historian. His knowledge of the history of education in New York City is awe inspiring and he has taught me to look at the development of education and our unique school system from beginning to end to understand its intricacies. Without these three men, I would not have developed the passion for my topic nor have had the support needed to see this through fruition. I am also eternally gratefully to Dr. Pam Mills and Dr. William Sweeney who gave me my first taste of life in academia and who always treated me as an equal. Their understanding of chemistry content and pedagogy is infectious and they have unknowingly made me a better educator.

I began this endeavor five years ago and at that time my two biggest supporters were my parents, Dorothy and Thomas McNamara. There has never been a journey in my life that my parents were not beside me, cheering my successes and making sure I learned from my failures. My father, Tom, was a retired FDNY firefighter (Hook and Ladder 102 in Bedford-Stuyvesant) and my mother, Dorothy was a secretary and the biggest fan Brooklyn could ever have. They instilled their love of education into all of their children. It was heartbreaking for my family when my father became ill and passed away in January, 2011. However, my mother’s death only 100 days after his in April, 2011 was almost more than we could bear as a family. I am forever grateful to my brothers and sisters, Alison, Tom, Janice, Jim and Matthew, for their constant support and encouragement, especially after the passing of our parents. Although my parents are not here physically to accept the accolades and praise that they deserve, I wanted to acknowledge that this could not and would not have been possible without them. I am blessed to have had them in my life and they will always be with me. ~ DMcN

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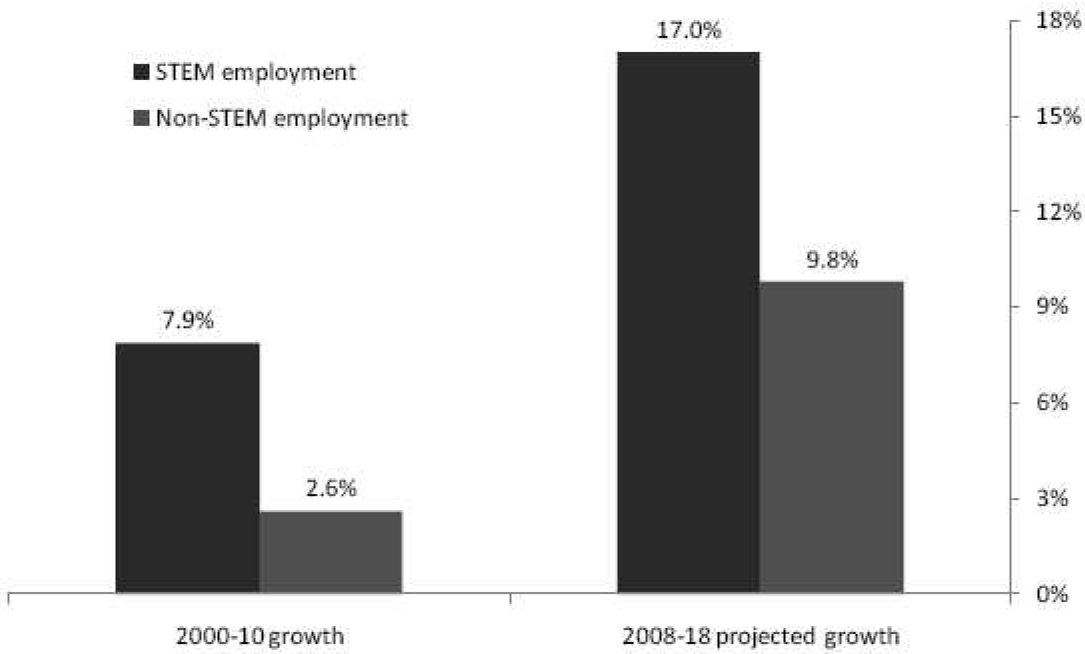
Chapter 1 – Introduction and Research Questions

Overview and Significance

According to the U. S. Bureau of Labor, there are approximately 2.6 million unfilled jobs in the United States. This seems like an oxymoron as we struggle with the recession that has enveloped the country and most of the rest of the world. What could the reason be for so many unoccupied positions? The answer is that most of the jobs require the knowledge and skills in a broad area called S.T.E.M. (Science, Technology, Engineering, Mathematics). The areas for employment that exist under this umbrella are healthcare, aerospace, science lab technicians and computer design, sustainability product development & installation and other diverse fields that rely on S.T.E.M. educated employees (Cover, Jones, & Watson, A., 2011)

Figure 1 - Recent and Projected Growth in STEM and non-STEM Employment



U.S. Department of Commerce, Economic and Statistics Administration, Issue Brief #03-11, July 2011

One of the key factors in this contradiction of events is the fact that our current high school graduates are not prepared for post-secondary work that is required in the S.T.E.M. course majors. The results of the 2009 ACT® test[1] are a good indicator of this deficit: only 42% of high school graduates scored at the college readiness level in mathematics and 28% reached this same benchmark in science. This indicator would be the bare minimum a student would need to pursue these content areas and become proficient while in college. Even more disturbing are the results of the subsets of students within this statistic: only 12% of African-American and 27% of Hispanic high school graduates score at the college readiness level in mathematics and only 6% of African-American and 13% of Hispanic high school graduates score at the college readiness level in Science (ACT, 2009) . One of the residual effects of low measured achievement is the fact that only 17% of all college majors in the United States are in the S.T.E.M. fields (Kurtz, 2011).

The reality is that these career choices are higher paying than most other employment opportunities and as previously stated, such jobs are readily available. (See Figure 1) Along with other nations, China and India are making great strides to increase their own S.T.E.M. infrastructure, human capital for these countries is readily available. (National Research Council, 2011a) Although the United States once could boast with confidence the innovation and drive that led us to become a world economic leader, this is far from the current state of affairs.

The country is at the cross-roads of a great dilemma but this can also be a time for great challenge and opportunity. We have the ability to seize this opportunity and create a new supply

[1] The ACT® contains five curriculum- and standards-based assessments: English, Mathematics, Reading, Science, and an optional Writing Test. The assessment is used as a college admissions and placement test and measures the skills and knowledge needed for first-year college success.

of human capital to fill this gap. We must expand our talent pool and the first step would be to prepare students with a solid S.T.E.M. background and not just the cherry picking that currently exists (Britton, Raizen, Kaiser & Porter, 2000). Every student in the U.S. deserves the opportunity to experience a S.T.E.M. program of study so that his or her understanding of the content can be enhanced, and informed choices can be made as to career options (Committee on Science, Engineering and Public Policy, 2007). In reality, science and mathematics have historically been segregated to the upper grade students (Barton, 2003). Many of the schools dedicated to the sciences are located in high income areas. In addition, it will be seen that through the reorganization of the New York City public school system, the naming of some of the new schools can be loosely associated with the income level of the area of the city in which they are located (Ancess & Allen, 2006: Gebeloff, 2011). For example, schools having science or technology in their new name are located in more affluent areas of New York and schools with leadership, community and democracy have been relegated to neighborhoods with less social and financial capital. Also of note is that the large, comprehensive high schools which might have given low-income students an opportunity to study some of the rigorous courses needed for post-secondary readiness in the pursuit of a S.T.E.M. degree bearing program, are steadily being closed in high-poverty areas in New York City (Council of the City of New York, 2005).

Although S.T.E.M. is the acronym for the science, technology, engineering and mathematics courses that are needed for our students to be competitive in the current working force, only one aspect of the curriculum will be explored in depth. A specific look will be taken at the current access and entrance to chemistry in the New York City public schools. More specifically, there will be an examination of the chemistry enrollment of all city students during the 2009-2010 school year.

Chemistry is usually reserved for the college-bound or more mathematically inclined student. Students planning to pursue medicine or engineering in college are usually targeted for chemistry in their upper high school years. Therefore, a student's access to chemistry can be severely constrained by missed opportunities in math and science, as well as school-measured academic capabilities based on sometimes questionable assessments (Harmston & Pilska, 2001). Schools must demonstrate that children are making adequate progress towards certain benchmarks that are measured by standardized tests (Hursh, 2005). In spite of the efforts made by federal, state and local government to create school reform laws concerning accountability measures, severe inequities are chronically prevalent in urban schools, where children are denied access to essential opportunities in areas such as science. To improve the learning of all students, the playing field must be leveled in terms of prerequisite preparation and equal access to advanced courses in science and mathematics. (Friedman, 2005; Kim & Sunderman, 2005)

There are a variety of factors that contribute to the access and entrance into chemistry on the high school level. Although greater detail will be provided in Chapter 2 – Review of the Literature: New York City Public School Context, these factors deal with issues both internal and external to the school itself. Some of the external factors for inclusion are the socioeconomic status and racial make-up of both the school population and the citizens in the area in which the school is located. One focus will be on the geographic areas of the city and the types of schools that are appearing in these areas (The Council of the City of New York, August, 2005).

Next, an examination of the internal factors of both the NYC Department of Education and the high schools themselves will be conducted In 2002, Mayor Michael Bloomberg gained mayoral control of the New York City public school system. This shift in the control of the largest school system in the United States changed not only the structure of the department but initiated fundamental shifts in the operations and management of the schools themselves. In 2003, the thirty-two school districts of New York City were reorganized and replaced by ten geographic regions. In 2005, schools were given the option to choose between continued affiliation with their geographic region or join the Autonomous Zone. As a member of the Autonomous Zone, principals were given more independence in the administration of their buildings but with this newfound freedom also came responsibilities that would be scrutinized through a new accountability system. In 2007, Mayor Bloomberg and Chancellor Klein initiated another reorganization which dissolved the ten regions and replaced these with School Support Organizations and the Autonomous Zone became the Empowerment Support Organization. Further discussion on the School Support Organizations will be found in the methodology section.

These changes also created shifts in the methods of school reporting and accountability. The Progress Report was one of the documents that evolved from these changes. Analysis for this document along with the Accountability & Overview Reports, will be presented. (http://schools.nyc.gov/accountability/tools/report/default.htm)

Other internal issues that will be explored are the factors that contribute to chemistry coursework on the high school level. The courses offered, teachers and the facilities in New York City will be compared to see if there is any correlation between the licensing of the teachers in a particular district and the science courses that are offered at the school within the district. The presence or absence of laboratory facilities of the schools will also be compared to see if this has any influence on the offering of chemistry or other higher order science courses in high school.

But to begin, we have to ask the question that has been asked about science ever since it was included in the secondary course of study in 1893. Who is to learn science and how much is relevant to the common citizen? How much more is needed to pursue a degree and/or career in science related fields?

The opportunity to study science in secondary school beyond the minimum requirement for a high school diploma is a right for all students. Although graduation requirements vary from state to state, there are very few American students pursuing higher level science courses on the secondary level. The United States is in a position where relatively few students are participating in science and engineering in college, and those who do pursue science tend to be non-minorities (Basu & Barton, 2007). It would seem that entry to and success in the study of science is a accomplishment that is inaccessible to many. Since chemistry is usually reserved for the upper grade levels in secondary school, and therefore often an elective, it is regularly ignored by upperclassmen and given low priority by school administrators. Chemistry course-taking is a problem that many schools experience; nationally, one-fourth of the students in high school biology do not move on to chemistry in high school. (National Center for Education Statistics, 2009). One of the hypotheses of this study is New York City's rate is considerably lower. A cursory view of the five boroughs of New York City indicates that there is an inverse relationship between the percentage of high school student who took biology and then moved to chemistry and poverty level as measured by free lunch status (See Table 1 and Figures 2 and 3).

Table 1 – Comparison of the Percentage of Students that continue on to Chemistry and the Percentage of Free Lunch (Poverty Level Indicator) in each of the Five Boroughs (2009-2010) (nyStart, 2011; https://www.nystart.gov/nystart/u/index.do

Borough	% Chemistry after Living Environment	Free Lunch
Manhattan	34.0%	66.8%
Bronx	20.0%	79.5%
Brooklyn	23.0%	70.1%
Queens	28.7%	59.4%
Staten Island	39.0%	39.0%

Figure 2 – Graphic Representation of Percentage of Free Lunch Students vs. Chemistry Enrollment

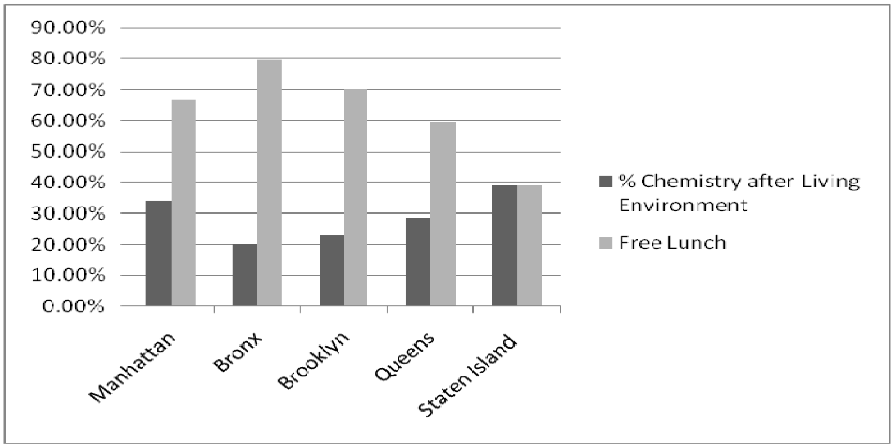
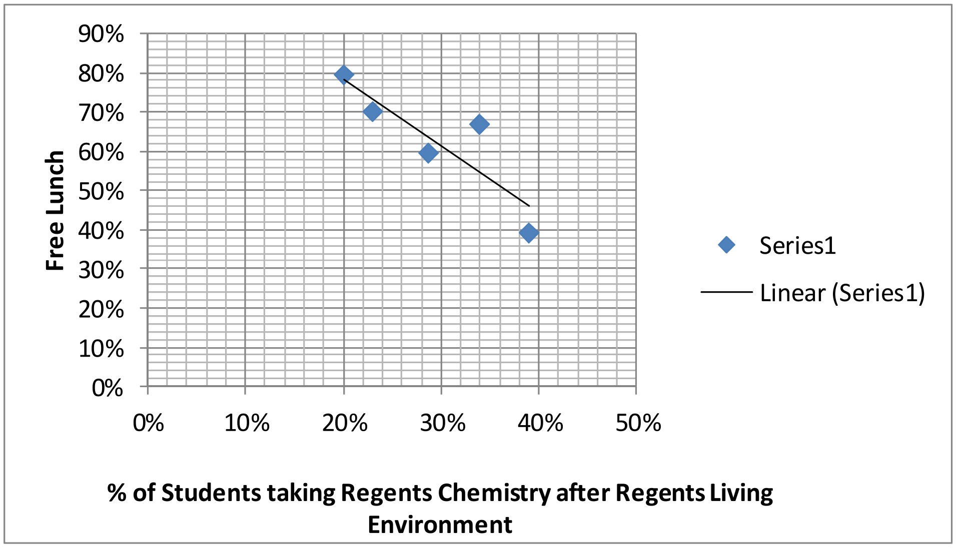


Figure 3 – Pearson Correlation of Free Lunch vs. Chemistry Enrollment



Correlation (Pearson's *r*) = -0.868131806 *

*****As indicated by the Pearson Correlation Coefficient, there is a strong inverse correlation between the percentage of students taking Regents Chemistry after taking Regents Living Environment and the percentage of Students receiving Free Lunch. As the percentage of students receiving Free Lunch increases, the percentage of students taking Regents Chemistry decreases.

Similarly, a perfunctory look at the percentage of high school biology students in New York City moving to Chemistry the following year is also inversely proportional to their status as minority students. (See Table 2 and Figures 4 and 5). A more robust analysis of this data will be conducted but this data sets the tone for this study. The graph of the data (Figure 4) shows a significant difference.

Table 2 - Comparison of the Percentage of Students that continue on to Chemistry and the Percentage of Minority Students in each of the Five Boroughs (2009-2010) (nyStart, 2011 https://www.nystart.gov/nystart/u/index.do

Borough	% Chemistry after LE	% Minority (Black/Hispanic)
Manhattan	34.0%	79.3%
Bronx	20.0%	92.5%
Brooklyn	23.0%	78.8%
Queens	28.7%	60.6%
Staten Island	39.0%	38.0%

Figure 4 – Minority Students vs. Chemistry Enrollment

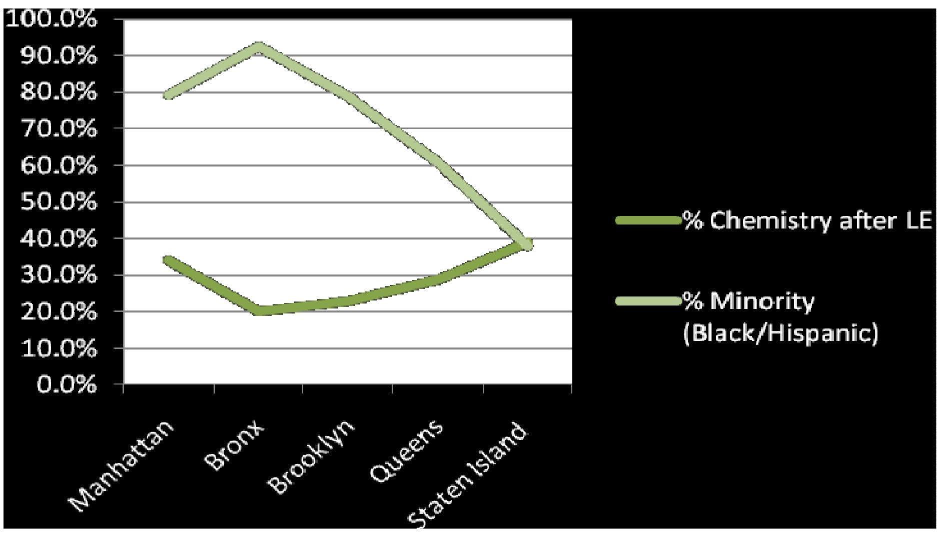
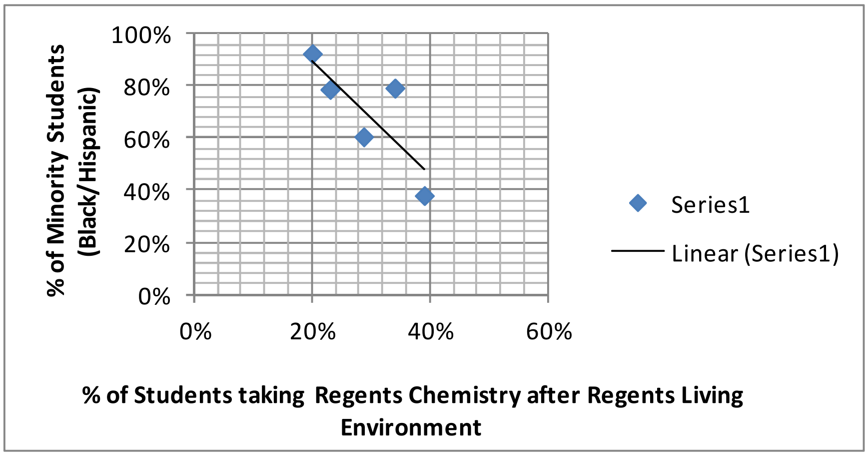


Figure 5 - Pearson Correlation of Minority Students vs. Chemistry Enrollment



Correlation (Pearson's *r*) = -0.800815617*
As indicated by the Pearson Correlation Coefficient, there is a strong inverse correlation between the percentage of students taking Regents Chemistry after taking Regents Living Environment and the percentage of Minority Students. As the percentage of Minority students increases, the percentage of students taking Regents Chemistry decreases.

Scientific Literacy

To begin to understand the need for access and entry to high school chemistry, it is important to know what is meant by science education in general. This is considered to be the pedagogy that shares science content for all citizens and not just those who are or intend to become a part of the scientific community (DeBoer, 2000). In this context, science is considered to be both "pure" science and social science for the average citizen. In other words, for a person to be considered scientifically literate he or she "has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately". (National Academy of Science, 1996) In the United States, it is expected that all students receive a solid scientific background in the four areas of "pure" science (earth science, biology, chemistry and physics) as well as some knowledge of social science in terms of sustainability and health care issues, over the span of primary and secondary school (K-12).

Chemistry is the study of all forms of matter and the conversions that occur in matter, changing it from one form to another. Chemistry is considered by some scientists to be the central science, having its connections in the technical world on one end and the natural world on the other. It is essential to all of the other areas of science for a full understanding of the nature and working of the world around us (Brown & LeMay, 1977; Malin, 2011). Scientific and technological literacy (STL) is another of the keystones needed by students. The ability to think critically about issues such as healthcare, the sustainability of the environment and the economic implications of these issues are of utmost importance. In terms of career opportunities and the economic capital of science literate citizens, a strong S.T.E.M. workforce is considered to be an indicator of a sustainable economic base for a society (Holbrook, 2009). There has been a substantial amount of lobbying for the advancement of STEM education in the K-12 public schools. In an address that President Obama made on November 23, 2010, he announced the launching of several nationwide programs to help motivate students and inspire them to choose science and mathematics as viable career choices.

Specifically he stated,

> "The hard truth is that for decades we've been losing ground. One assessment shows American15-year-olds now rank 21st in science and 25th in math when compared to their peers around the world." (Chang, ***White House Pushes Science and Math Education,*** New York Times, Science Section***, November 22, 2009)***

One of the competitive priorities of the U.S. Department of Education's Race to the Top applications addresses science, technology, engineering, and mathematics (STEM). States that applied were required to submit plans that addressed rigorous courses of study, cooperative partnerships to prepare and assist teachers in STEM content, and prepare more students, particularly underrepresented groups, for STEM study and careers.

As can be seen (Figure 6) the average 15-year old student in the United States is below the OECD average in mathematical literacy (487; 496) and slightly above the average in science literacy (502:501). However, the position of the 15 year old students in the United States among the other countries in the study is more telling. In mathematical literacy the US Students rank 25th in mathematical literacy and 17th in science literacy within the 35 countries in the Organization for Economic Cooperation and Development (OECD, 2009).

Figure 6 - International Math and Science literacy, 2009 (National Center for Educational Statistics) http://nces.ed.gov/programs/coe/indicator_msl.asp

Mathematics literacy scale					
OECD country and average score					
Korea, Republic of	546	New Zealand	519	Denmark	503
Finland	541	Belgium	515	Slovenia	501
Switzerland	534	Australia	514	Norway	498
Japan	529	Germany	513	France	497
Canada	527	Estonia	512	Slovak Republic	497
Netherlands	526	Iceland	507	**OECD average**	**496**
Austria	496	United Kingdom	492	Ireland	487
Poland	495	Hungary	490	Portugal	487
Sweden	494	Luxembourg	489	Spain	483
Czech Republic	493	**United States**	**487**	Italy	483
Greece	466	Turkey	445	Mexico	419
Israel	447	Chile	421		
Non-OECD country or other education system and average score					
Shanghai-China	*600*	Hong Kong-China	555	Liechtenstein	536
Singapore	562	*Chinese Taipei*	*543*	*Macao-China*	*525*
Latvia	482				
Lithuania	477	Uruguay	427	Colombia	381
Russian Federation	468	Thailand	419	Albania	377
Croatia	460	Trinidad and Tobago	414	Tunisia	371
Dubai-UAE	*453*	Kazakhstan	405	Indonesia	371
Serbia, Republic of	442	Montenegro, Republic of	403	Qatar	368
Azerbaijan	431	Argentina	388	Peru	365
Bulgaria	428	Jordan	387	Panama	360
Romania	427	Brazil	386	Kyrgyz Republic	331
Science literacy scale					
OECD country and average score					
Finland	554	Canada	529	Germany	520
Japan	539	Estonia	528	Switzerland	517
Korea, Republic of	538	Australia	527	United Kingdom	514
New Zealand	532	Netherlands	522	Slovenia	512
Poland	508	**OECD average**	**501**	Iceland	496
Ireland	508	Czech Republic	500	Sweden	495
Belgium	507	Norway	500	Austria	494
Hungary	503	Denmark	499	Portugal	493
United States	**502**	France	498		
Slovak Republic	490	Luxembourg	484	Turkey	454
Italy	489	Greece	470	Chile	447
Spain	488	Israel	455	Mexico	416

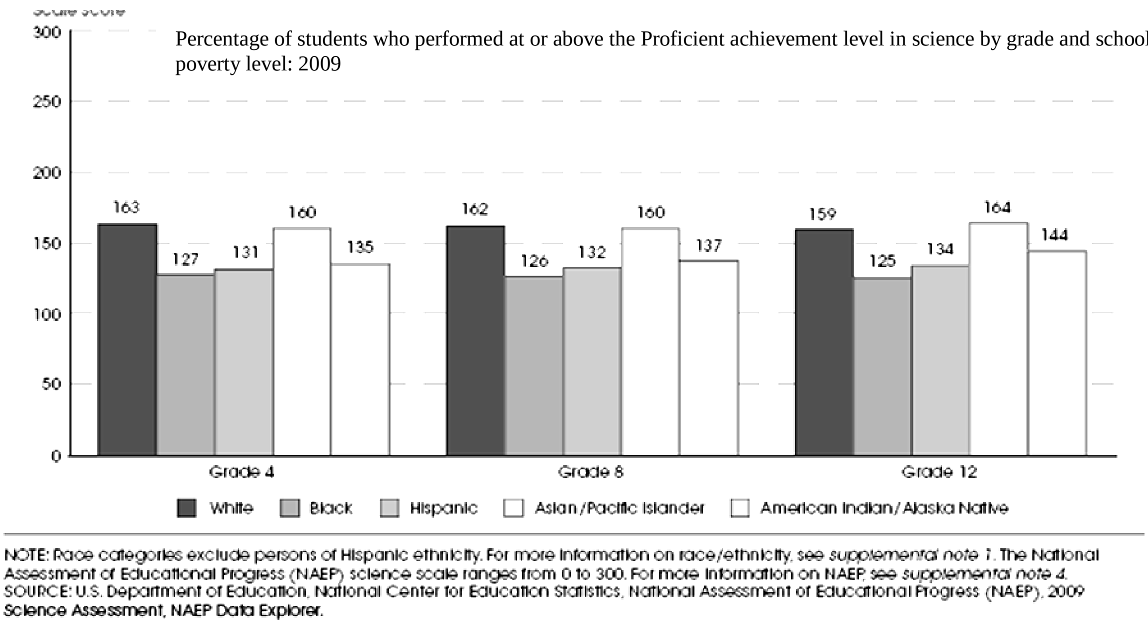
Human Capital and the Need for a robust S.T.E.M. Workforce

The United States of America was at one time a world leader in human capital, social capital and world economy. Innovation in technology and creativity were strong suits when describing our nation's attributes. With the advent of more global means of communication and its impact on all the nations of the world, this status has shifted over the last few decades. The ability of all nations to access knowledge via expansion of global communication has enabled many countries to expand on their own human capital and economic base. Two reports that provide this comparative information are the Trends in International Mathematics and Science Studies (TIMMS) which gives reliable and timely data on the mathematics and science achievement of U.S. 4th- and 8th-grade students compared to that of students in other countries, and Programme for International Student Assessment (PISA), which is an international study aimed at evaluating education systems worldwide by testing the skills and knowledge of 15-year-old students in participating countries/economies.

According to the 2009 PISA report, the United States of America is the only OECD (Organization for Economic Cooperation and Development) country where 25-34 year olds are not better educated that the 55-64 year olds in the country. In comparison, Korea has a 58% increase in the educational attainment of their 25-34 year olds when compared to their 55-64 year olds. American students ranked 25th (Mathematics) and 17th (Science) of the thirty-five OECD countries. When this is compared to the TIMMS Report of 2007, it can be seen that there is a decline in the science achievement of the students in the United States from 8th grade to high school. According to the 2007 TIMMS report, U.S. 8th grade students ranked 11th of the forty-nine entities that participated in the assessments, with Massachusetts and Minnesota ranking 3rd and 6th respectively (if the individual states were within the country ranking). In terms of measured achievement, Finland leads the ranking. The 2010 study benchmarked fifty-five countries worldwide in their supply of skills critical for innovation, competitiveness and sustainability. Each country was scored on 14 variables representing three types of skills – literacy and basic skills, occupational skills and global knowledge economy skills. The U.S. was ranked fifth with Singapore close behind. Although these measurements come from two different reports, each of the reports illustrates the educational achievements of various nations. It is not just that the students in the United States are not gaining ground, although this is certainly an area for concern. It is the fact that coupled with this stagnation is the ever increasing gains being made by other nations.

The issue of equity may be a reason for the variation in the performance of the United States with the distance between the average National Assessment of Educational Progress (NAEP) scale scores (Figure 7) for Asian and White students scoring above the OECD average but African-American and Hispanic students scoring much below this average (Darling-Hammond, 2010). Amy Wilkins, vice president of government affairs and communications at Education Trust, has stated that White children consistently outperform African American and Latino children. “What we see by the end of high school is that African American and Latino twelfth graders have about the same math and reading skills as White eighth graders,” she said. “Our African American and Latino kids who are launching themselves into adulthood are doing academic skills at the same level as White middle-schoolers. By age 29, Whites are two to three times more likely to have a bachelor’s degree than African Americans. “A poor kid is ten times less likely than the most affluent kids in our country to have a B.A. by the time they’re 24,” she said, citing the differences in education levels for whites and minorities.” (W.K. Kellogg Foundation Summit, May 4, 2012)

Figure 7– Percentage of Students Performing at or Above Proficiency level in Science, 2009 (National Center for Educational Statistics) http://nces.ed.gov/programs/coe/indicator_msl.asp



Another of the reasons given for this decline in global status is the fact that fewer students are completing a post-secondary education and of those that do, fewer and fewer are choosing academic coursework that will lead to a degree in one of the S.T.E.M. careers, such as engineering (Friedman, 2005). Technology and scientific knowledge are crucial tools in today's society. (Cavallo & Laubach, 2001). Students who do not select science and mathematics electives in high school are ill-prepared to study these areas in post-secondary setting. This chain of events leads to the decline in the number of S.T.E.M. degreed graduates that are prepared for the lucrative careers in the S.T.E.M. fields. When students do not study elective science in high school, they are less likely to major in science in college, which decreases the pool of graduates who pursue science-related careers. The United States is currently experiencing a troubling decline in the number of scientists and engineers. Half of the workers in this group are over the age of 40. Additionally, 40% of NASA employees are over the age of 50; since NASA jobs are restricted to American citizens, there are not enough people with the scientific and technical skills to fill the jobs. As characterized by former NASA administrator Sean O'Keefe,

> "The harsh fact is that the U.S. need for the highest quality human capital in science, mathematics, and engineering is not being met…There will not be enough qualified American citizens to perform the new jobs being created today – including technical jobs crucial to the maintenance of national security. We lack not only the homegrown science, technology, and engineering professionals necessary to ensure national prosperity and security, but also the next generation of teachers of science and math at the K-12 level… The nation is on the verge of a downward spiral in which current shortages will beget even more acute future shortages of high-quality professionals and competent teachers. As a consequence of the shrinking science & engineering pipeline, increased competition for people with technical skills arises as a further nationwide trend. Simply stated, scientists and engineers are no longer limited to traditional technical companies, but are sought after by various industries such as the banking and the entertainment industries and even academic institutions now offering very competitive salaries to world-class academics. Making things worse for NASA is that highly qualified science and engineering graduates' interest in government employment is steadily declining."

(O'Keefe in his statement before the Senate's Committee on Governmental Affairs' Subcommittee on Oversight of Government Management, the Federal Workforce and the District of Columbia on March 6, 2003)

Americans have fallen to 17th in the world in the number of students who earn science degrees. Radical reforms are needed to reverse this trend, but improvements are many years away since sustained reform must be initiated in elementary and middle school science to reverse the trend (Friedman, 2005).

When addressing the issue of elementary science education, it is a commonly held belief that it is deficient at best. In the New York City public school system, elementary school teachers hold a "common branch" license which is generally seen as having strength in pedagogy but perhaps not in some of the areas of content knowledge. (Bulunuz & Jarrett, 2010). As the student enters middle school, if interest in science is not triggered, the student will more than likely choose other content electives during his or her high school years (Osbourne, Simon & Collins, 2003). The issue of teacher preparation in the United States as compared to teacher preparation in other countries that participate in the TIMSS assessment is one of interest. A survey was completed by the Educational Testing Services of Princeton and among some of the more intriguing findings was the fact that the United States teacher education programs, unlike most of other thirty-seven participating countries do not have early intervention and rigorous screening processes in place. In addition, the programs in the U.S. are fragmented due to the larger variations in state legislatures, policies and types of support available (there are over 1,500 institutions preparing teachers in the United States). Other countries tend to use more high stakes filters when selecting teachers for their teacher preparation programs (Wang, Coleman, Coley & Phelps, 2003)

Throughout the elementary and secondary science curricula, scientific investigations should be presented to students so that they are asked to read for understanding, identify the questions that are being posed, formulate answers that can be substantiated and communicate this information to others. These are meta-cognitive skills that should be reinforced throughout the grades so that students graduating from secondary school will be capable of independent thinking on the post-secondary level (Harmston & Pilska, 2001). Critical thinking in science necessitates effective problem solving capabilities, effective communication and adherence to rigorous standards of excellence (Paul & Elder, 2006).

It is the role of teachers and guidance counselors to help students understand the importance of science education during the secondary school years. Students must learn to understand that they are global citizens and are in need of basic scientific concepts to make informed decisions as well as seeing the relevance of science education in terms of the global economy and employment opportunities (Friedman, 2005).

S.T.E.M. course-taking is partly a matter of preference. Students with the interest and ability in mathematics and science will be inclined to take more mathematics and science classes in high school and be more likely to be guided to these courses by school personnel. This will lead to a similar scenario on the post-secondary level since this occurs in a scaffold-type manner. But it is also a matter of opportunity. Poor middle school preparation, tracking, inadequate guidance counseling, low-quality instruction or a simple absence of available courses, lead to the fact that too many students are permanently knocked off the pathway to a STEM career early in high school. This is particularly true for low-income and minority students. No one tells them or their parents that by failing to enroll in rigorous college prep curriculum, they are effectively making a life decision to forgo the opportunity to pursue a career as a scientist or engineer. (Carey, 2006) Parental involvement is a critical issue.

Historical Trends in Science Education

Science education is defined as the area of study that is concerned with sharing science content and process with individuals, usually children, not traditionally considered part of the scientific community. It is composed of both science content and pedagogy and traditionally, the content included in science education is in the areas of physical and life sciences. Secondary science education was initiated when the British Academy for the Advancement of Science (BAAS) published a report in 1867 asking for training of the “scientific habit of mind”. The purpose was to prepare future members of the British Academy for the Advancement of Science and called for pre-professional training. This, the publication stated, should be accomplished through training in the secondary schools. To accomplish this goal, Thomas Henry Huxley and John Tyndall worked to create the London School Board which was established in 1870. Both men were exceptional scientists in their own right and are noted for their contributions in natural science and physical science respectively.

At the same time, the science education in the United States was uneven and scattered. There was a benign inattention to science education. The general condition of science teaching was as varied as the communities in which it was taught. Some schools stressed college preparation and others stressed skills for employment. The teacher and the school exercised personal judgment in the teaching of science (Atkins & Black, 2003). Science education was therefore unfocused and piecemeal in its content and delivery. A science curriculum was slow in development and only emerged as a result of a conference composed of thirty leading secondary and college educators from the National Education Association. In 1892, these educators appointed a Committee of Ten. This committee was composed of ten male educators and was chaired by Charles Eliot of Harvard University. The three sub-committees appointed in science met in Chicago and submitted a report to the Committee of Ten in 1893 (Kliebard, 1995). From this report, the general recommendations of the Committee of Ten regarding science education were that biology should precede chemistry and physics, the laboratory skills being taught were necessary and should occupy 60% of the class time, physiology should be taught during the latter part of high school, students should make careful sketches and drawings of observed specimens and the primary purpose of the science course was not memorization but the acquisition of knowledge and intellectual growth through the careful observation of nature. All of the subcommittees presented their recommendations, and in 1894 the Committee of Ten submitted a final report, known as *Report of the Committee on Secondary School Studies* (NEA, 1893, p. 26, 139–140). Although only approximately 10% of high school graduates attended college at this time, a uniform high school curriculum, standards and teaching methods, as well as the length of the school day were established by this influential group of educators. (Friedman, 2005) From 1930 through 1950, both the number of students being taught and the diversity of the population in American classrooms were changing dramatically. As a response to the Great Depression in the 1930s, science textbooks had their focus in topics that were economically based. Crop rotation, soil erosion and the nutritional value of inexpensive produce were emphasized during this era. It will be seen that throughout history, the study of science will be in direct response to the developments that take place in the socio-economic world. The developments in science and technology during World War II would have a direct impact on the focus of science education in the ensuing decades (Raven, 2002).

There was a positive public opinion of scientists in post-war America because of the many advances made in science during the Second World War. These advances in technology were supported by government funding and the fact that the United States had attained international prominence as a world leader. However, in the 1953 report drafted by the United States Commissioner of Education for the incoming Eisenhower Administration, there was no mention of the quality of education in the primary or secondary levels of education. This was all about to change radically. On October 4, 1957, the Russians announced the successful launching of an artificial satellite into orbit. The unanticipated success of Sputnik I began the "Space Race" and snapped the United States into immediate action. Reports from the Soviet Union credited their accomplishments on the fact that they had an efficient, centralized system of scientific training. Back in the United States, education became the immediate scapegoat in the "Space Race" and the perceived inferiority of the science education received in the school system. Congress responded to Sputnik by passing the National Defense Education Act (NDEA) in 1958, a four year program that provided funding for graduate students in mathematics, science and foreign languages and funding for school construction. The government also enlisted the help of the National Academy of Science. Also asked to participate was the newly founded National Science Foundation that had been established in 1950. The focus was on in-service teachers and a plan for reform was begun on two fronts – a Summer Institute for in-service teachers and the production of curriculum materials strictly focused on science content. Pedagogy was purposely excluded. The curriculum consisted solely of formal lecture and lab work. The term "Big Science" was applied to the movement and this work was done by interdisciplinary teams of researchers. Most of the work was done collaboratively by scientists, engineers and researchers in university settings and backed with government funding. The teacher was intentionally eliminated. Although this was seen as a time of crisis in the history of scientific education, the fact was that it did serve to bring awareness to scientists about their responsibilities in educating the public about the nature of science in this new age.

This period in education was known as "The Golden Age of Science". More than $117 million was spent on over 50 course improvement projects during the years of 1957 through 1975. The bulk of the reformers were scientists with specialties in physics, biology, chemistry or geology and their view of significant science was seen through their specific content specialty. The curricula were based on the assumption that science is a way of knowing and experiential in nature. Students were actively experimenting, observing, comparing, inferring, inventing and evaluating. Unfortunately, even though the implementation and design of the science curriculum seemed to be more cohesive than before, studies showed that this was not a successful model. The scientists were not happy with the way that the materials translated in classroom practice. They felt that they had to "teacher-proof" the material that they were creating to ensure the content was the focus. On the other hand, the teachers felt that the scientists did not understand the level of comprehension that the students could manage. They felt the need to “water-down” the content. Science curriculum materials of the 1960’s were commonly seen as too difficult for the typical students and only partially implemented by teachers. However, fundamental changes did take place in what the students learned and the way they were taught as a result of the scientists’ efforts (Rudolph, 2002). By the mid-1970s science reform became the subject of public criticism. A movement called “Back to Basics” was starting to make its way into science education and the textbooks that were being used became the focus of some religious groups. A conservative tide was emerging in the United States and the National Science Foundation came under attack for some of the curricula that it had created. The inclusion of Darwin’s Theory of Evolution in the BSCS (Biology Sciences Curriculum Studies) publications was particularly troublesome for the fundamentalists. In April, 1975, all of the programs that were started by the National Science Foundation came under review. The consequence of this scrutiny was that federal funding was switched from this curricula effort and was instead used in research and college science programs. The back to basics movement had taken a strong hold by the end of the 1970s and science was no longer the priority it had been throughout the 1960s and early 1970s. The fundaments of reading, arithmetic and written communication moved to the forefront of the educational movement at this time. The next big upheaval in education came in 1983 with the publication of A Nation at Risk. It included the following inflammatory statement:

> “If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have even squandered the gains in student achievement made in the wake of the Sputnik challenge. Moreover, we have dismantled essential support systems which helped to make these gains possible. We have, in effect, been committing an act of unthinkable, unilateral educational disarmament.” (National Education Commission, 1983)

The results of this report were swift and total. The policy of education was changed dramatically. In some of the states, secondary students would be required to take the five new basics in order to earn a high school diploma – four years of English, three years of mathematics, three years of science, three years of social studies and one year of computer science. In addition, the college bound student was required to take two years of a foreign language and the science courses would need to be revised for both the college bound student and the student planning to go right into the workforce. Issues of global importance such as ozone depletion, pollution, global warming and deforestation became the focus of goal setting. Action was called for on a global scale. A prime example was the 1983 Nation Commission on Education's recommendation of *Chemistry in the Community* as a way to bridge the scientific content with the increasing awareness and inclusion of environmental issues. In 1988, the American Chemical Society released the first edition of the Chemistry in the Community (*ChemComm*) materials. The program uses an issues-oriented, science, technology, and society (STS) approach. The chemistry is taught with a need to know, spiral approach where the basics are taught without emphasis on details and intended for those students who did not plan to major in the sciences or engineering.

In the 1980s there was dissatisfaction with science instruction in the classroom. Many students saw science as stagnant, boring and relatively difficult to understand or enjoy. At the same time there were two research efforts being conducted in science education. One group of researchers reached the conclusion that learners of science are not passive but active recipients of scientific knowledge and that they bring their own notion of the natural world into the classroom (Barton, 2003: Tobin, Espinet, Byrd & Adams, 1988). The second was that the current epistemological views of science held that the development of scientific knowledge occurs through the collective collaboration among all of the members of the scientific communities. It was understood that the curricula that had been developed outside the classroom by scientists in the “Golden Age of Science” would not be faithfully adopted by the classroom teacher (Atkins et al., 2003). The goal was to create “teacher-proof” materials that would work regardless of the teachers’ background or teaching methods. The result was a focus on specific disciplines that did not adequately take into account the existing school science programs. Despite these complications, the notion of an inquiry-based, student centered approach to science is still emphasized today.

With the reemergence of the need for a better prepared American citizen, the proposal for National Standards in Education was initiated. In 1989, the National Council of Teachers of Mathematics (NCTM) released the first standards document in the United States, *Curriculum and Evaluation Standards.* All of the major mathematics professional organizations were behind the creation of this document.

In the same year, the Department of Education issued this statement, “By the year 2000, American students will leave grades 4, 8, and 12 having demonstrated competency in challenging subject matter including English, mathematics, science, history and geography. U.S. students will be first in the world in science and mathematics achievement.” (United States Department of Education, 1989)

In 1992, the National Research Council of the Academy of Science was given a grant to develop standards. The shared responsibility by several groups for the standards sought to make all parties responsible and it was hoped it would discourage the practice of blaming others for the lack of success. Though the National Research Council was given the dubious honor and the funding for developing the standards for science education, two other organizations were major contributors. The three organizations and their responsibilities follow:

1. The American Association for the Advancement of Science (AAAS) – developed a vision for what it means to be a scientifically literate individual.

2. The National Research Council (NRC) - established a broad set of standards for science education.

3. The National Science Teachers Association (NSTA)[2] – developed the tools, including the guidelines, curricula and teacher training for the implementation of the standards.

The American Association for the Advancement of Science proposed Project 2061, a long-term initiative for K-12 education in science, mathematics, and technology. The project was named after the next return of Halley's comet and visualized a future where all Americans are science literate. The seminal document that was created by the AAAS was called, *Science for All Americans.* This document was then set in six school district-based centers where teachers transformed the *Science for All Americans* document by grade and sequence to create the basis for the *Benchmarks for Science Literacy* (AAAS, 1993).

No less than eight reports followed and all of the reports had a key belief – that the curriculum elements in each of the content areas needed to be readdressed and restructured. This in itself generated a great deal of discussion among educators and served as the precursors to the standards in the content areas. (Conley, 1997)

In the early 1990's, the Organization for Economic Cooperation and Development project was fashioned by thirteen participating countries. Among the features studied in each core were the strategies employed for changing science, mathematics or technology education. Greater responsibility was deferred to the teachers themselves for making the changes, not solely on devising methods of teaching but also having a greater role in the selection of content. By 2000,

[2] It is worth mentioning that of the three organizations, only NSTA is composed exclusively of science educators.

several of the new and broadly used programs had little or no direct participation by scientists. (Atkins & Black, 2003)

The face of education in the United States has undergone several evolutionary stages and we now find ourselves in a quandary when we compare the state of education here to that of other nations. As we move well into the 21st Century, declining international status and an increasingly smaller and "flatter" world (Friedman, 2005; Darling-Hammond, 2010) has created a brand of educational hysteria comparable to that felt fifty years ago when the Russians launched Sputnik. We are increasingly dependent on a technically-trained workforce that come from other nations, and continually outsource the production to meet our needs. These developments force the question: "What can be done to reverse this trend and move the United States back into the forefront?"

The Control of Education in the United States

In order to follow the educational developments and decisions that are made in the United States, it is important to understand the power base for these developments and decisions. Although education is not mentioned in the Constitution, it is compulsory in the states of the United States. The control and funding of education comes from three sources: federal (10%), state (46%) and local (44%) governments. Many policies such as curricula, employment and funding are decided locally, usually through school boards that are elected by school districts. In New York City and under mayoral control, community school boards were disbanded in 2002 and the Panel for Educational Policy was put in place. The panel is a twelve-member body of which seven members are appointed by the mayor and swerve at his discretion and five by borough presidents. However, many of the directives such as standardized testing and curriculum standards are issued at the state level. The New York State Department of Education, a part of the University of the State of New York, is responsible for the supervision of all public schools in New York, standardized testing and the development and processing of state tests and Regents Examinations. Other responsibilities of the New York State Education Department include professional licensing, higher education and management of cultural institutions. The federal Department of Education (USDE) was established as the Commission of Education in the Labor Department in 1867 with the intent of collecting and disseminating information on schools and teaching that would be of benefit to the all of the states. The role of the federal government in education has grown through the years and federal aid was instrumental in the establishment of the land-grant colleges and universities, vocational education and post-secondary educational assistance to veterans following World War II, to name a few. The U.S. Department of Education was formed in the 1960's and other federal agencies such as Head Start contribute approximately 10.8% to elementary and secondary education. (U.S. Department of Education, 2012) There is no doubt that federal support has enhanced and expanded public education over time. The conundrum lies in the amount of power each of these governing bodies has or should have in educational policies.

With the introduction of the federal No Child Left Behind Act of 2001 (Public Law 107-110) the call was for increasing the standards of accountability for states, school districts and schools, as well as providing parents more flexibility in choosing which schools their children will attend. With the election of President Obama and the appointment of his Secretary of Education, Arne Duncan, and the passage of the American Recovery and Reinvestment Act of 2009, an increased emphasis on education continues on the federal level. Most recently, the Common Core – a group of core curriculum topics in English Language Arts and Mathematics – has been adopted by forty-six states and three territories of the United States. This common core is meant to serve as a national core curriculum. A science framework called the Next Generation Science Standards was released in draft form in the summer of 2010. Although not an integral part of the Common Core, all indications point to the fact that the format and performance measures will mirror those of the common core. Forty-six of the fifty United States have agreed to adopt this when the final version is complete. For now, the English Language Arts performance standards address the skills needed in the content areas such as science. For example, students will be tasked with reading more complex non-fiction text as well as writing an argument by introducing a substantive claim including counterclaims, reasoning, evidence and purposeful and logical sequencing. However, the understanding of science content is not a part of the Common Core.

The Global Economy, Human Capital and S.T.E.M.

In April of 2010, President Obama addressed the National Academy of Science and stated unequivocally that the United States would ". . . . move from the middle of the pack to the top of the pack in science and mathematics within the next decade. The key to meeting these challenges – to improving our health, to harnessing clean energy, to protecting our security, and succeeding in the global economy – will be reaffirming and strengthening America's role as the world's engine of scientific discovery and technological innovation." In closing, President Obama identified three overarching priorities for S.T.E.M. education:

1. Increasing S.T.E.M. Literacy so all students can think critically in these subject areas.
2. Improving the quality of math and science teaching so American students no longer are outperformed by those in other nations.
3. Expanding S.T.E.M. education and career opportunities for underrepresented groups, including minorities and women.

This set the groundwork for what was to be the next major educational push in the area of S.T.E.M. education. In July, 2010, Secretary of Education Duncan announced a $4.35 billion

“Race to the Top Initiative” for which states would have to compete. Among the items for qualification for this federal funding was the need for qualified and competent teachers as well as innovative and creative programs for raising student achievement. (*U.S. Department of Education, 2010*)

The purpose of this study was to determine quantitatively the impact of various school characteristics on access to and enrollment in high school chemistry and to identify the issues that may contribute to the inequities in high school education, specifically S.T.E.M. education. It is necessary to provide an education that includes the skills and content needed to be successful in the 21st Century. Such success embraces employment opportunities for educated citizens well versed in citizenship science. This was the motivating factor for the inclusion of S.T.E.M. in the “Race to the Top Initiative. In 2009, Americans aged 25-34 with a bachelor of science degree earned more than twice as much as young adults without a high school diploma or the equivalent, 50% more than those with a high school degree and 25% more than those with an associate degree (Aud, et al., 2011) The roots to understanding the social justice implications lie in the higher order science and mathematics education that is being given at the high school level to all of the citizens of the United States. Exposure to content in mathematics, science, technology and engineering at the secondary level could encourage students to pursue these fields as they move to the post-secondary level and beyond.

Access to higher education opportunities in the areas of S.T.E.M. transition into a plethora of employment prospects and in essence, have a beneficial effect on quality of life for the individual as well as enhanced global status and increased stability for the nation. Currently, as stated previously, only 17% of today’s college majors in the United States are in the S.T.E.M. fields (Kurtz, 2011). How do we increase the number of American students who enter S.T.E.M.

majors and related careers? It is with this query that this study will focus on the following questions of equity for all high school students in the pursuit of greater S.T.E.M. learning opportunities.

Research Questions

With a focus on the critical area of Chemistry,

1. What is the relationship between school characteristics and chemistry access/enrollment in the New York City public high schools?

    a. How does the chemistry enrollment in NYC compare to the state enrollments, overall, by borough and by neighborhood?

    b. Are there statistical correlations between chemistry access and socioeconomic factors such as racial status (Black, Hispanic, White, Asian, Other) and/or financial status (percentage of free lunch students)?

    c. Are there statistical correlations between chemistry access and systemic factors such as school size and expense per student?

    d. Are there statistically significant correlations between chemistry access and the availability of science laboratory facilities in the schools?

2. What role does geographic location play in the access to chemistry in high school as measured by a correlation between the socio-economic status of the district in which the school is located and the access to chemistry and S.T.E.M. content courses?

3. What issues of social justice can be identified through this study and those like it and can and will any of these have an effect on secondary school policy in New York City, New York State and/or the nation?

Chapter 2 – Review of the Literature: New York City Public School Context

The review of the literature for this study is intended to lay the conceptual groundwork for the core objective of the study – to determine whether disparities exist in chemistry access for students in New York City's public high schools. The major areas of research that support the need for this study on possible inequalities are divided into ten sections, addressing both urban science education, specifically in the area of Chemistry, and the need for increased Science, Technology, Engineering and Mathematics content among American students in general.

Science Citizens and Human Capital

Science Literacy is the right of every citizen on the planet and a necessity for those who consider themselves responsible citizens. It enables people to make better decisions, which in turn creates a positive impact and helps to enrich their lives and the lives of others. The average citizen should have a working knowledge of science content in chemistry, biology, physics and geology or earth science. This way of thinking became commonplace following the publication of "Science for All American" in 1991. In the two decades since its publications, the term science literacy has come to also include science citizens and the belief that we should think of our world in terms of scientific systems as they are situated in the global scheme. This is certainly evident in the Next Generation Science Standards. Students will be asked to see the scientific world as a much more integral part of their everyday lives.

As a society, few significant benefits would be enjoyed without the implementation of the principles of science and for many, the study of chemistry specifically. The ability to argue from a knowledgeable vantage point on societal issues such as carbon footprint and climate change, the understanding of the contents of consumer products such as household cleaners and medicines and the awareness about chemicals to understand harmful from necessary and beneficial are all the desired outcomes of a complete science education that would included chemistry. It has evolved, therefore into an essential core subject in the schools and helps guide the students to develop argumentative skills and make socially sound judgmental decisions based on scientific ideas (Kolsto, 2001). The term science literate (Fang, 2005; Holbrook & Rannikmae, 2009) was commonly used for several years to describe this capability but currently citizen science is considered to be a more apt term (Holbrook, 2010). Citizen science refers to the increasing scale of access to science by the public in general. A noted driving force in the effort is the increasing reliance on technology which is causing an explosion of citizen science involvement and activities.

It is quite evident that there is a critical need for a scientifically-educated workforce in the United States. The New York City school system is the largest in the country and should be spearheading a movement in this direction. Despite a dearth of information on the importance of science, technology, engineering and mathematics curriculum in schools in the United States, it will be seen that little is being done to foster STEM education in New York City, especially in terms of underrepresented minority students (Lewis, Menzies, Nájera & Page, 2009). For students to become more competitive in the STEM career pipeline, much more has to be done to ensure that all students have the opportunity to take advantage of these rapidly growing fields, especially in this time of economic uncertainty.

Restructuring – Small School Movement in New York City School Districts

Although small schools were the common form of educational setting when organized education began in the United States, this setting was eventually replaced due to the growing population in many urban areas. The large comprehensive schools, especially on the high school level, became the norm in cities throughout the country. They were designed to serve all students and usually had college preparatory courses as well as general education and vocational programs. Due in part to student disengagement and poor academic achievement, the small school movement began to take root in the large urban settings with Chicago taking the lead.

In 1988, The Chicago School Reform Act was passed and with it, the small school movement began to take hold. Small school workshops were conducted at the University of Illinois for educators interested in beginning their own small schools within the city. In the early 1990s, small schools within the schools in Chicago were created and supported by a group called the Small School Coalition. In 1995, the second Chicago School Reform Act was passed and this granted mayoral control of the Chicago school system. Then Mayor Richard M. Daley appointed a 5-member School Reform Board of Trustees. One of their first duties was to assist in the formation of small schools. The criteria would be that the student body size would be kept small (100-350 for elementary and less than 500 for secondary), have a self-selected faculty and be autonomous in terms of curriculum, budget and organization. In 2001, the mayor appointed Arne Duncan as Chief Executive of the Chicago Schools and later than same year, Duncan created the Office of Small Schools in Chicago. From here, the movement moved east.

In 2002, Chancellor Joel Klein and Mayor Michael Bloomberg launched a campaign to change the conventional structures of high school in New York City. With the help of the Bill and Melinda Gates Fund ($51.2 million) and the blessing of those who were anxious for any reform that promised a change in the downward spiral of the urban high school statistics, (Steifel, Berne, Iatarola & Fruchter, 2000; Council of the City of New York, 2005) new and small secondary schools were introduced to New York City. It was planned that over a period of 5 years, approximately 200 new and smaller secondary schools would be initiated to replace the large comprehensive schools that had dominated the New York City high school landscape.

The smaller school would either be new stand-alone buildings or would share buildings with other independent public schools. The plan was for each of these newly slated schools to function independently, maintaining their own administration and staff. There was ample research on the benefits of the smaller schools (Bickel, Howley, Williams & Glascock, 2001; Ready, Lee & Welner, 2004) However, some of the decisions that were being made in the choice of the schools seemed to fly in the face of this reality and in many cases, not only did little to foster the STEM growth of the students in the smaller school settings but actually thwarted these efforts. In addition, these smaller schools seemed to be concentrated in areas of the city where there is a higher percentage of poverty level and therefore also characterizes this as an issue of social justice and democratic science education. (Barton, 2003; Bainbridge, Lasley & Sundre, 2003; Ancess & Allen, 2006)

Through an effort to improve overall education on the secondary level, many urban schools have been restructured. This is the process of phasing out the more traditional, larger schools and replacing them with high schools that are smaller in size (Vander Ark, 2003). Access to some of the more rigorous courses in mathematics and science has been hampered by this movement and inadvertently, the students have been the unsuspecting casualties. Thus, subjects like high school chemistry are disproportionately distributed in the high schools. Some of the more selective schools and those that are larger in size and have multiple science offerings make these courses accessible to their students, but the smaller, restructured schools do not and in many cases cannot due to limitations in facilities and faculty. The situation was brought to the public's attention as follows:

> Although Mayor Michael R. Bloomberg tries to interpret the recent data on high school graduation rates as progress, the figures suggest some disappointing conclusions. The rising graduation rates and simultaneous falling college-readiness rates suggest rampant grade inflation and granting credit for less and less educational achievement. The pressure to pass students along is even greater in small schools because of the limitations on their ability to let students repeat

> classes or customize schedules according to the students' needs. It is noteworthy that the schools producing a large percentage of college-ready students are large, comprehensive and well-established high schools that offer diverse programs to accommodate the interests of different students. (Editorial, *New York Times, June 23, 2011).*

Another interesting fact is that most of the high schools that have been restructured in the New York City public school system are located in areas of highest need and areas that serve the most under-represented populations (Ancess & Allen, 2006; U.S. Census Bureau, 2010). The habitual absence of the higher order mathematical and science courses in these restructured schools as well as their placement in the high school sequence further exacerbates the situation. The National Association of State Directors of Career Technical Education Consortium has stated that for students to benefit from the opportunities in secondary school, they should adhere to a rigorous agenda in both science and mathematics. This consortium grouped all occupations into sixteen possible clusters or categories (Agriculture; Architecture & Construction; Arts, A/V Technology & Communication; Business; Education; Finance; Government; Health Science; Hospitality & Tourism; Human Services; Information Technology; Law, Public Safety; Manufacturing; Marketing, Sales, Service; Science, Technology, Engineering & Mathematics; Transportation). This is a broad grouping but it uncovered the fact that fourteen of the sixteen require four years of science and four years of mathematics. (National Association of Career Technical Education Consortium, 2006)

New York City Economics and School Achievement Levels

The poverty levels in the City of New York are as varied as the populations that inhabit its five boroughs. Statistics taken from 2010 indicated that the Bronx has the highest poverty rate of the five boroughs with 28.5% of its citizens living below the poverty line[3]. Brooklyn is next at

[3] Living below the poverty line is defined as earning under $18,000 a year for a family of three (3).

a rate of 21.5%, Manhattan is 14.6% and Queens is 12.9% and Staten Island has the lowest poverty rate at 11.2%. However, geographic areas or neighborhoods within the boroughs also vary greatly in the level of poverty per its inhabitants.

A table was created by mapping the School Districts to the Poverty in New York City Document http://schools.nyc.gov/schoolsearch/Maps (NYC Commission for Economic Opportunity, 2006) and the New York City Department of City Planning. http://www.nyc.gov/html/dcp/html/neigh_info/nhmap.shtml (Refer to Table 3)

The large comprehensive high schools in New York City that have been restructured and converted into several smaller schools within the same building have been overlaid with the borough in which they are located and the specific neighborhood within that borough. Since it was felt that New York City and even the five individual boroughs have such large geographic regions, neighborhoods would be a better indicator of socioeconomic status and this could easily be compared to the socioeconomic status of the city as well as the borough in which the neighborhood is located. The results are as follows:

Table 3 – Restructured Schools by location and poverty level within NYC (NYC Public School High School Directory 2009-10, NYC Department of City Planning, 2011 http://www.nyc.gov/html/dcp/

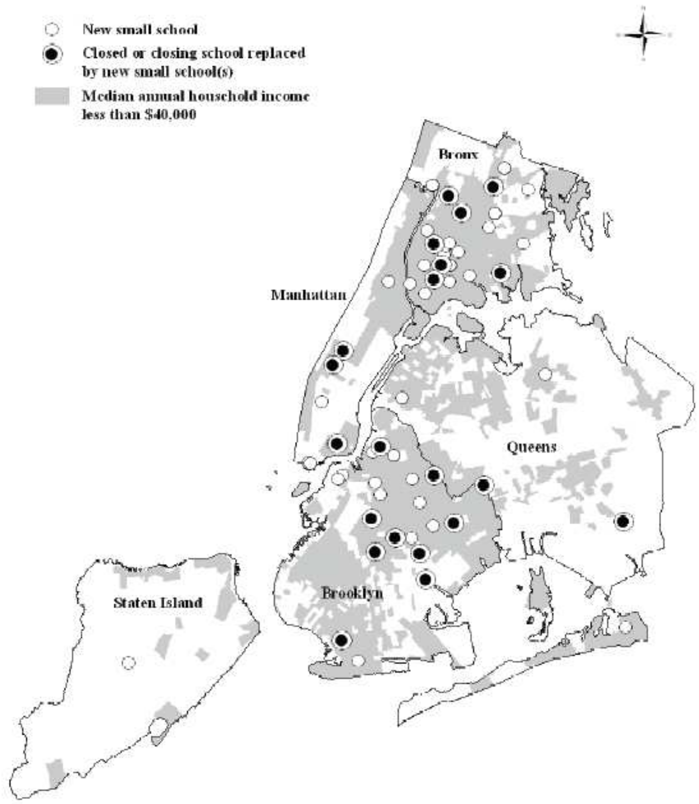
School	Borough	Borough Poverty Level	Neighborhood	Neighborhood
Evander Childs HS	Bronx	28.5%	Williamsbridge	34.3%
Thomas Jefferson HS	Brooklyn	21.5%	East New York	50.5%
Adlai Stevenson HS	Bronx	28.5%	Mott Haven	62.7%
Walton High School	Bronx	28.5%	Kingsbridge	47.3%
Herbert Lehman HS	Bronx	28.5%	East Tremont	57.6%
Prospect Heights High School	Brooklyn	21.5%	Prospect Heights	37.3%
Martin Luther King High School	Manhattan	14.6%	Upper West Side	12.0% *
Bayard Rustin HS for Humanities	Manhattan	14.6%	Chelsea	19.4%
Christopher Columbus High School	Bronx	28.5%	Pelham Parkway	32.3%
Park West High School	Manhattan	14.6%	Upper West Side	12.0% *
George Washington High School	Manhattan	14.6%	Washington Heights	44.1%
Erasmus Hall High School	Brooklyn	21.5%	Crown Heights	37.3%
Harry S. Truman HS	Bronx	28.5%	Pelham Parkway	32.3%
Seward Park High School	Manhattan	14.6%	LES/Chinatown	50.0%

*The Upper West Side is the outlier in this investigation. It is of note that most of the student body in the high schools in these geographic areas do not reside here.

Figure 8 highlights the fact that most of the closed schools and the new small schools that replaced them are located in low-income areas of central Brooklyn and the Bronx, those with median household incomes of less than $40,000. All of the closed schools have been converted into educational campuses (complexes).

Figure 8

Locations of Closed or Closing Schools and New Small Schools, 2007-2008 School Year



SOURCE: MDRC calculations from the New York State Report Card and data on new small schools provided by the NYC Department of Education (DOE) for school years 2002-2003 through 2007-2008, and U.S. Census Bureau Summary File 3 2000 data.

NOTES: The map shows locations of the 23 large and midsize schools that ceased admitting new ninth-grade students between the 2002-2003 and 2007-2008 school years as well as the 115 schools that were designated as new small schools by the DOE and served their first cohort of ninth-grade students during the same period. (More than one school could be at a location, with an average of four small schools at the former site of each closed school.) Three midsize schools that were closed were colocated within a single building. Median annual household income is shown at the census track level.

As can be seen, each of the restructured schools (with the exception of the schools on the Upper West Side) is located in neighborhoods within their borough that exceed the poverty level of that borough. (Frankenberg, 2009) In addition, all but one of these schools are located in the three boroughs with the highest poverty level in the city of New York. At the time of this study there was no restructuring of schools in Staten Island and limited restructuring of large comprehensive schools in Queens.

The Down Side of the Small School Movement

A systemic shift to smaller high schools in New York City appears to promise greater individual success in the pursuit of knowledge and higher education and closing the achievement gap between those that have and those that do not. (Ilg & Massucci, 2003). However, the issue of size is one that may prohibit the course offerings in the high schools, especially those courses that require higher order thinking and specially licensed teachers. The small schools usually lack the diverse curricula offerings and high order content licensed faculty – especially in mathematics, science and postsecondary counseling that is found in the large comprehensive high schools (Bloomfield, 2009). Another issue that may be unique to the student in New York City is the selection process for the high schools. A student's previous test scores and/or class grades can potentially keep him or her from attending a "screened" program at some of the more selective smaller high schools. This filtering system may eliminate some of the students that would most benefit from the smaller setting. (New York City Department of Education, 2009) Another issue in the smaller schools is the fact that they do not have the capacity for offering large selections of elective courses. This is partially due to limited staff and resources at the school. The smaller school offers a more uniform curriculum to its student body and one which is potentially limiting in terms of preparing students for postsecondary success (Carey, 2006; Deil-Amen & DeLuca, 2010). Both Darling-Hammond (2010) and Herszenhorn (2005) have written regarding the preparation of students for science-related post-secondary opportunities. However, there are few studies that can substantiate the shortcomings of the smaller schools in terms of lack of opportunities in studying advanced coursework. And there are other unintentional negative consequences of the small school movement in the City of New York. Due to poor planning and space and budget constraints, many of the small schools have been placed within shared spaces. (See Figures 9a, 9b, 9c) Usually this space has been within the large comprehensive school which is being deconstructed. This is causing conflicts between the students in the various schools as well as with the administration and shared personnel (safety agents, facilities managers and science lab staff). It was found that the practice of housing small schools within large struggling schools replicated and even exacerbated the detrimental conditions of the large, failing school. (Council of the City of New York, 2005)

Findings of a sample New York City Small School Analysis taken in 2005 by the Council of the City of New York yielded the following results:

1. Evander Child Complex – 105% higher crime rate
2. Thomas Jefferson Complex – 84% higher crime rate
3. Adlai Stevenson Complex – 84% higher crime rate
4. Walton Complex – 17% higher crime rate
5. Herbert Lehman Complex – 8% higher crime rate
6. Prospect Heights Complex – 5% higher crime rate

This triggered some immediate revisions to the basic plans for the Small School Movement in New York City. Additionally, these buildings were not designed to house several smaller schools within its walls. These buildings do not offer autonomous spaces and so the administrators of each of the schools must work in conjunction when scheduling shared spaces such as gymnasiums, libraries, science laboratories and lunchrooms. This has been problematic in many high schools. Because these shared spaces are located centrally, students from one or more of the smaller schools must walk through other schools within the building, often vandalizing the bulletin boards in the hallways. Variations in school policies such as banning cell phones and the wearing of hats and ”do-rags" cause additional tension between students that must adhere to these rules in their school, yet share space with schools that have a more lenient approach to these policies (Ancess & Allen, 2006). It appears that the human element was an oversight in the new configuration of schools.

And what of the issue of equity and parity in these small schools in relation to the large comprehensive high schools? The small school movement in New York City was accompanied with the addition of many perks for the administration of these schools to ensure their success. A special division was created at the central office for personalized guidance, small schools were given a large budget with which to launch their programs and added supports from not-for-profit constituencies were major incentives given to the small schools.

Additionally, during their first few growing years, the small schools were not required to accept the general public school population which includes special needs students (Bloomfield, 2009). Data from these schools would almost have to be falsely skewed toward greater success, given the parameters stated here. In addition, the comprehensive high schools were overwhelmed by influxes of students who had histories of poor attendance, behavior problems and low academic achievement. Many of those students came from closed failing schools that were replaced with small schools. (Hernandez, 2009)

Figure 9a - Complete list of Reorganized Schools in the Bronx
(New York City Department of Education, 2010) http://schools.nyc.gov/default.htm

Bronx	School Name	Academic Campus
8X	Bronx Guild	Adlai Stevenson Campus
8X	Gateway School for Environmental Research and Technology	Adlai Stevenson Campus
8X	Millennium Art Academy	Adlai Stevenson Campus
8X	Pablo Neruda Academy for Architecture and World Studies	Adlai Stevenson Campus
8X	School for Community Research and Learning	Adlai Stevenson Campus
8X	Herbert H. Lehman High School	Herbert Lehman Campus
8X	Renaissance High School for Musical Theater & Technology	Herbert Lehman Campus
7X	Alfred E. Smith Career and Technical Education High School	Alfred E. Smith Campus
7X	Bronx Haven High School	Alfred E. Smith Campus
7X	Mott Haven Village Preparatory High School	South Bronx Campus
7X	New Explorers High School	South Bronx Campus
7X	University Heights Secondary School	South Bronx Campus
7X	Urban Assembly School for Careers in Sports	South Bronx Campus
9X	Bronx International High School	Morris Campus
9X	Bronx Leadership Academy II	Morris Campus
9X	High School for Violin and Dance	Morris Campus
9X	Morris Academy for Collaborative Studies	Morris Campus
9X	School for Excellence	Morris Campus
9X	Bronx Expeditionary Learning High School	William H. Taft Campus
9X	Bronx High School for Medical Science	William H. Taft Campus
9X	Bronx High School of Business	William H. Taft Campus
9X	Dream Yard Preparatory School	William H. Taft Campus
9X	Jonathan Levin High School for Media and Communications	William H. Taft Campus
9X	The Urban Assembly Academy for History and Citizenship for Young Men	William H. Taft Campus
10X	Bronx Engineering and Technology Academy	John F. Kennedy Campus
10X	Bronx School of Law and Finance	John F. Kennedy Campus
10X	Bronx Theatre High School	John F. Kennedy Campus
10X	Marble Hill High School for International Studies	John F. Kennedy Campus
10X	Belmont Preparatory High School	Theodore Roosevelt Campus
10X	Bronx High School for Law and Community Service	Theodore Roosevelt Campus
10X	Fordham High School for the Arts	Theodore Roosevelt Campus
10X	Fordham Leadership Academy for Business and Technology	Theodore Roosevelt Campus
10X	Knowledge, Power Prep Academy International HS	Theodore Roosevelt Campus
10X	West Bronx Academy for the Future	Theodore Roosevelt Campus
10X	Discovery High School	Walton High School Campus
10X	High School for Teaching and the Professions	Walton High School Campus
10X	International School for Liberal Arts	Walton High School Campus
10X	Kingsbridge International High School	Walton High School Campus
10X	The Celia Cruz Bronx High School of Music	Walton High School Campus
11X	Astor Collegiate Academy	Christopher Columbus Campus
11X	Christopher Columbus High School	Christopher Columbus Campus
11X	Collegiate Institute for Math and Science	Christopher Columbus Campus
11X	Global Enterprise High School	Christopher Columbus Campus
11X	Pelham Preparatory Academy	Christopher Columbus Campus
11X	Bronx Academy of Health Careers	Evander Child Complex
11X	Bronx Aerospace High School	Evander Child Complex
11X	Bronx High School for Writing and Communication Arts	Evander Child Complex
11X	Bronx Lab School	Evander Child Complex
11X	High School for Contemporary Arts	Evander Child Complex
11X	High School of Computers and Technology	Evander Child Complex
12X	Bronx Coalition Community High School	James Monroe Campus
12X	High School of World Cultures	James Monroe Campus
12X	Monroe Academy for Business/Law	James Monroe Campus
12X	Monroe Academy for Visual Arts & Design	James Monroe Campus
12X	The Cinema School	James Monroe Campus

Figure 9b - Complete list of Reorganized Schools in Brooklyn
(New York City Department of Education, 2010) http://schools.nyc.gov/default.htm

Brooklyn	School Name	Academic Campus
19K	Academy of Innovative Technology	Franklin K. Lane/Jamaica Avenue Campus
19K	Brooklyn Lab School	Franklin K. Lane/Jamaica Avenue Campus
19K	Cypress Hills Collegiate Preparatory School	Franklin K. Lane/Jamaica Avenue Campus
19K	Franklin K. Lane High School	Franklin K. Lane/Jamaica Avenue Campus
19K	Multicultural High School	Franklin K. Lane/Jamaica Avenue Campus
19K	FDNY High School for Fire and Life Safety	Thomas Jefferson Educational Campus
19K	High School for Civil Rights	Thomas Jefferson Educational Campus
19K	Performing Arts and Technology High School	Thomas Jefferson Educational Campus
19K	World Academy for Total Community Health HS	Thomas Jefferson Educational Campus
14K	Brooklyn Preparatory High School	Harry Van Arsdale Educational Campus
14K	Williamsburg HS for Architecture and Design	Harry Van Arsdale Educational Campus
14K	Williamsburg Preparatory School	Harry Van Arsdale Educational Campus
15K	Secondary School for Journalism	John Jay High School
15K	Secondary School for Law	John Jay High School
15K	Secondary School for Research	John Jay High School
17K	Academy for College Preparation and Career Exploration: College Board School	Erasmus Hall Educational Campus
17K	Academy of Hospitality and Tourism	Erasmus Hall Educational Campus
17K	High School for Service & Learning at Erasmus	Erasmus Hall Educational Campus
17K	High School for Youth and Community Development at Erasmus	Erasmus Hall Educational Campus
17K	Science, Technology and Research Early College High School at Erasmus	Erasmus Hall Educational Campus
17K	High School for Public Service: Heroes of Tomorrow	George W. Wingate Educational Campus
17K	International Arts Business School	George W. Wingate Educational Campus
17K	School for Democracy and Leadership	George W. Wingate Educational Campus
17K	The School for Human Rights	George W. Wingate Educational Campus
17K	Brooklyn Academy of Science and the Environment	Prospect Heights
17K	Brooklyn School for Music & Theatre	Prospect Heights
17K	International High School at Prospect Heights	Prospect Heights
17K	The High School for Global Citizenship	Prospect Heights
18K	It Takes a Village Academy	Samuel J. Tilden Educational Campus
18K	Kurt Hahn Expeditionary Learning School	Samuel J. Tilden Educational Campus
18K	Samuel J. Tilden High School (closed ~2010)	Samuel J. Tilden Educational Campus
18K	Academy for Conservation and the Environment	South Shore Educational Campus
18K	Brooklyn Bridge Academy	South Shore Educational Campus
18K	Brooklyn Generation School	South Shore Educational Campus
18K	Brooklyn Theatre Arts High School	South Shore Educational Campus
18K	Victory Collegiate High School	South Shore Educational Campus
32K	Academy for Environmental Leadership	Bushwick Educational Campus
32K	Academy of Urban Planning	Bushwick Educational Campus
32K	Bushwick School for Social Justice	Bushwick Educational Campus

Figure 9c - Complete list of Reorganized Schools in Manhattan and Queens
(New York City Department of Education, 2010) http://schools.nyc.gov/default.htm

Manhattan	School Name	Academic Campus
2M	Bayard Rustin High School for the Humanities	HS for Humanities Educational Campus
2M	Humanities Preparatory Academy	HS for Humanities Educational Campus
2M	The James Baldwin School	HS for Humanities Educational Campus
2M	Manhattan International High School	Julia Richman Educational Campus
2M	Talent Unlimited High School	Julia Richman Educational Campus
2M	Vanguard High School	Julia Richman Educational Campus
2M	Food and Finance High School	Park West Campus
2M	High School of Hospitality Management	Park West Campus
2M	Manhattan Bridges High School	Park West Campus
2M	The Facing History School	Park West Campus
2M	The Urban Assembly School of Design and Construction	Park West Campus
2M	Essex Street Academy	Seward Park Campus
2M	High School for Dual Language and Asian Studies	Seward Park Campus
2M	Lower Manhattan Arts Academy	Seward Park Campus
2M	New Design High School	Seward Park Campus
2M	The Urban Assembly Academy of Government and Law	Seward Park Campus
3M	High School for Arts, Imagination and Inquiry	Martin Luther King Jr. Campus
3M	High School for Law, Advocacy and Community Justice	Martin Luther King Jr. Campus
3M	High School of Arts and Technology	Martin Luther King Jr. Campus
3M	Manhattan Theatre Lab High School	Martin Luther King Jr. Campus
3M	Manhattan/Hunter Science High School	Martin Luther King Jr. Campus
3M	The Urban Assembly School for Media Studies	Martin Luther King Jr. Campus
6M	High School for Health Careers and Sciences	George Washington HS Campus
6M	High School for International Business and Finance	George Washington HS Campus
6M	High School for Law and Public Service	George Washington HS Campus
6M	High School for Media and Communications	George Washington HS Campus
Queens	School Name	Academic Campus
27Q	Beach Channel High School	Beach Channel Educational Complex
27Q	Channel View School for Research	Beach Channel Educational Complex
27Q	Academy of Medical Tech: A College Board School	Far Rockaway Educational Complex
27Q	Far Rockaway High School	Far Rockaway Educational Complex
27Q	Frederick Douglass Academy VI High School	Far Rockaway Educational Complex
27Q	Queens HS for Information, Research, and Technology	Far Rockaway Educational Complex
29Q	Excelsior Preparatory High School	Springfield Gardens Campus
29Q	George Washington Carver High School for the Sciences	Springfield Gardens Campus
29Q	Preparatory Academy for Writers: A College Board School	Springfield Gardens Campus
29Q	Queens Preparatory Academy	Springfield Gardens Campus
29Q	Business Computer Applications HS	Campus Magnet Educational Campus
29Q	Humanities & Arts Magnet High School	Campus Magnet Educational Campus
29Q	Law/Government Community Service	Campus Magnet Educational Campus

Note: None of the schools in Staten Island (Richmond) have been reorganized.

Accountability

Through the restructuring of the New York City school system, several accountability pieces were put in place to monitor the progress of these changes. One of the many accountability measures initiated since the beginning of mayoral control of the schools is the NYC Department of Education Progress Report. http://schools.nyc.gov/Accountability/tools/report/default.htm The pilot implementation began in the 2006-2007 school year. (Jennings & Pallas, 2009). This report is a summary of each school's progress during one academic year. For high schools, there are three basic areas of progress that are measured for a school as it compares to up to 40 other "peer" schools. A "peer" school has been determined to be one that has a similar student population. The three areas of the progress report are:

1. School Environment – determined by parent, teacher and student surveys including questions on academic expectations, communication, engagement and safety & respect.
2. Student Performance – determined by both four year and six year graduation rates and weighed diploma graduate rate
3. Student Progress – determined by credit accumulation during each of the first three years and Regents pass rates in each of the content areas (English, Science, Mathematics, U.S. History and Global History)

The total point value for the Progress Report is 100 points with a possibility of up to 16 extra points for closing the achievement gap and moving high needs students toward graduation. Of the original 100 points, 85 can be amassed in the areas of student performance and student progress. Sixty of those points are in the area of student progress alone. As stated above, the student progress is partially based on the student earning 10+ credits per year for each of his/her first three years in high school. Regents pass rate in the content area is the other part to the student progress. Science is the subdivision and there is no further delineation as to which science regents the student passed. Since it is commonly accepted that Living Environment is the gatekeeper for most students, this would be the primary science regents upon which a school is judged.

The purpose of this report is to facilitate the ongoing increased academic achievement of the students in the school. This document is one of the many tools that have been produced by the Office of Assessment & Accountability to enhance the ability of principals and teachers to target areas of weakness and strive to resolve these areas of limitation for the students. Through tracking, identifying steps to improve students' progress and revisions in the academic plans for the students, it is believed that schools can help in the academic progress of every student. The Progress Report is the indicator that is used to see how well this process is being achieved at each of the schools in the city.

The Progress Report's three categories and the point value allotted to each is as follows:

1. School Environment (15% of overall score) – this measures the pre-conditions for learning. Of the 15%, 5% is based on student attendance and the other 10% is divided equally (2.5%) between high expectations, engagement, safety and respect. Attendance is measured directly and the other four are taken from student, teacher and parent surveys.
2. Student Performance (25% of the overall score) – this measure is based on students who graduate with a Regents Diploma in 4 years or 6 years. A Regents Diploma is the requirement for a New York State endorsed diploma.
3. Student Progress (60% of the overall score) – this measures the ability of a school to help students in their progress through high school and in attaining a Regents diploma. One of the major matrices for this portion of the Progress Report is percentage of students earning 10+ credits per year. (New York City Department of Education, 2009) As can be

seen, 85% of the School's Progress Report is based on Students Achievement.

Significant overlap can be seen in the student performance and student progress portion of the Progress Report. For example, as a student earns 10+ credits per year, the graduation rate will increase. This translates into a direct correlation. One of the questions posed by this study is the quality of the student progress. Although the number of credits is clearly stated, the type of credit earned and the rigor of the course provided is not stipulated and therefore can vary from school to school or even department to department within a school (Winters, 2008).

With all of that being said, it is important to note that a principal in a New York City high school is evaluated on the outcomes found in this yearly Progress Report. The first page of the report states, "Schools are assigned letter grades based on their overall Progress Report score. Schools that get "A"s and "B"s are eligible for rewards. This reward has been in the form of monetary recompense for the principal. Schools receiving "D"s and "F"s or 3 consecutive "C"s, face consequences including change in school leadership or school closure". Of all the schools that received the letter grade of "F" in the first year of Progress Report implementation, 77% went from "F" to an "A" or a "B" the following year (Jennings & Pallas, 2009). A possible factor in raising the Progress Report grade for the school might be to offer less rigorous coursework that the students can master within the timeframe of one academic year. This may lead to more students reaching the 10+ credit benchmark each academic year. Knowing that a poor grade may lead to school closure and the possible removal of the principal as well as job instability for the teachers, and the alternative is possible financial reward and consistency in teaching positions, school personnel would be hard pressed to raise this letter grade as quickly as possible.

Principals' Incentive

Additionally troublesome is the fact that the City's contract with the Council of School Supervisors and Administrators (CSA) enabled school leaders to earn bonuses based on the success of their students as reflected on the School Progress Report. On November 19, 2009, Chancellor Klein announced that principals of schools whose Progress Report scores were in the top 20 percent citywide would receive bonuses of up to $25,000. He further delineated the bonuses as follows:

- Principals receive $25,000 if their schools scored in the top 1 percent (four principals); $17,000 if their schools scored in the top 2-5 percent (12 principals); $12,000 if their schools scored in the top 6-10 percent (16 principals); and $7,000 if their schools scored in the top 11-20 percent (31 principals);

- An additional 17 principals who did not qualify for the CSA bonus but whose schools will receive bonuses as part of the school-wide performance bonus program will get a bonus of $7,000 if their schools met their targets (14 principals) and $3,500 if their schools met 75 percent of their targets (three principals).

In all schools where principals are receiving bonuses, assistant principals received half of the bonus amount that their principal received. A total of 80 high school and secondary school principals, as well as 160 assistant principals, received $56 million in bonuses as a result of this decision. (Fryer, 2011; Springer & Winters, 2009)

It can be argued that this incentive was instrumental in motivating the school administrators to increase the graduation rates at the schools involved. However, it has recently come to light that the following key findings do not support the financial incentive of $56 million tax payer dollars. As reported by Rand Education in a Research Brief (2011):

Key Findings:

- The researchers found that the NYCDOE's School-wide Performance Bonus Program did not improve student achievement at any grade level. http://www.rand.org/pubs/monographs/MG1114.html
- The program did not affect teachers' reported attitudes, perceptions, or behaviors.

- The majority of the schools developed award distribution plans that reflected preferences for equal sharing of bonuses.
- Many teachers in this study reported that the bonus was desirable but also reported not changing their teaching practices in response to the program.

Needless to say, it was announced that the Principal Bonus Program would be permanently discontinued. (*New York Times, July 17, 2011*). Researchers of the study by Rand Education hypothesized that one of the reasons for the failure of the program might have been that all of the schools in the city are already under extreme pressure to raise student test scores or face actions such as school closures (RAND, 2011).

School Facilities – Laboratories

The distribution of science-related resources in public urban high schools is another example of inequities within the system. The lack of science classrooms, science demonstration rooms, laboratories, and technical equipment such as burettes and chemicals often presents problems for adequate instruction (Rebell & Wolff, 2006). Unfortunately, there is not enough statistical evidence to support the hypothesis that the absence of these resources prohibits the availability of chemistry in high school. However, the school's commitment to science is evident if these resources are not available to the students. The value of the course is suggested through the presence of these resources and a subtle message is conveyed. These resources also allow for more inquiry-based, hands-on pedagogy. Chemistry is a discipline that lends itself to the constructivist style and students tend to retain more information when taught in this manner. It is virtually impossible to teach with constructivist methods without basic lab materials. Chemistry as a discipline will be more attractive to students if they know they can participate in experiments rather than passively sit in the classroom (Eick, 2002; Hofstein & Lunetta, 2004). Resource constraints have significant effects on the quality and availability of high school chemistry programs.

The history of the science laboratory experience for students in the United States has been a functioning part of the curriculum for more than 160 years. Laboratories were introduced in the U.S. in the late 1800s and although the goals of high school science have changed radically, the high school laboratory experience has been slow to keep up with the intended purpose of science education (Sheppard & Horowitz, 2006). The purpose of science education today is to provide science literacy for all the citizens of the United States. (DeBoer, 2000). Although many will debate the issue of science literacy for all based on social justice and equal access (Barton, 2003), this placement of the science laboratory experience is seen as essential in most academic circles if science education is to be rigorous and of high quality. The science education literature continues to articulate that laboratory work is an important medium for enhancing attitudes, stimulating interest and enjoyment and motivating students to learn (Hofstein & Lunetta, 2004).

When the science laboratory was first introduced in the United States, it was received with less than open arms. Laboratory work was seen as not up to the caliber of serious scientific endeavors and instructors often had to purchase the supplies and equipment needed to conduct experiments at their own expense. Further, the facilities to conduct these experiments were invariably relegated to the basements of school facilities and other non-essential spaces. Josiah P. Cooke conducted his laboratories in chemistry and mineralogy at Harvard in his father's shed (Sheppard & Horowitz, 2005) and Benjamin Silliman set up his first chemistry lab in Yale by paying the college rent for the space and purchasing his own equipment (Singer, Hilton & Schwiengruber, 2006).

In the early 19th century, science was taught essentially as history. Students learned through textbooks and lectures and by memorization and recitation. Educators and scientists made little effort in sharing scientific theories and methods of study. It was generally understood that the role of a scientist was to embark on scrupulous observations and accumulation of facts to develop theories and/or laws about science. (Reese & Rury, 2008; Rutherford, 2005) Science was taught in elementary schools throughout the U.S. but with no uniform quality or quantity. The science content also varied throughout the country with no consistent curriculum.

It was during the late 19th century that there was a change in the teaching of science. A key player in this development was a German chemist named Justus von Liebig. Liebig conducted a chemistry laboratory at the University of Giessen in Germany from 1824 through 1852. During this time period, students became immersed in his training and research methodology as well as the practical applications and techniques in the laboratory (Sheppard & Horowitz, 2006). His reputation became world known through his publications which contained his ideas and accomplishments. These publications attracted U.S. students and educators alike. One of these was Eben Horsford who conducted work in the laboratory of Liebig for two years. Upon his return to the United States he established a scientific school modeled after that of Liebig's and began the first laboratory course in chemistry in the U.S. The school was named the Lawrence Scientific School after Abbott Lawrence, the benefactor of the school and it opened in 1847. Soon other colleges and universities followed suit and one of the newly graduated students of the Lawrence Scientific School at Harvard, Charles W. Eliot accepted the position of professor of chemistry at the newly founded Massachusetts Institute of Technology. One of his prime responsibilities in this position was to establish and supervise chemistry laboratories at MIT. Other colleges and universities soon followed suit and laboratory facilities started to become commonplace.

While these developments were occurring on the college and university level, public high schools were not in existence. A small number of private secondary academies were sprinkled in some larger urban areas, but less that 1% of the eligible secondary population attended school at this level. The U.S. had established elementary schools and these were flourishing by the mid-19th century. To support broad based publicly supported high schools, reforms needed to be made. A tax supporting high school was introduced and challenged several times but in 1874 it was upheld in Kalamazoo, Michigan and soon the public high school became commonplace. Students were expected to follow their education in the primary grades with high school education that was free, public and followed the same comprehensive curriculum. As the high schools were established, (Reese, 1995) the curriculum was linked to that taught in the elementary schools but soon it was seen that this curriculum was not expanded to that taught at the college and university level. The acceptance into a college or university was based solely on that institution's entrance examination and these were not unified or systemic. Each college or university had its own requirements and many did not require a certain number of credits for entrance. Some did not even have high school as a mandatory pre-requisite (Sheppard & Horowitz, 2006).

High Schools continued to gain in popularity and as the number of graduating students increased, a need for better articulation between high school and college was seen. To remedy this situation, the National Educational Association established the Committee of Ten (Tyack & Ravitch, 2001). The function of this committee was to align the high school curriculum so that it would reflect the academic content knowledge needed by graduating students who intended to continue their education in the universities and college in the United States. The members of the committee included three high school principals, five university presidents and the U.S.

Commissioner of Education. Chairing the committee was Charles W. Eliot, who had resigned his position at MIT and subsequently accepted the position as president of Harvard. In this capacity, Eliot had broadened the admission policy and he imposed a mandatory science requirement for entrance. He also established an admission credit and advanced standing to any students who had completed specific chemistry and physics experiments while in high school (Holton, 2010).

The Committee of Ten quickly organized nine sub-committees in the academics subject areas with three of these being in the sciences: physical sciences, natural sciences and earth sciences. Eliot was influential in selecting the members of the sub-committees and ensured that Ira Remsen of John Hopkins headed the sub-committee on the physical sciences (Bruner, 1996). Some of the recommendations of this sub-committee which focus on the importance of the laboratory in science education are:

1. That in secondary school physics and chemistry be taught by a combination of laboratory work, textbooks and through didactic instruction carried on co-jointly, and that at least one-half of the time devoted to these subjects should be given to laboratory work.
2. That the laboratory work in physics be largely of a quantitative nature.
3. That careful notebook records of laboratory work in both physics and chemistry should be kept by the student at the time of the experiment.
4. That the laboratory work should have the personal supervision of the teacher at the laboratory desk.
5. That the laboratory record should form part of the test for admission to college and that the examination for the admission should be both experimental and either oral or written.
6. That a committee to consist of Mr. Fay and Mr. Krall have charge of making a list of 50 experiments in physics and 100 experiments in chemistry to be subject to the approval of the Conference. (National Education Association, 1893)

In order to implement the findings of the Committee of Ten, the Committee on College Entrance Requirements was established in 1895. Not only did this committee uphold the findings of the Committee of Ten on the importance of the laboratory experience in science but they went further and stated that the work in laboratory science should be done individually and with each student having his or her own equipment (Kliebard, 1995). Although this is an expensive endeavor, this stipulation was made in unison with the construction of additional school buildings. Laboratories became an integral part of the high school building blue print and the funding for these projects came directly from state taxes. New York became one of the leading states in this endeavor with the following conditions for high schools receiving the allotted state funding: (1) Provide laboratory facilities for individual experimentation (2) Teachers had to complete two years of laboratory science instruction to be eligible for state certification (Tyack & Ravitch, 2001).

The need for teacher preparation institutions increased as the need for knowledgeable science teachers increased. Summer programs aimed at instructing science teachers in the ways of conducting science laboratory experiments and equipment manipulation began to take hold and institutions quickly saw the benefit of the works of Edwin Hall, *Laboratory Manual of Physics*, Remsen, *A Laboratory Manual*, Eliot & Storer, *An Elementary Manual of Chemistry* and Cooke, *Laboratory Practice.* Supply companies also saw this as a golden opportunity and soon began to sell accompanying sets of equipment for each of the experiments in the more popularly purchased laboratory manuals (National Education Association, 1893).

Unfortunately, little emphasis was placed on how the students learned the content presented in these labs but there was an abundance of emphasis on the skills that were acquired through the laboratory experience. Students were expected to absorb the inductive reasoning behind each of these labs simply by carrying out the prescribed procedures (Rudolph, 2002). Between the years of 1890 and 1910 there was debate as to how the high school labs were to be introduced to the students as the number of high school students grew at an astronomical pace. Members of the Central Association for Science and Mathematics Teaching, including physicist Charles Mann, called for more dynamic and socially relevant experimentation. Thus a dichotomy existed and a tension between the two sides can be seen in the New York State Physics Regents. In 1890, the Physics Regents contained questions asking students to design laboratory experiments. By 1905 the new physics syllabus was so content heavy that there was no room for experimentation. Many schools eliminated the laboratory experience all together so that teachers had time to complete this extensive content. Advocates for the inclusion of the labs protested vehemently and in 1910, the New York State Board of Regents instituted a requirement of 30 double period laboratory experiments in the Physics Regents syllabus. (http://www.p12.nysed.gov/osa/hsgen/archive/rehistory.htm, 1987)

During the 1920s, the project method of teaching laboratory science became popular as a dynamic and impelling method of teaching an activity that is created by the individual student or a small group of students. First-hand experience in a real life situation was the key to the project method. It would now be seen as the constructivist method of teaching the laboratory portion of science but at the time it was considered to be inductive reasoning or no more than an educated guess. (Sheppard & Robbins, 2005) As the science content continued to grow exponentially, teachers found it difficult to create lists of projects for the ever increasing number of high school students that entered their classes. It was also a fruitless endeavor as the results of these quasi-experiments was already known.

The high school science laboratory remained as part of the curriculum even with these opposing tensions. Teachers, school buildings, scientific supply companies and leading scientists all advocated for the placement of the science lab in high school science education. In the ensuing decades there was an increasing emphasis on the practical goals and benefits of science in everyday life and the application of scientific knowledge (Singer, Hilton & Schwiengruber, 2006). Science education and the accompanying laboratory experiments and activities directly reflected these new social challenges. The Great Depression of the 1930s shifted the emphasis of science to agriculture and employment opportunities. Experiments in chemistry focused on metal plating and industrial topics such as the production of coke in the coal industry. Similarly, during the years of World War II, science experimentation reflected the real world application of metal corrosion and technology and seemed to add a more vocational slant to the science curriculum. This was in direct response to a more militaristic and defensive standpoint that was being felt in the United States. As with the curriculum and the textbooks, the impact of the socio-economics have a direct correlation on the science subject matter being taught and therefore the auxiliary components of the coursework such as the laboratory experience (Singer, et al., 2006).

Following the end of World War II, the "baby boomers" began to put an additional strain on an already burgeoning school system. Both physically and financially, the public school system in the United States was struggling to keep abreast of the increasingly growing population of high school aged students entering its doors. Again, the high school curriculum was under attack for being geared toward the social aspects of adolescent life at the expense of maintaining a rigorous educational foundation. A movement toward a more academic and less vocational curriculum was begun and this continued fluctuation came to a decisive head with the Soviet Union's launching of Sputnik in 1957. The outcry seemed unanimous and instantaneous; the United States had to move its science education agenda toward creating a new generation of engineers and scientists that would be capable of defending the nation from threats by other countries such as the Soviet Union (Singer, et al., 2006). With the support of the newly created National Science Foundation the work began in earnest. This brought about a new approach in using the laboratory experiments and activities in the lab. The laboratory was now seen as a way of thinking about science investigation as an intellectual process (Rudolph, 2002). Currently, the Committee on High School Laboratories defines the laboratory experience as follows:

> "Laboratory experiences provide opportunities for students to interact directly with the material world (or with data drawn from the material world) using the tools, data collection techniques, models and theories of science" (NSTA, 2010)

The New York City School Construction Authority is currently in the midst of "fitting every high school with science labs". In July of 2004, the plan was begun with these words from Deputy Chancellor Grimm: "The plan envisions not just brick and mortar but improving the educational environment in the classrooms through capital dollars". She also noted that at this time, there were over 100 high schools with the city of New York that operated without science labs. (*SCA Newsletter, 8/4/2004*).

The last time that there was such an emphasis in the New York City public schools was in the post-Sputnik era. (*National Defense Education Act of 1958*) This is also when the middle school policy was to keep the students through the ninth grade. At the time, this was done as a means of keeping costs down. It was much less expensive to build middle schools than high schools and retaining the students for an extra year on the middle school level was a cost-efficient move. Currently, there is also a need for laboratory facilities in middle schools.

The need for a laboratory on the high school level is imperative (Hofstein & Lunetta, 2004; NSTA, 2007). The New York State secondary school course requirements have changed and it is now a graduation requirement that all students successfully complete three years of study in science – one year in life science, one year in physical science and a third year in either life or physical science. Courses in Biology and related fields are considered life science courses and Chemistry, Physics Earth Science and similar courses are categorized as physical science courses. The laboratory in the science curriculum has a central role in science education.

Not only are laboratory activities NYSED (New York State Education Department) mandated, they are also essential for the inquiry based constructivist method of teaching the science to students (Atkins & Black, 2003).

The trademark of science is that all of its laws and theories have been developed through the tools of observation and discovery. The laboratory is a space that allows for this contextualized learning. It is assumed that when a student interacts physically with a problem or situation, he or she will be directly connected to the situation, understand the nature of the situation on a meta-cognitive level, and strive to problem-solve through natural curiosity (Hofstein & Lunetta, 2004; Dewey, 1910). There is no better venue for this type of education than the laboratory space in the school. Equipped with the paraphernalia that is associated with each of the science disciplines, the laboratory space provides the stage for the inquiry process to flourish. On a completely different note but one of equal importance is the issue of safety and the concerns for the students and teachers when working in chemistry education (NSTA, 2007; Singer, et al, 2006). Of all of the science disciplines, chemistry is arguably the most difficult to teach without the laboratory as a resource. In terms of safety, the use of chemicals must be conducted in a space that is meant for this purpose. A space that contains all of the safety requirements is not only mandated by law but also by common sense (Texley, 2005; Tamir, 1989). Unfortunately, in large urban areas, this may or may not be the case depending on a number of external factors which will be further explored in this study.

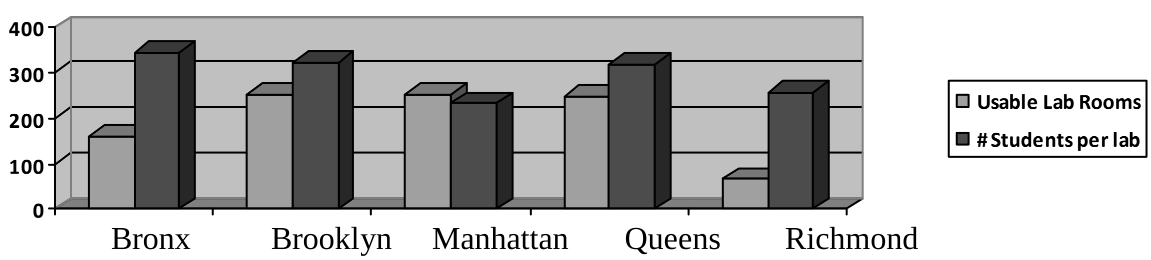
At present, the New York City School Construction Authority is in the midst of many laboratory construction projects. The scope of the work and where the work is situated is another concern in terms of the equitable nature of the sites selected. It is intended in this study that the data will support the hypothesis that various areas within the city are not receiving equitable facilities and this in turn has a detrimental effect on the quality and rigor of the education for those students attending schools in these geographic areas.

It can readily be seen in the chart below (Table 4) that the number of students per science laboratory facility is highest in the Bronx (330 students per lab space), next is Brooklyn (302 students per lab space), then Queens (296 students per lab space), Staten Island (254 students per lab space) and then Manhattan (222 students per lab space).

Table 4 – Number of Students Using Laboratory Space in NYC Schools by Borough (NYC School Construction Authority www.nycsca.org/, NYC School Facilities, http://www.opt-osfns.org/dsf

2009-2010 School Year	Bronx	Brooklyn	Manhattan	Queens	Richmond
High School Students	52,433	75,878	56,095	73,014	16,734
Demonstration Room (LE and ES)*	28	70	78	91	18
Laboratory (Chemistry, Physics)	131	181	175	156	48
Preparation Room - Lab Specialist[4]	45	96	57	85	15
Total Usable Lab Rooms	159	251	253	247	66
Number of Students per Demo/Lab	330	302	222	296	254

*LE is defined as Living Environment and ES is defined as Earth Science



Licensed Chemistry Teachers

One of the areas of interest in delving into the availability and entry to High School Chemistry in New York City is the category of highly qualified teachers. Predominantly poor and minority children are much less likely to be taught by science teachers who have degrees in their field and certification in their area (Ingersoll, 2001). Research shows that the most direct

[4] These rooms are not used for educational purposes by the student body. They are for the preparation and storage of scientific materials and equipment. (Ex. Chemicals, specimens, instrumentation)

route to increased students achievement is high-quality teaching (NSTA, 2005). High quality instruction has been found to matter more for student outcomes than student backgrounds (Darling-Hammond, 2010). The availability of qualified chemistry teachers is one of the major road blocks for ensuring equitable opportunities for access to chemistry in the New York City public high schools (Darling-Hammond, Holtzman, Gatlin & Heilig, 2005). One reason for the shortage of qualified chemistry teachers is the high turnover rate. Richard Ingersoll (2001) concluded that after three years, almost 30% of all beginning teachers leave the profession and this increased to 40% after 5 years. Of those who are trained to become teachers, two of five opt not to go into the profession. (NSTA, 2005).

One of the reasons given for this phenomenon is teacher dissatisfaction due to the lack of administrator support and the low pay. Teachers are more likely to remain at a school if there is a low teacher-student ratio, better equipment and resources and if they have a higher salary (Ingersoll, 2001). They enjoy teaching more if they have consistent professional support and development (Eick, 2002).

The areas of greatest need are science, mathematics and special education. This is not only true for the City of New York but nationally as well. In the report, *Rising Above the Gathering Storm*, (Committee on Science, Engineering and Public Policy, 2007) one of the key recommendations is to increase America's talent pool by vastly improving K-12 mathematics and science education. In order to do this a solid teaching force is needed in all high schools in the U.S. The No Child Left Behind (NCLB Act of Congress, 2001) definition for highly qualified teachers includes the following:

- Have completed a bachelor's degree
- Hold full State certification
- Pass rigorous subject content and pedagogy tests to demonstrate competence in assigned subject

- Middle and high school teachers may demonstrate competence in their assigned subject(s) by holding a degree major in the assigned subject

During the 2005-2006 school year[5], there were 29,522 teachers of Chemistry in the United States. Of those Chemistry teachers, 2,329 of them were teaching in schools in the State of New York. Of all of the teachers of Chemistry in the U.S., 88% were certified in Chemistry, and in New York State, 87% were certified. The number of certified teachers has increased but the high demand for teachers has kept the rate of certified teachers about the same or at a slight decrease. (CCSSO, 2007).

A major factor in the lack of increase in the number of certified teachers by state is the continued demand and the insufficient supply of well-prepared teachers. (CCSSO, 2009). Strategies for retaining qualified science and mathematics teachers include: implementing more effective discipline, giving teachers more autonomy and authority, high salaries, and reducing unnecessary paperwork and teacher workload. Attention to teacher quality and retention is essential, since the teacher is one of the most important factors in developing positive attitudes in science. (Brown, Anfara & Rooney, 2004: Barton, 2006; Darling–Hammond, 2010).
Below (Table 5) is a chart of the number of certified science teachers in the New York City high schools, 2008-2009 delineated by content area license and then further delineated by district (Table 6).

[5] This is the most recent national statistical information available. (CCSSO, 2007)

Table 5 – New York City public high school science teachers (2009-2010) certified by license: (New York State Testing and Accountability Reporting Tool, 2010) http://www.p12.nysed.gov/irs/pmf/2009-10/home.html

Biology	
Biology & Gen Science 7-12 (5020)	421
Bio Gr 5-9 (4014)	28
Bio Gr 7-12 (5010)	854
Biology and General Science (526B)	39
AP Sup Bio & General Science (AP20)	3
Bilingual Bio & Gen Science Spanish (676B)	1
Swd Biology 7-12 (9046)	5
Total Biology Teachers	**1351**
Chemistry	
Chemistry Gr 5-9 (4015)	4
Chemist & General Science 7-12 (5040)	119
Chemistry 7-12 (5030)	305
Chemistry and General Science (539B)	9
Total Chemistry Teachers	**437**
Earth Science	
Earth Science Curriculum Development Coordinator (EA38)	1
Earth Science (5070)	253
Earth Science and General Science (568B)	2
Earth Science 7-12 (5421)	1
Total Earth Science Teachers	**257**
Physics	
Physics & General Science 7-12 (5060)	68
Physics 7-12 (5050)	118
Physics and General Science (658B)	2
Lab Spec or Physical & General Science (6588)	2
Total Physics Teachers	**190**

Table 6 – Science Teachers by Discipline in each of the NYC School Districts – 2009-2010
(New York State Testing and Accountability Reporting Tool, 2010)
http://www.p12.nysed.gov/irs/pmf/2009-10/home.html)

District	**Biology**	**Chemistry**	**Earth Science**	**Physics**
District 1	16	3	1	3
District 2*	182	67	40	23
District 3	38	16	8	7
District 4	17	6	4	6
District 5	7	6	2	5
District 6	21	11	9	2
District 7	37	10	4	1
District 8	55	11	2	5
District 9	35	14	7	6
District 10*	89	36	10	18
District 11	44	11	6	5
District 12	32	8	1	3
District 13*	56	31	6	15
District 14	27	11	5	4
District 15	15	2	5	2
District 16	12	2	0	1
District 17	43	10	7	3
District 18	23	10	4	3
District 19	30	7	5	3
District 20	46	13	8	9
District 21	57	17	15	4
District 22	42	18	10	8
District 23	4	3	1	3
District 24	63	20	12	6
District 25	38	11	11	5
District 26	46	20	22	11
District 27	62	12	7	3
District 28	63	10	16	8
District 29	16	8	3	1
District 30	49	13	12	3
District 31*	72	18	9	12
District 32	14	2	5	2
All Districts	**1351**	**437**	**257**	**190**

***It should be noted that the numbers in certain districts are skewed because of the specialized high school located in that district.**

School Policy and Subject Choice

Secondary students' access to science can be determined by what courses are offered in their high schools (Council of the City of New York, 2005). The number of class sections in relation to school size is indicative of how much science is available and to what extent students are encouraged to enroll in these courses. The level of these courses demonstrates the rigor in science content, which can vary considerably from school to school. The existence of prerequisites also determines access to the higher level science such as chemistry. This can be in the form of required courses such as Biology (Living Environment) or Algebra, which are "entrance" courses and may prohibit certain tracks of students from having equal access to chemistry (Lynch, 2001). The career pathway of a particular student is often a judgment call by a school administrator or guidance counselor and this often determines course selection on the secondary level (Deil-Amen & DeLuca, 2010).

Racial disparities are common when it comes to access to advanced science in the secondary schools. Higher order content courses usually have a disproportionate share of White and Asian students (Maulucci, 2010), while Black and Hispanic students are relegated to lower level science classes, often not even reaching the point where they can take chemistry (National Center for Education Statistics, 2009) There is an under representation of diverse student populations in higher order science education and it is necessary to identify the underlying factors behind this inequity. The scarcity of students of color has previously been attributed to the rationale that students from these marginalized racial groups are lacking in the preparation necessary to move beyond the first level STEM courses (Anderson & Kim, 2006). By relying on this theory, the school has been taken out of the equation and so, lacks culpability. It is necessary that we confront the predisposition of educational institutions to reproduce minority student failure and disempowerment (Barton, 2006).

Another pitfall of some of the higher order science and mathematics coursework is the fact that the curriculum is necessarily scaffolded. The majority of the advanced mathematics and science courses are placed at the end of the sequence of courses taken by the students. However, in racially mixed schools, curriculum tracks are generally “color-coded”. Honor or advanced courses are reserved primarily for the White and Asian students while the lower tracks are disproportionately filled with students of color (Oakes, 2005). Even in schools where these courses are offered, most of the population does not get the opportunity to select these courses during their high school tenure. Students in the advanced programs not only come upon a larger quantity of curricular material but they are also asked to interpret the material in a different manner. Struggling students are guided to coursework that is less rigorous in order to achieve high school graduation and are not asked to think, investigate or create but merely to respond with rote precision. Due to educational policies that are in place, students are not challenged to pursue these classes which could increase their chances of attaining marketable skills and knowledge. As the proportion of science and engineering jobs requiring advanced degrees is increasing, (See Figure 1) the number of Americans in pursuit of appropriate degrees is in continuing decline, an almost inversely proportionate dilemma (Darling-Hammond, 2010). This can be said of most of the urban settings throughout the United States so although New York City is not the only urban area where this imbalance exists, it will serve as the prototype for this study in inequitable distribution of STEM education and more specifically, inequitable access to high school chemistry coursework.

Secondary schools exert control over who may take chemistry and whether it is offered at all for its students, and many factors are involved in this determination. Choices are constrained by what the school offers, what rules govern subject selection, and school schedule limitations. The master schedule is created by a school programmer and the choice of courses and their placement within the grid are determined well before the students preferences are considered. The goal of scheduling is to reduce major conflicts and challenges, which at times can disregard the educational needs of some the students. Also, there may be very few electives (chemistry is an elective more often than not), since limiting course offerings is a strategy for selective tracking to assure greater academic progress and to limit expenditure (Rivera Maulucci, 2010). The availability of qualified teachers in the content area is also one of the shortfalls as well. As can be seen in Table 7, there is a discrepancy among the districts between the number of certified chemistry teachers and the number of students in the chemistry courses.

The role of the guidance counselor is also critical in the determination of which students are selected for the more rigorous academic subjects. Counselors sometimes advise select students to avoid chemistry and other rigorous coursework in their course selection for fear of their getting poor grades (Smith, 2002). There is a need for guidance counselors and administrators to make more informed decisions when it comes to course selection so that underrepresented minorities are encouraged to pursue the sciences and mathematics. It has been found that an increase in pertinent information about college and career choices through guidance counseling significantly increases initial enrollment in 4 year postsecondary institutions, especially as affected by socioeconomic status in high school achievement (Plank & Jordan, 2001). Lack of communication in communities of color, coupled with the lack of trustworthy counseling on the high school level, can make a difference in curtailing talent loss, especially in male African American students (Muhammad, 2008).

Table 7 – Chemistry Teachers and Types of Chemistry with Enrollments
(New York State Testing and Accountability Reporting Tool)
http://www.p12.nysed.gov/irs/pmf/2009-10/home.html)

District	Chemistry Teachers	Regents Chemistry Students	Non-Regents Chemistry Students	Advanced Placement Chemistry	Total Chemistry Students
District 1	3	278	194	0	472
District 2	67	3,440	3,378	285	7,103
District 3	16	796	236	80	1,112
District 4	6	462	113	0	575
District 5	6	357	56	27	440
District 6	11	494	155	18	667
District 7	10	361	131	17	509
District 8	11	337	130	0	467
District 9	14	532	420	0	952
District 10	36	2,096	1,205	183	3,484
District 11	11	726	296	32	1,054
District 12	8	227	506	0	733
District 13	31	1,731	575	135	2,441
District 14	11	631	417	0	1,048
District 15	2	210	171	0	381
District 16	2	30	176	0	206
District 17	10	636	359	0	995
District 18	10	198	468	0	666
District 19	7	267	516	0	783
District 20	13	1,267	175	55	1,497
District 21	17	1,087	1,256	34	2,377
District 22	18	1,811	1,049	99	2,959
District 23	3	58	144	0	202
District 24	20	900	873	0	1,773
District 25	11	1,081	623	0	1,704
District 26	20	2,341	628	63	3,032
District 27	12	886	95	20	1,001
District 28	10	1,364	970	54	2,388
District 29	8	301	266	0	567
District 30	13	822	596	48	1,466
District 31	18	2,051	767	182	3,000
District 32	2	127	206	0	333
All Districts	**437**	**27,905**	**17,150**	**1,332**	**46,387**

Budget and Its Effects

Urban science education experience continues to be afflicted by inadequate resources. Outdated texts, unusable or nonexistent science labs, limited equipment and supplies and large class sizes are often the norm (Brown et al, 2004; Council of the City of New York, 2005).

Increased financial support is necessary to rectify students' access to the tools necessary to achieve success in science. By allocating additional money for resources, salaries, and training, the fair distribution of opportunities will increase positive outcomes that enhance social and economic justice (National Research Council, 2011) The State Supreme Court of New York agrees with this assertion. In 2006, after 13 years in the courts, the state's highest court delivered the case's final ruling. The Court of Appeals ruled that the state must provide its children with the opportunity for a sound basic education, defined as the "opportunity for a meaningful high school education, one which prepares them to function productively as civic participants." The court's rulings became legislation benefitting public school students throughout New York State: the Education Budget and Reform Act of 2007. The State was ordered to pay approximately $14 billion over 4-5 years to provide the opportunity for a sound, basic education for all the children of New York City (Campaign for Fiscal Equity vs. State of New York, 2006). This amount includes $5.3 billion in operating funds, phased in over four years, and $9.2 billion, phased in over five years, for capital improvements, which is intended for things such as reduced class sizes, computers & other technologies, and science laboratories, all of which will help improve urban students' access to quality science instruction and the adequate facilities necessary for scientific pursuits.

During the 2009–10 school year, the Department of Education's total budget was $21.9 billion, including $3.4 billion to pay pensions and interest on Capital Plan debt. The Department's $18.5 billion Operating Budget (the total budget less pension and debt service costs) includes funding for principals, teachers, textbooks and supplies. It covers the cost of standardized tests, after-school programs, school buses, heating and cooling for school buildings, safety, and school lunches. It pays for central administration and field support offices, which work with schools to provide support and help improve student achievement. The Operating Budget also pays for non-DOE costs, such as $1.3 billion for special education services provided at non-DOE "contract" schools; another $64 million for non-public schools, such as yeshivas and parochial schools; and $418 million for charter schools. The Department also has a Five-Year (2010-2014) Capital Plan Budget that includes $11.3 billion to cover costs associated with building new schools, renovating existing buildings, and investing in other new assets within school buildings. In the 2009–10 school year, approximately $9 billion of funding, not including most fringe and pension, resides in school budgets. Below is a listing of major categories of school allocations.

1. **Fair Student Funding:**

   Fair Student Funding (FSF) dollars – approximately $4.5 billion in the 2009-10 school year – are used by schools to cover basic instructional needs and are allocated to each school based on the number and need-level of students enrolled at that school. All money allocated through FSF can be used at the principals' discretion. [6]

2. **State and Federal Categorical** programs are restricted by the State or Federal governments on how they can be distributed and, in many cases, how they can be used by schools. They total approximately $2 billion. Examples include Title I (approximately $600 million), other federally-funded "Title" programs (e.g., Title III, Title II-A), IDEA, Universal Pre-K, and Attendance Improvement/Dropout Prevention.

3. **Contracts for Excellence Funds** come from the State as a result of their commitment to increase funding to New York City. These funds total approximately $600 million and

[6] Schools in District 75 and programs in District 79 are not funded via Fair Student Funding

must be allocated according to the State's methodology. The funds must also be spent by schools according to the City's Contract for Excellence with the State.

4. **Programmatic Allocations** go to internally restricted programs include City initiatives that remain outside of Fair Student Funding because of their unique structure or priority, like the parent coordinator initiative or new school start-up funds. The way these funds can be spent is often restricted.
5. **Related services funding** pays for mandated special education supports that supplement core classroom instruction services. These dollars are in addition to the funds special education students receive as part of the Fair Student Funding allocation. http://schools.nyc.gov/AboutUs/funding/default.htm

And so, it is with this contextualization, the work on the Access and Entrance into high school chemistry in New York City will be framed. The groundwork has been set as to the importance of this topic and the importance of this central science in the high school course choice for every young adult. It will be our commitment to all of our high school students, but especially our underserved and often neglected students that will determine the future success of the United States within the world economies and more importantly, the quality of life of the future citizens. Education is the lynch-pin that will open employment opportunities and thus the human capital of our current high school students. High level S.T.E.M. education will ensure employment opportunities leading to a better quality of life. This can only be realized by students who have at the very least, been offered the rudiments of higher order mathematics and science. Without this opportunity, ever-growing, highly salaried and socially advantageous career options are inaccessible to select populations.

Chapter 3 – Research Methodology

Introduction

Chapter 3 is intended to discuss the methods used to analyze the data that was gleaned for the research questions. The New York City public school system is a massive organization. The system has been reconfigured from its infrastructure down to all of the individual schools. At the time of this study, the No Child Left Behind Act (2001) introduced by President George W. Bush was in full swing. Many of the features of that Act were incorporated into the fiber of the educational systems that exist in the state, city and boroughs of New York. Those that will be addressed in this study are as follows

1. The emphasis on science as a core academic subject
2. Narrowing socio-economic and racial gaps by creating common expectations
3. Ensuring highly qualified and effective teachers for all students
4. High Standards for Every Student in Every State
5. Ensuring High Schools Prepare Students for College and the Workplace

The purpose of this study was to determine quantitatively the impact of various school characteristics on access to and enrollment in high school chemistry and to identify the factors that may contribute to the inequities in high school education, specifically S.T.E.M. education.. Examination of the importance of citizen science or the need for technologically and scientifically literate citizenry will be addressed. The critical piece to this conundrum is the access that our students have to coursework that leads to the acquisition of this science knowledge. Although this is a complex series of mathematics, science, engineering and technology courses and exposure to content in each of those areas, the focus will be New York City students' access to and enrollment in secondary chemistry. The context through which this issue will be examined is the restructuring and accountability initiatives that have been underway in New York City public high schools (Herszenhorn, 2007). The enrollment figures were collected for all of the high schools in the thirty-two school districts within New York City (nyStart, 2011). Various school characteristics, organizational variables and district specific data will provide a lens through which inequities in access can be explored. Each of the research questions will be examined as follows:

Research Questions

With a focus on the critical area of Chemistry,

1. What is the relationship between school characteristics and chemistry access/enrollment in the New York City public high schools?

    a. How does the chemistry enrollment in NYC compare to the state enrollments, overall, by borough and by neighborhood?

    b. Are there statistical correlations between chemistry access and socioeconomic factors such as racial status (Black, Hispanic, White, Asian, Other) and/or financial status (percentage of free lunch students)?

    c. Are there statistical correlations between chemistry access and systemic factors such as school size and expense per student?

    d. Are there statistically significant correlations between chemistry access and the availability of science laboratory facilities in the schools?

2. What role does geographic location play in the access to chemistry in high school as measured by a correlation between the socio-economic status of the district in which the school is located and the access to chemistry and S.T.E.M. content courses?

3. What issues of social justice can be identified through this study and those like it and can and will any of these have an effect on secondary school policy in New York City, New York State and/or the nation?

Setting for this Study

In 2002 Mayor Michael Bloomberg gained control of the New York City public school system. He used his authority to reorganize the zoning of the schools. This was accomplished in 2003 by converting the then thirty-two school districts into ten geographic regions. In 2005, several of the schools joined the Autonomous Zone (later referred to as the Empowerment Zone) which was spearheaded by Eric Nadelstern. These schools became autonomous and the principals of these schools had the freedom or power to make major decisions for their schools which also came with responsibility and culpability for these decisions. This gave the schools the power to be released from their region but not from the rules and regulations which were imparted by the New York State Department of Education.

In 2007, Mayor Bloomberg and Chancellor Klein announced that the regions were to be dissolved and the school system was again going to be reorganized. The new configuration for the schools was called School Support Organizations and for the first time in the history of the school system of New York City, schools would not be supported based on geographic proximity, but rather by self-selection in one of the school support organizations. This was the configuration of the schools during the period when this research was conducted. (See Table 8)

Table 8 - New York City Department of Education Organizational Schema
(New York City Department of Education, 2010) http://schools.nyc.gov/default.htm
School Year 2009 - 2010

% of Schools in the NYCDOE	Category	School Support Organization
36%	ESO*	Empowerment
24%	LSO*	Integrated Curriculum & Instruction
11%	LSO	Community Support Organization
9%	LSO	Leadership Support Organization
6%	LSO	Knowledge Network
5%	PSO*	New Visions for Public Schools
5%	PSO	CEI – PEA
1%	PSO	CUNY
1%	PSO	Fordham University
1%	PSO	Academy for Educational Development

*ESO = Empowerment Support Organization
*LSO = Learning Support Organization
*PSO = Partnership Support Organization

- The Empowerment Support Organization was headed by Eric Nadelstern. Initially, schools were given $150,000 additional funds to be autonomous. The cost per school then went to $29,500 per year for the support from the network team who visited the schools directly and offered support. http://schools.nyc.gov/Offices/Empowerment/default.htm

- The Community Support Organization was initially headed by Marcia Lyles and the key services that they provided to their schools was accountability and instructional support, special needs support, youth development support, organization and professional development support and community services. This organization had three purchasing plans for the schools. The basic package was $33,750 and offered support of school leaders, the premium package, at $39,850 offered the professional development opportunities and support of school leaders, and the elite package at $66,675 per year offered a dedicated school-wide achievement team and the other offerings that came with the less expensive plan.

- The Integrated Curriculum and Instruction Support Organization was lead by Judy Chin and this organization was partnered with several service providers to the NYC Department of Education. Some of these were America's Choice, AUSSIE, CCNY Math/Science, Heart of Change, Mondo Professional Development, Reading Recovery, Schools Attuned Enrichment Model, Sopris West Educational Services, Teachers' college Reading & Writing Program, the UFT Teachers' Center and the Wilson Reading System. The price per school was $47,500 and included the above services (additional cost for some of them) and four seats at the Integrated Curriculum and Instruction institutes. www.icilso.org

- The Knowledge Network Support Organization was lead by Dr. Kathleen Cashin and this organization offered the following services: individual support and services for principals, a Principals' Institute, Core Knowledge Foundation Leadership Training, Professional Development from the UFT Teachers' Center, onsite support from the liaisons in the field, consultation in school and students data analysis, CEP development, analysis of high school cohort data, test sophistication, preparation for the Quality Review and Progress Report Analysis. The price per school per year was $42,438 base plus $10.00 per student for the Core Knowledge fee. www.knowledgenetworklso.org

- Leadership Learning Support Organization was lead by Laura Rodriguez and for a fee of $55,000 that was all inclusive, school would get the following: Customized, direct school support through three staff structures: Network Teams, Content Specific Team and Core Leadership Team. There was also specialized support for middle and high schools for Regents Readiness, fulfilling graduation requirements, College and Career Advisement, Conflict Resolution, Peer Mediation and Student Advisory. www.llsso.org

Table 9 – Breakdown of the schools by grade in each of the SSOs
(New York City Department of Education, 2010**)** http://schools.nyc.gov/default.htm

SSO	JHS IHS	HS*	Secondary*	K-12	K-8	Total
Academy for Educational Development	10					10
Center for Educational Innovation - Public Education Association	25	3	1		4	33
Charter	4	3	4	6	13	30
CUNY - Center for School Support and Success	1	4	7			12
Community LSO	34	31	8	30	9	112
District 75		6	9	29	6	50
Empowerment	73	147	41	1	37	299
Fordham University	4	2				6
Integrated Curriculum and Instruction LSO	57	54	6	2	24	143
Knowledge LSO	21	9	3		21	54
Leadership LSO	31	21	3		9	64
New Visions	3	45	9		4	61
Replication	2	5	1			8
	265	**330**	**92**	**68**	**127**	**882**

**High School is defined here as Grades 9-12; Secondary School as Grades 6-12*

As can be seen in Table 9, the Empowerment School Support Organization had the largest number of schools under its umbrella and in fact, over 44.5% of the high schools at the time, selected the Empowerment SSO as their support organization.

In the 2010-11 school year, the New York City public school system reorganized into a new formation which again, has no geographic continuity. Schools self-selected to be in clusters which are further sub-divided into networks. These are the two divisions that grew from the school support organizations. Currently there are five clusters and approximately 60 networks – each of the networks has a total of 20-25 schools. In this reorganization, each of the networks is self-supporting and has one to two instructional leaders to support the work done in the schools within that particular network. Since this configuration was created after the time period of this study, it will not be mentioned again in this dissertation.

As part of New York City's Children First New Schools Initiative, Chancellor Joel Klein and Mayor Michael Bloomberg devoted resources towards creating a fleet of new small secondary and high schools intended to replace and improve the city's larger comprehensive schools. The goal was to create 200 new smaller schools with enrollments under 600 students. These schools were designed to incorporate best practices in school design to provide rigorous, high quality education to students in traditionally underserved areas of the city (Haycock, 2001; Iatarola, 2005; Ilg & Massucci, 2003). Behind the small schools initiative was the notion that small, more autonomous schools would be more inviting, safe and personal spaces where students would be challenged by high-level rigorous curriculum (New York City Department of Education, 2009).

Many of the schools coexisted with other large high schools (See Figures 9a – 9c), therefore, part of this reform involved restructuring the design of the traditional comprehensive high school to accommodate shared space and services (such as cafeteria, gymnasiums, libraries). Consequently, additional funding was being provided to schools that housed a new small school program to ease these transitions. Financial support was also being given to the large high schools that were hosting small school campuses for new educational programs and collaborative efforts between the schools. As a result, some large schools had to close down or downsize in order to compensate for loss in enrollment or space for the new programs (Overby, 2003). Additional supports were also allocated to the small schools to help ensure success, such as the addition of the Office of Small Learning Communities.

http://schools.nyc.gov/ChoicesEnrollment/SpecialPrograms/SLC/default.htm

Selection of the Schools for Inclusion

A snapshot of the Chemistry enrollment was taken, using the 2009-2010 school year as a lens with which to view this possible imbalance in science education. During the 2009-2010 academic year, there were 503 secondary schools which were composed of grades 9 – 12 or some part of that four year combination. For this study, the following criteria were used to identify the high schools in the study:

1. Each of the schools must serve the general high school population of students

2. Each of the schools must have all four of the high school years populated – Grades 9, 10, 11 and 12. This includes the schools that are currently being phased in or phased out.

Of the 503 high schools that were initially included, 358 did meet the above specifications and were included in the data sets. Included are the Career and Technical Education Schools (CTE). Although these have been omitted from other studies, the students who attend these schools have the same graduation requirements as the general education students and therefore are a part of this study. This represents 71.2% of all public high schools in the city of New York. High schools that were omitted from this study were removed due to the following reasons:

1. Incomplete Cohorts of Students: Twenty-eight high schools did not have the full cadre of students needed for this study. As schools are initiated, most begin with the grade nine students and then add grade levels as the students move from grade level to grade level. Similarly, as schools are closed or phased out, new freshman classes are not opened and so a school begins a close out year with grades 10, 11 and 12 and loses a grade each succeeding year. http://schools.nyc.gov/community/planning/changes/default.htm

2. Transfer schools: Created for students who are having a difficult time in completing high school via the traditional pathway. Alternative Schools and Programs cover a plethora of educational configurations. In addition to the site that is designated by the District code 79, there are alternative academic options that can be explored at Referral Centers throughout the city. These programs include but are not limited to: GED plus, Phoenix Academy, Access, Learn to Work, Co-op Tech, Re-Start and LYFE. http://schools.nyc.gov/Offices/District79/SchoolsProgramsServices/default.htm

3. District 75 schools: Provide citywide educational, vocational and behavior support programs for students who are on the autism spectrum, have significant cognitive delays, are severely emotionally challenged, sensory impaired and/or multiply disabled. District 75 consists of 56 school organizations, home and hospital instruction and vision and hearing services. http://schools.nyc.gov/Offices/District75/default.htm

4. Specialized High Schools: There are nine specialized high schools in NYC during the period in which this study was based. For eight of these schools, admission is based solely on the score attained on the Specialized High School Admissions Test (SHSAT). They are the Bronx High School of Science (District #10), The Brooklyn Latin School (District #14), Brooklyn Tech High School (District #13), The High School for Math, Science and Engineering @ CCNY (District #5), The High School of American Studies @ Lehman (District #10), Queens High School of Science @ York (District #28), Staten Island Tech High School (District #31) and Stuyvesant High School (District #2). The ninth specialized school, Fiorello LaGuardia High School of Music & Art and Performing Arts bases student admission on academic record review as well as an

audition.

http://schools.nyc.gov/ChoicesEnrollment/Middle/SHSI/Specialized+High+Schools+Insititue+Publications.htm

5. Charter Schools: These schools are publicly funded and open to all students in New York City through a non-discriminatory admissions lottery. Each charter school is governed by a not-for-profit board of trustees which may include educators, community members, and leaders from the private sector. Charters have freedom to establish their own policies, design their own educational program, and manage their human and financial resources. Charter schools are accountable, through the terms of a five-year performance contract, for high student achievement. www.schools.nyc.gov/choicesenrollment/high/default.htm

Each of these schools is designed for special populations and therefore may not have the typical course offerings found in schools that are attended by the general education students in the New York City public schools. Of these remaining 358 high schools with general education populations, eighty-seven do not offer Regents Chemistry. Of these eighty-seven schools, all but three are designed on the small school model which is prevalent in the most troubled districts within New York City (Monk & Haler, 1993; Overby, 2003).

Through the reorganization of schools which began in earnest with mayoral control of the schools in 2002, a variety of school models were introduced. Although there were small schools established in the past, this transformation was on a much larger scale than ever undertaken before. Before this movement, a New York City public high school student oft times went to his or her zoned school. The zoned schools were located in the child's home community and were composed of thousands of students. The transition of approximately twenty-three large schools into almost two hundred new small schools took nearly a decade to achieve (Quintet al., 2010).

The impact of these drastic changes to the high school curriculum in terms of course offerings in the advanced science content areas will be explored.

In total, there were 252,690 (NY Start, 2010) students in the New York public high school grades 9 – 12 during the 2009-2010 school year. Although the number of students varies between the New York City (274,154 student) www.schools.nyc.gov/aboutus/data/stats/default.htm) and New York State (www.nystart.gov/nystart/u/index.do) reports, the percentages of high school students in each of the boroughs remains the same for the 2009-2010 school year [20% - Manhattan, 19% - Bronx, 28% Brooklyn, 27% - Queens and 5.5% - Staten Island]. A further breakdown of the percentages by district will be presented (See Table 12). This study is focused on the students who were in chemistry classes in the general population public high schools. There were many variations of chemistry offered in schools during this school year and so an analysis of the number of students in each variety was examined.

At the time of this study, the New York City Department of Education had not only begun to restructure individual schools in an effort at reform, the entire structure of the Department of Education was being revamped (Herszenhorn, 2007). As such, the thirty-two school districts that composed the New York City public school system were dissolved and in their place, school support organizations were created (See Table 9). These support organizations were centered on specific themes and schools were asked to select the organization to which they wanted to be affiliated. The school support organizations did not have any geographical requisites and therefore, any school could become part of any school support organization for a fee. The New York State Department of Education did not recognize these school support organizations or SSOs, and retained and continues to retain the 32 districts. Data was collected for the 2009-2010 school year. Since then, the New York City Department of Education has again restructured and replaced the SSOs with Children First Networks. These are grouped into six major clusters (Wong, Sproul & Kasok, 2008). This reorganization is not included because it was begun after the dates of this study. These city-made structures do not lend themselves to the type of information needed by this study and so the districts will be used to delineate the data so that a clear picture of social-economic areas and the rigor of the science offerings can be compared and analyzed.

The first sets of comparisons conducted on this information were between and among enrollments among the districts, boroughs and city. The rationale for selecting school districts was because the majority of the data was disseminated by school district. This presented baseline data for the access to high school chemistry within the city and the five major geographic divisions, known as the boroughs of New York City. These were in turn compared to the access of chemistry to all high school students in the State of New York (NY Start, 2011). (See Table 11) This presented baseline data for each of the geographic areas. The additional data set of poverty level was superimposed on the actual geographic area so that a more developed view of environmental characteristics could be seen (U.S. Census Bureau, 2010; The Community Service Society of New York, 2009). (See Tables 10 and 12) This data set was then used as the identifying marker for all further comparisons made in this study.

Examined first were the variables that correlated to the access and enrollment in high school chemistry courses. Schools were categorized according to location by borough and then school district. The school district was then mapped onto the geographic district (59 in total) as defined by the New York City Department of Planning www.nyc.gov/html/dcp/html/neighbor/neigh.shtml. Although the geographic districts were used for a variety of indicators such as poverty level, the school districts were chosen as the preferred data set as the thirty-two school districts supplied more of the information needed for this particular study. The fifty-nine geographic districts in New York City were a secondary source of data collection. (See Table 10)

Chemistry courses accessible to the high school students in New York City were seen as being of three different varieties. Although secondary chemistry is seen as a rigorous course offering, there are several variations of offerings that can cover a range of interest and ability levels. For this reason, Chemistry was then divided into three sub-sections: General Chemistry, which included any courses that did not necessarily meet the chemistry core standards needed to be coded[7] as a Regents Chemistry course, Regents Chemistry courses and Advanced Placement Chemistry courses[8]. (See Tables 21-23)

The variables used to compare these schools and chemistry courses were geographic, socio-economic and administrative. The first set of variables consisted of factors that are independent. The socio-economic factors included: racial composition, percentage of free lunch eligibility and percentage of English language learners. (See Tables 17 and 18) The next set of variables were considered to be controlled centrally by the New York City Department of Education and included administrative factors such as the school size, (See Table 14) expenditure per student at the school level, number of licensed teachers at the school and the laboratory facilities in the school. An additional outcome variable used was the dependent indictors of academic achievement. (See Table 13) The four-year graduation rate, attendance rate and percentage of over-aged students were all analyzed for each of the districts in the City of

[7] NYS Chemistry Core course must cover the core curriculum mandated by NYSED as well as having the students meet the minimum laboratory requirements of 1200 minutes of laboratory seat time accompanied by written laboratory reports that meet minimum satisfactory ratings.
[8] Advanced Placement Chemistry courses are specifically those that have met the requirements set forth by the College Board.

New York and comparisons were made between these factors and the poverty level of the district.

Next, the reorganization of schools was addressed, noting the districts and boroughs where these changes had been made. A correlation of the socioeconomic profile of those districts was superimposed on the affected schools in the districts. The first of the issues with the reorganization of the schools is their geographic location. High schools in the less affluent socio-economic areas were slated to be dissolved and in their place, several smaller themed high schools were organized. Many of these smaller schools offer fewer courses for a number of reasons, not the least of which is their smaller sized faculty and smaller and varied facilities in which to run a school. (See Table 15) The placement of several small schools within a building which once held a large high school causes duplication in the number of administrative offices needed and the shared common space dilemma. Often lunch periods, laboratories and gymnasium facilities must be staggered to accommodate the numerous school schedules and the laboratory and gymnasium facilities fall into the same purview. If schools that occupy shared space do not work in tandem, schedules for the changing of class and school rules and regulations can vary, sometimes causing dissent among the various school communities (Council for the City of New York, 2005: Bloomfield, 2009).

Next, the public secondary schools within New York City were compared on the basis of schools that offered chemistry and those that did not have chemistry offered at their schools. (See Tables 18 and 19) High school science diploma requirements in the State of New York require that all students take a three year sequence composed of at least one year of physical science, one year of life science and the third in either a physical or life science. As previously mentioned the life science courses are in the area of biology and the physical science courses are composed of

chemistry, physics or earth science course. Only one of these courses must meet the NYS Core Curriculum Standards and laboratory requirements. The majority of schools choose Living Environment (Biology) or Earth Science as their gatekeeper because these are considered less rigorous, have a lower cut score for a passing grade and have been historically proven to be the assessments that many of the students can attain as part of their graduation requirement (NYSED High School Regulations 100) http://www.p12.nysed.gov/part100/pages/1005.html However, schools have the option of then offering non-core science courses to complete the three year sequence mentioned above. These courses can be as rigorous as Advance Placement Sciences such as A.P. Biology, A.P. Chemistry or AP. Physics. Each of these courses must have curriculum approval by the College Board to be designated as such.
http://apcentral.collegeboard.com/apc/public/repository/ap08_chemistry_coursedesc.pdf

Alternatively, courses can be non-core and fall into the less academically challenging category. Some, but not all of the environmental science and forensics courses that are offered as secondary level science courses, are questionable. And although there are New York State Science Standards that serve as guidelines for non-Regents high school science courses, the course syllabus in science is not monitored centrally in the New York City Department of Education. This coupled with the autonomy given to the principals leads to a vast spectrum of science electives and degrees of rigor in these courses.

Under the Children First Initiative which was launched in the spring of 2003, schools in New York City were deemed autonomous but with accountability (Wong, et al, 2008). Principals were given the ability of selecting the curriculum for their schools among other things but were also to be held accountable for the success or failure of their schools. The success was to be determined through the use of the Progress Report, Quality Review, Learning Environment

Survey and the Annual School Report Card issued yearly for each of the 1,619 schools in the city. Principals are not only rated by the information found in these reports, but they are also given financial incentives for major successes and possible removal and the threat of the school being closed for continued failure. Since Student Progress (60%) [Timely promotion of cohort to the next grade level] and Student Performance (25%) [Number of Regents examinations passed] accounts for 85% of the School Progress Report, it is a considerable motivator for the principal of the school. Methods of maintaining or increasing the score on the progress report could include offering less rigorous coursework to the students. The motivator is that students earn 10+ credits per year more readily if the coursework is less demanding.

Research Method for Data Collection

Initially, the data collection for this study involved systems that were not privy to the general public. However, the data needed to complete the questions posed in this study and the resulting analysis of the data were all available through publicly accessed sites. The sites used and the information obtained at each of these sites can be found below:

1. National Center for Educational Statistics - http://nces.ed.gov/
    a. New York State Secondary School totals
    b. National Secondary School Chemistry enrollment
2. The New York State Testing and Accountability Reporting Tool - www.nystart.gov
    a. Regents examination totals per school, district, city and state
    b. School size for each of the high schools and secondary schools
    c. Schools that do not offer any Regents Chemistry by School and District
3. The New York State Education Department Information Reporting and Technology Services for K-12 Schools – www.p12.nysed.gov/irs/pmf/2009-10/home.html
    a. Distribution of Classroom Teachers by Degree Status
    b. Distribution of Classroom Teachers by Certification Status

c. Course Code Registration by District

4. The New York City Department of Education – www.nycdoe.gov

    a. Total High School population for each borough, district and school

    b. Demographic information by borough, district and school

    c. Four year graduation rate for each high school

    d. Percentage of English Language Learners by borough, district and school

    e. Percentage of Free Lunch students by borough, district and school

    f. Per students expenditure by school

    g. Attendance rate by borough, district and school

    h. Percentage of over-aged students in the high school by school

5. The New York City Department of City Planning – www.nyc.gov/html/dcp/html/neigh_info/nhmap.shtml

    a. The mapping of the fifty-nine geographic districts in New York City

    b. The poverty level in each of the geographic districts in New York City

    c. The total population in each of the geographic districts in New York City

    d. The demographic composition of each of the geographic districts in New York City

It was decided that the data would be collected in terms of the thirty-two school districts in New York City rather than the city-defined geographic district. These required additional calculations as there are fifty-nine geographic districts in New York City. Each of the school districts was superimposed on the geographic districts of New York City. Sections of the geographic districts were then assigned to the school districts. For example, School District #2 actually encompasses Community Geographic Districts #1, #2, #4, #5, #6 & #8. Therefore the total populations of these geographic districts was considered and then the poverty rate per capita for those districts was used to determine the closest approximation of the poverty level for School District #2. Each of the community districts within the school district was divided by the total population of all of the community districts within that school district. The percentage taken from this calculation was then used to determine the poverty level percentage for that fraction of the school district total. The totals of all of the fractional portions were then added together to get a more accurate picture of the average poverty level in the school district. For example:

$$\frac{\text{Community School District \#1 Total Population} \times \text{\% Poverty Level}}{\text{Community School Districts \#1, 2, 4, 5, 8 Total Population}} = \text{Fractional Portion}$$

This calculation was then repeated for Community District #2, #4, #5 and #8 and the total of those fractional portions was computed. The procedure was repeated for each of the school districts composed of more than one community district (See Table 10).

Table 10 - Poverty Level in Each Geographic Area of New York City, 2009-2010 School Year (New York City Department of City Planning, 2010) http://www.nyc.gov/html/dcp/

Borough	Community District	School District	Total Population	Poverty Level
Manhattan	3	1	164,550	50.0%
Manhattan	1,2,4,5,6,8	2	611,549	8.9%
Manhattan	7	3	208,267	12.0%
Manhattan	11	4	117,671	46.5%
Manhattan	10	5	107,007	43.3%
Manhattan	9,12	6	320,409	40.9%
Bronx	1	7	82,109	65.0%
Bronx	2,9,10	8	337,148	42.2%
Bronx	4	9	139,611	59.7%
Bronx	5,6,7,8	10	446,807	49.0%
Bronx	11,12	11	259,918	35.7%
Bronx	3	12	68,525	66.7%
Brooklyn	2,3	13	242,684	35.0%
Brooklyn	1	14	160,376	43.9%
Brooklyn	6,7	15	223,754	36.2%
Brooklyn	3	16	143,970	46.1%
Brooklyn	8,9	17	200,018	37.8%
Brooklyn	17	18	165,843	34.3%
Brooklyn	5	19	173,208	50.5%
Brooklyn	10,11,12	20	479,819	45.9%
Brooklyn	13	21	106,082	45.1%
Brooklyn	14,15,18	22	523,690	32.9%
Brooklyn	16	23	85,412	51.9%
Queens	2,4,5	24	442,939	36.5%
Queens	7,8	25	390,074	33.3%
Queens	11	26	116,209	17.7%
Queens	9,10,14	27	374,833	35.6%
Queens	6	28	116,068	20.7%
Queens	12,13	29	419,964	29.7%
Queens	1,3	30	380,365	33.5%
Staten Island	1,2,3	31	452,987	22.3%
Brooklyn	4	32	104,310	51.6%

Chemistry enrollment was determined using the National Center for Educational Statistics (http://nces.ed.gov/) for the total number of high school students nationally and for the percentage of those students in Chemistry classes. This site also supplied the ethnic percentages of high school students nationally. The National Center for Educational Statistics only had actual data up until the year 2006 and so is included in the narrative but not in the actual statistical analysis. The data for the State, City, Borough and District Chemistry students was collected from the New York State and New York City sites listed above. These percentages are used as a comparative measure to assess potential inequities in New York City's high school chemistry enrollment in comparison to high school chemistry enrollments throughout the State of New York (See Table 11). Although it will be seen that there is a difference on the city and borough level, the major inequities will be seen on the district level (See Table 10) where there is a clearer delineation of the poverty level by neighborhoods throughout the city of New York.

The next determination that was made was whether or not a public high school in New York City met the criteria for inclusion. As stated before, schools that serve the general high school aged population and contained all four of the high school grades were included. These schools were then categorized by enrollment size. Small high schools were defined as having enrollments of 1-499 students, medium schools having enrollments of 500-1499 students and large high schools having enrollments of 1,500+ (Lee, Smerdon, Alfeld-Liro, Brown, 2000). After the schools were grouped by size, (See Table 15) descriptive statistics were generated and analyzed statistically using SPSS software to determine if school size was a contributing variable.

Next, schools were grouped by borough and district to analyze differences in chemistry availability geographically. Data on ethnic composition and socioeconomic status of the population in the specific school district was mapped onto the chemistry availability in the schools in that district and a statistical analysis was made. (See Figure 11) Further, the types of chemistry offered were also considered in this analysis to see if there was any disparity in the rigor of the chemistry offerings and the ethnic or socioeconomic make-up of the population in that district. (See Figures 15 -18)

School districts were further analyzed to determine if there was a causal relationship between the number of chemistry licensed teachers in the district and the availability of chemistry in the districts. (See Figure 22) New York State requirements mandate that Regents Chemistry be taught by a Chemistry licensed teacher. This was also reinforced by the NCLB policy enacted at the national level. However, New York City has been granted waivers in this area because it would be nearly impossible to have a Chemistry certified teacher in every Chemistry classroom in the city. The full programs given to teachers must include five units. Each of these units is a class that meets 200 minutes per week as per the New York State regulations. In the majority of city high schools, Living Environment and/or Earth Science is the science course taken by 9^{th} graders. Since there are more 9^{th} graders in the high schools than any other group of students, licensed Biology and Earth Science teachers are more abundant than Chemistry or Physics teachers (see Tables 5 and 6). Often, biology and earth science teachers are required to teach sections of chemistry and/or physics to fill out their five units. Thus, these chemistry courses are taught by licensed science teachers but not necessarily chemistry licensed teachers. This analysis was conducted to determine if the “highly qualified teacher” requirement had any effect on the chemistry enrollment in a school district or the types of chemistry that were offered in that district. Although causality is difficult to determine by the relationship between these two variables, an argument for this cause and effect will be presented later in this study.

Multivariate correlation was used to study the statistical correlations between chemistry access and the organizational variables of school size, expenditure per student at the school level, number of licensed teachers at the school and the laboratory facilities in the school. (See Figure 13) A geographic area's poverty level was defined as the independent variable upon which the organizational variables will be computed. A two-tailed Pearson correlation was applied and significant differences based on a confidence level of 95% ($p < .05$) were identified.

The variety of chemistry course offerings were charted to establish the accessibility of any and all high school Chemistry courses in a particular district. While Regents Chemistry is the prevalent course offering, the other levels of this content area will be explored for access by students. Both Non-Regents Chemistry courses and Advanced Placement Chemistry courses were compared along with Regents Chemistry to determine access in the various school districts in the city. (See Figures 14-18) These three levels of Chemistry complexity were analyzed to see if there is a correlation between the percentages of students in these courses and the poverty level and demographics of the geographic areas. The levels of chemistry represent the dependent variable and the school size and geographic location represent the independent variable. Codes were assigned for each level (1 for Non-Regents, 2 for Regents and Honors Chemistry, and 3 for AP Chemistry). Bivariate and multivariate correlations were used to compare schools that offer any or all types of chemistry with schools that did not offer chemistry. School size along with geographic location were variables that will factor into this testing. School size was coded as (1 = small schools of 1 – 499, 2 = medium schools of 500-1499 and 3 = large schools of 1,500 students or more).

The final portion of this research is focused on teacher qualification and school facilities. (See Figure 22) Ensuring highly qualified and effective teachers for all students is a statement taken directly from the No Child Left Behind legislature. Attention was given to both the quantity and quality of the chemistry course offerings in the different districts in the city. This was compared to the number of New York State certified Chemistry teachers in that district. Although certification in the content area is only one of a number of parameters when considering “highly-qualified”, this is the only measurement that can be concretely defined and quantified. The percentage of teachers certified in chemistry was analyzed for potential implications regarding the quality of chemistry offerings in New York City high schools, and whether or not the availability of certified teachers affected a school’s ability to offer chemistry as an option for students. In addition, the number of laboratory rooms dedicated to the instruction of science was noted in each school and then for each district. (See Figure 13) Although laboratory space is usually shared space in the sciences, rooms that are considered “full laboratories” have the elements needed when offering chemistry courses. Because of the nature of chemistry, a prep room for the making of solutions is needed as well as showerheads for safety and gas jets for Bunsen burner use. These particular labs were counted and this provided an additional quantifiable variable that was analyzed through linear correlation with chemistry offerings. Causality is speculative but a defendable argument will be presented given the findings.

Research Design

The purpose of this study was to determine quantitatively the impact of various school characteristics on access to and enrollment in high school chemistry. Mixed methodology was used in the form of surveys, interviews and data analysis to form a triangulation or cross examination of the results of this investigation. Triangulation is a powerful technique that facilitates validation of data through cross verification from more than two sources. In particular, it refers to the application and combination of several research methodologies in the study of the same phenomenon. (Johnson & Onwuegbuzie, 2004).

The primary research methods for this study were the quantitative descriptive study and correlation research. These methods are referred to in some textbooks as non-experimental methods because variables are not manipulated. (McMillan, 2004). Correlation research was used to describe relationships between several sets of data. Predictions were then made based on the relationships that exist. Multivariate correlations were then correlated to create bivariate and multivariate correlation matrices. The Pearson Product moment coefficient (Pearson *r*) was calculated using SPSS Software. A positive Pearson *r* indicates the relationship between the sets of data are directly proportional, an inverse Pearson *r* indicates the relationship between the data sets is inversely proportional and a Pearson *r* value of zero means that there is no relationship between the data. As the values move closer to +1.00 or -1.00, there is a stronger correlation between the data sets. This relationship may or may not mean causality but it is a strong argument that the data is related, possibly as a cause and effect relationship. For this study, the magnitude of the relationship must be statistically significant at the 0.05 level. Descriptive studies were then done using the results of the correlation research. Generalizations were made based on the numerical findings and an argument for the inclusion of chemistry in the more disadvantaged socioeconomic areas of the city was supported by these statistical relationships. Descriptive statistics were also used to analyze differences between schools that offered chemistry courses and those that do not. Also, multivariable analysis was used to study the interrelations among the variables, drawing inferences about school characteristics that are relevant to the research questions (Picciano, 2007).

Survey Design

Since the information about schools that offer chemistry can be gathered from the data bases listed, survey design was used to collect data from individual New York City high schools that do not offer any chemistry coursework. (See Appendix A) This survey included questions on the types of science courses offered at the school, the sequencing of science courses within the school, whether the category for the course(s) is physical science or life science, timeframe for the laboratory section of the course, grade level of the students in the course and the certification level of the teachers of these science courses. A portion of the survey was devoted to a free write by the principal or the assistant principal assigned to science as to the reasoning behind not offering high school chemistry. The survey was developed with input from several school science supervisors and teachers to improve clarity in item construction. Selected-response items were included for analysis, and school representatives were invited to provide additional comments, if desired. All necessary modifications were made to keep this survey to a one-page length to help to ensure a high percentage response rate. Participation in the survey was strictly voluntary and this along with any correspondence with the schools including the coding for the item analysis went through the proper channels at the New York City Department of Education. The New York City Department of Education and City University of New York Institutional Review Board clearance was obtained as soon as the 2nd examination was approved. Most of the data reporting utilizes percentages, but codes are used for chemistry type (Non-Regents, Regents, Advanced Placement), and school size data (small, medium, large).

Determination of the Independent and Dependent Variables

The data from the websites was entered into SPSS for precise statistical analysis. The independent variables were determined by processing this information. Codes were used for school size ["1" = small schools (less than 500 students), "2" = medium size (500-1499 students) and "3" = large (1500^+ students)]. Types of chemistry were coded as well. These codes were then used to determine frequency distribution. For example, the four year graduation rates for districts and district chemistry enrollment. (Leithwood & Jantzi, 2009)

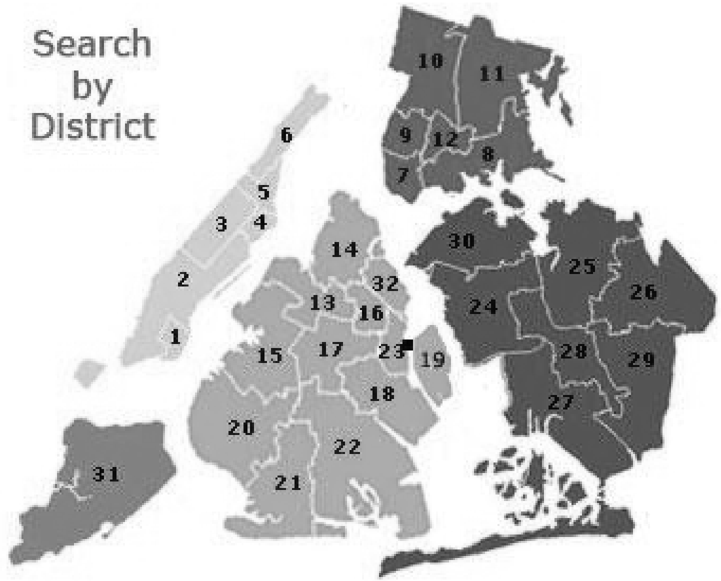
The primary dependent variable in this study is whether or not a school offers chemistry. An additional continuous independent variable for the study is the poverty level of the geographic area of the schools in question. This information helped to determine if there was a correlation between the access of Chemistry in high school and the location of the high school in terms of demographics and poverty level. An overview of the number and percentage of high school chemistry students in the geographic areas studied (See Table 11) begins to unveil the inconsistency during the 2009-10 school year. The difference in percentages of students in the country, state, city and boroughs is telling and further analysis of the underlying causes will be discussed in the coming chapters.

Table 11 - Percentages of High School Students taking Chemistry by Geographic Area
2009 (National Center for Educational Statistics) http://nces.ed.gov/indicator_msl.asp
(New York State Testing and Accountability Reporting Tool, 2010)
http://www.p12.nysed.gov/irs/pmf/2009-10/home.html

Geographic Area	Total HS Population	Total HS Chemistry	% HS Chemistry
New York State	642,927	153,659	23.9%
New York City	274,154	46,332	16.9%
Manhattan	56,095	9,536	17.0%
Bronx	52,433	6,397	12.2%
Brooklyn	75,878	11,989	15.8%
Queens	73,014	11,390	15.6%
Staten Island	16,734	2,895	17.3%

Further analysis will also include a closer look at the individual school districts within the Boroughs of New York City (see Figure 10). Each of the five boroughs contains areas that are vastly different from one another and a more precise evaluation can be drawn from examining the data at a more granular level.

Figure 10 - Map of the Schools Districts of New York City, http://schools.nyc.gov/default.htm



Chapter 4 – Results

Introduction

This chapter presents data to respond to the research questions. Both quantitative data and qualitative data are presented. These methodologies together provide different lenses to describe the state of the availability of high school chemistry and the implications for the students in New York City high schools during the 2009-10 school year. Examined at the most rudimentary level, this seems to be an innocuous topic and one that is easily analyzed. However, the complexity of this issue will be made clear as the layers of questioning are presented and then addressed using empirical and anecdotal evidence.

Prior to addressing the two main research questions and the secondary questions in each, the lens through which the access and entrance to high school chemistry must be established. Since the School Districts are numbered, this is an ordinal value and cannot be used as a variable in determining a correlation. The number on the district holds no more value than a placeholder and in fact is considered ordinal and cannot be used to determine relationships with other sets of variables. Instead, each of the school districts will be represented by the average poverty level of the inhabitants in that district. (See Table 12) When using this value for the particular school district, a broader understanding of the social and economic issues can be seen when determining the access to chemistry that students in certain areas are afforded. Bivariate correlation and/or multivariate correlation were the main means of analyzing the collected data. When possible, the multivariate correlation was the preferred method as it was felt that this was the preeminent means of identifying the variables that correlate to the prospect of studying high school chemistry in New York City.

Initially, a framework for the access and entrance in Chemistry will be established by comparing New York City, its boroughs (Manhattan, the Bronx, Brooklyn, Queens and Staten Island) and school districts (thirty-two in all) to that of the State of New York. (See Table 12) Of significant note is the fact that each of these geographic areas has again been tagged and represented not solely by its name but also by the poverty level of the community that inhabits the geographic area. It is felt that this layer of information further fleshes out the correlations generated when comparing the factors. Using this underpinning as a framework for the ensuing questions follows a key dynamic in the area of urban education. CUNY Graduate Center professor, Dr. Anthony Picciano urges researchers in urban education to “follow the money”.

Following the establishment of these broader data sets, the chapter is divided into two main subsections, each dealing with one of the research questions. The first section analyzes measures of academic and administrative indicators. Academic measures of achievement, secondary behavioral measures, fiscal and facilities inputs and socioeconomic factors are included in this section for examination. The following section will systematize the organizational factors that may contribute to New York City high school students’ access to Chemistry courses. Included here is attention to possible access to high school Chemistry via non-Regents Chemistry courses as a segue toward higher order science and a closer look at the schools and district that have access to the most rigorous Chemistry offering, Advanced Placement Chemistry. Finally, the role that teacher certification plays in the access to Chemistry is examined and the potential impact this has on access to Chemistry in the city.

Chemistry Enrollment: State, City, Boroughs, School Districts

An association between the high school chemistry enrollments in the state of New York, the City of New York, the boroughs of New York and the School Districts within those boroughs was assessed. (See Figure 11) A relationship is deemed statistically significant if a correlation at the ($p<0.05$) level is indicated. This is the strength of the association and the direction is shown with a positive or inverse indicating directly or inversely proportional, respectively.

Figure 11 – Correlation of Chemistry Students, Minority Students with Location Poverty

Correlations

Percentages based on the Geographic Area		Percent Poverty	Percent Chemistry	Percent Minority
Percent Poverty	Pearson Correlation	1	-.230	**.633****
	Sig. (2-tailed)		.160	.000
	N	39	39	39
Percent Chemistry	Pearson Correlation	-.230	1	**-.329***
	Sig. (2-tailed)	.160		.041
	N	39	39	39
Percent Minority	Pearson Correlation	**.633****	**-.329***	1
	Sig. (2-tailed)	.000	.041	
	N	39	39	39

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The multivariate correlation matrix produced indicates that there is a correlation between location and the total number of Chemistry students. Since there are 39 subjects with two degrees of freedom, the Pearson correlation coefficient for ($n-2 = 37$ samples) would be 0.325 for 35 samples and 0.304 for 40 samples for significance at the ($p<0.05$) level of significance. Location in and of itself lacked definition, so the poverty area of location was used as a determining factor. As seen in Figure 11, there is an inverse correlation between geographic locations as represented by poverty level in the area and percentage of students taking a chemistry course in the 2009-10 school year. This correlation is at -.329 and is significant at the (p<0.05) level and when represented as a statement, can be reported as follows: As the poverty level in New York State, New York City, the boroughs of New York City and the districts within the boroughs increases, the number of high school students taking chemistry courses in the 2009-2010 school year decreases. Given the same parameters as the statement above, the percentage of minority students is directly related to the poverty level of the locations mentioned. This correlation is at .633 has a significance of (p<0.01) level. If we take these two related statements, we can be confident that the percentage of chemistry students/courses will decrease in public high schools in an area as the poverty in that location increases and these high schools are mainly composed of minority students. As can be seen above, there is a strong direct correlation between minority students and poverty level by location. This indicates that the higher the poverty level in a geographic area, the more likely that minority students will attend schools in this area. There is also an inverse correlation between poverty level in a geographic location and the total percentage of students in a high school chemistry course in the high schools in that area, indicating that as a geographic are increases in poverty level, fewer public high school students were enrolled in a chemistry course during the 2009-10 school year.

Table 12 was used to set the parameters of this study. It can be seen that percentages of students enrolled in some level of high school chemistry during the 2009-2010 academic year does vary by region. The table lists the percentages for national, state, city, borough and school district enrollments in high school chemistry for this time period.

TABLE 12 – Geographic Locations, Total High School Population, Percentage Enrolled in Chemistry Courses National Center for Educational Statistics, http://nces.ed.gov/indicator_msl.asp New York State Testing and Accountability Reporting Tool, 2010, http://www.p12.nysed.gov/irs/pmf/2009-10/home.html

Location	Poverty Level	Total HS Population	Total Chemistry
1 – NYS	15.3%	642,927	27.0%
2 – NYC	20.1%	274,154	15.4%
2a – Manhattan	17.6%	56,095	17.0%
2b – Bronx	27.1%	52,433	12.2%
2c - Brooklyn	21.9%	75,878	15.8%
2d – Queens	12.0%	73,014	15.6%
2e – Richmond	9.8%	16,734	17.3%
M - D#1	50.0%	1,847	25.5%
M - D#2	8.9%	36,105	19.6%
M - D#3	12.0%	8,556	13.0%
M - D#4	46.5%	3,088	18.6%
M - D#5	43.3%	1,825	24.1%
M - D#6	40.9%	4,674	14.3%
X - D#7	65.0%	6,046	8.4%
X - D#8	42.2%	9,698	4.8%
X - D#9	59.7%	6,137	15.5%
X - D#10	49.0%	16,546	21.1%
X - D#11	35.7%	9,434	11.2%
X - D#12	66.7%	4,572	16.0%
K - D#13	35.0%	11,200	21.8%
K - D#14	43.9%	6,464	16.2%
K - D#15	36.2%	2,624	14.5%
K - D#16	46.1%	2,794	7.4%
K - D#17	37.8%	7,090	14.0%
K - D#18	34.3%	3,470	19.2%
K - D#19	50.5%	6,506	12.0%
K - D#20	45.9%	12,058	12.4%
K - D#21	45.1%	12,096	19.7%
K - D#22	32.9%	10,410	28.4%
K - D#23	51.9%	1,166	17.3%
Q - D#24	36.5%	12,645	14.0%
Q - D#25	33.3%	8,886	19.2%
Q - D#26	17.7%	15,887	19.1%
Q - D#27	35.6%	10,827	9.2%
Q - D#28	20.7%	11,895	20.0%
Q - D#29	29.7%	3,034	18.7%
Q - D#30	33.5%	9,840	14.9%
R - D#31	9.8%	16,734	17.3%
K - D#32	51.6%	3,126	10.7%

Academic Indicators

Access to and entrance in high school chemistry courses depends on several components, not the least of which is academic. Both the academics of the students and the academic records of the schools in each district were analyzed to see if these indicators have significant correlation. The science achievement measurement was calculated by comparison of the percentage of students in the district enrolled in Regents Living Environment to the percentage of these same students who were enrolled in Regents Chemistry. This was done at the borough level and as seen in the graphic depiction in Chapter 1, (Table 2 and Figures 4 and 5) there is an inverse correlation between the percentage of students enrolled in Chemistry after Living Environment and minority student status. There is also an inverse correlation between the percentage of students enrolled in Chemistry after Living Environment and percentage of Free Lunch students (Table 1 and Figures 2 and 3). The more dramatic correlation appears to be between the percentages of Chemistry/Living Environment to minority student. The graphic created is almost an exact mirror image indicating a near perfect inverse correlation between these two measures. However, since the treatment sample is so small – only the five boroughs - the correlation is not significant enough to show that this is more than a random occurrence. Further data collection and analysis was therefore done on the district level which is a more precise indicator of the disparity as it relates to socioeconomics and demographics. (Figure 12) It is important to note that high school students do have the option to attend public high schools that are located outside of their school district of residence. However, recent findings indicate that a disproportionate number of the city's neediest students continue to wind up in large, lower-performing high schools, even as the number of small schools has increased. (Hemphill & Nauer, 2009).

Figure 12 – Academic Achievement Factors and Chemistry Enrollment by School District Poverty Level

Correlations

		4-Yr Graduate	4-Yr College	Science Achievement	Mathematics Achievement	Chemistry Enrollment	District Poverty
Four Year Graduation	Pearson Correlation	1	.221	.320	**.380***	.208	-.077
	Sig. (2-tailed)		.225	.074	.032	.253	.674
	N	32	32	32	32	32	32
Four Year College	Pearson Correlation	.221	1	**.617****	**.582****	**.459****	**-.476****
	Sig. (2-tailed)	.225		.000	.000	.008	.006
	N	32	32	32	32	32	32
Science Achievement	Pearson Correlation	.320	**.617****	1	**.807****	**.802****	-.288
	Sig. (2-tailed)	.074	.000		.000	.000	.110
	N	32	32	32	32	32	32
Mathematics Achievement	Pearson Correlation	**.380***	**.582****	**.807****	1	**.652****	**-.383***
	Sig. (2-tailed)	.032	.000	.000		.000	.031
	N	32	32	32	32	32	32
Chemistry Enrollment	Pearson Correlation	.208	**.459****	**.802****	**.652****	1	-.222
	Sig. (2-tailed)	.253	.008	.000	.000		.221
	N	32	32	32	32	32	32
District Poverty	Pearson Correlation	-.077	**-.476****	-.288	**-.383***	-.222	1
	Sig. (2-tailed)	.674	.006	.110	.031	.221	
	N	32	32	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 13 - Academic Factors (New York City Department of Education, http://schools.nyc.gov/default.htm)

D	Poverty Level	4 year grad%	4 year College	Chemistry/ Living Environment	Algebra/ Geometry	Chemistry Enrollment
1	50.0%	73.0%	67.0%	63.4%	67.0%	25.5%
2	8.9%	70.2%	49.0%	37.1%	42.1%	19.6%
3	12.0%	62.6%	44.0%	37.4%	50.0%	13.0%
4	46.5%	71.4%	39.0%	52.9%	71.6%	18.6%
5	43.3%	71.8%	49.0%	64.0%	64.3%	24.1%
6	40.9%	77.7%	48.0%	27.3%	51.0%	14.3%
7	65.0%	70.5%	31.0%	20.4%	27.5%	8.4%
8	42.2%	58.4%	39.0%	12.5%	26.5%	4.8%
9	59.7%	69.1%	34.0%	25.5%	33.1%	15.5%
10	49.0%	71.2%	30.0%	41.9%	35.5%	21.1%
11	35.7%	73.0%	36.0%	22.8%	34.1%	11.2%
12	66.7%	59.5%	25.0%	16.1%	22.9%	16.0%
13	35.0%	79.8%	49.0%	63.7%	42.1%	21.8%
14	43.9%	74.3%	43.0%	28.3%	37.3%	16.2%
15	36.2%	67.1%	38.0%	23.2%	30.5%	14.5%
16	46.1%	62.8%	35.0%	2.8%	15.9%	7.4%
17	37.8%	73.7%	37.0%	34.5%	43.7%	14.0%
18	34.3%	50.2%	34.0%	16.3%	27.8%	19.2%
19	50.5%	84.2%	32.0%	13.9%	38.6%	12.0%
20	45.9%	67.8%	49.0%	35.5%	45.4%	12.4%
21	45.1%	62.2%	31.0%	30.8%	43.6%	19.7%
22	32.9%	84.1%	47.0%	66.7%	76.0%	28.4%
23	51.9%	68.6%	38.0%	20.3%	28.5%	17.3%
24	36.5%	74.0%	36.0%	25.3%	43.2%	14.0%
25	33.3%	82.1%	43.0%	30.6%	44.6%	19.2%
26	17.7%	67.7%	45.0%	49.5%	66.7%	19.1%
27	35.6%	81.3%	34.0%	20.5%	33.9%	9.2%
28	20.7%	73.8%	53.0%	33.0%	63.4%	20.0%
29	29.7%	77.4%	36.0%	32.7%	40.7%	18.7%
30	33.5%	79.2%	56.0%	29.1%	43.7%	14.9%
31	9.8%	68.8%	58.0%	39.9%	53.4%	17.3%
32	51.6%	73.9%	18.0%	11.7%	42.8%	10.7%

To determine the science achievement at each of the high schools in each of the districts, the ratio of the first two science Regents courses, Living Environment to Chemistry was calculated. Similarly, the mathematics achievement in each of the high schools within each of the districts was determined through the ratio of students taking Regents Algebra I/Regents Geometry. (See Table 13) A multivariate correlation analysis was created to determine the relationships among the above factors. (See Figure 12) It can be seen that there is a .380 positive correlation at the ($p < 0.05$) level between achievement in mathematics and the four year high school graduation rate. This was the only correlation of any significance when the four year graduation rate was introduced as a variable in the study. The four year college indicator is one that has been determined through survey results. Students were asked what their future plans were when they would leave high school and although this is subjective in terms of relevant data, it is based on the desire of the students in high school and the fact is that these students have not actually entered a four year college. The results are telling and can arguably be used as a measure of self-efficacy given other similar data. What can be noted is that there is a correlation of .617, .582, .459 and .476 at the (p<0.01) level for four of the variables in this data set. When reading this metric it can be seen that the percentage of students who have intentions of attending a four year college are directly correlated to high science achievement at the 99% level, high mathematics achievement at the 99% level and have greater access to high school chemistry at the 99% level. On the other hand, schools in districts with high poverty level have the inverse relationship with these metrics, suggesting that children who attend schools in areas of high poverty are less likely to view a four year college education as a viable option, have less access to Chemistry and tend to have lower science and mathematics achievement levels.

Administrative Factors

Another set of variables measured were those related to the administration of the schools in the study. (See Figure 13) The characteristics of school size, per pupil expense and Chemistry lab/Chemistry student ratio were analyzed through a multivariate correlation matrix. The metric of school size was one that was a bit challenging. The former delineations of the schools by districts helped to organize the other characteristics used in this study but school size transcended this structure. The different school sizes were in some but not all of the school districts and there was no measure that could be used to align these perfectly. In addition, the three types of Chemistry courses offered in the high schools varied greatly in the small schools within the districts. To adjust for these factors, the first set of data for this particular question addresses per student expenditure and access to chemistry laboratory facilities but not the issue of small schools and Chemistry access. A correlation matrix was generated that compared the District Poverty level, Per Student Expenditure and the Chemistry lab/Chemistry student ratio per district. (See Figure 13)

Figure 13 – Per Student Expense and Lab/Student Ration by District

		District Poverty	Per Student Expense	Chemistry Lab/Chemistry Student Ratio
District Poverty	Pearson Correlation	1	**.505****	-.330
	Sig. (2-tailed)		.003	.065
	N	32	32	32
Per Student Expense	Pearson Correlation	**.505****	1	**-.416***
	Sig. (2-tailed)	.003		.018
	N	32	32	32
Chemistry Lab/Chemistry Student Ratio	Pearson Correlation	-.330	**-.416***	1
	Sig. (2-tailed)	.065	.018	
	N	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 14 – School Districts with Per Student Expense and Laboratory Access, New York City Department of Education, http://schools.nyc.gov/default.htm

District	Poverty Level	Per Student Expenditure	Lab/Student Ratio #students/#labs x 100
1	50.0%	$17,913	1.5%
2	8.9%	$19,154	1.2%
3	12.0%	$16,642	0.9%
4	46.5%	$18,748	1.6%
5	43.3%	$18,782	1.1%
6	40.9%	$18,139	1.5%
7	65.0%	$19,152	2.4%
8	42.2%	$17,399	4.1%
9	59.7%	$18,242	2.4%
10	49.0%	$17,429	1.0%
11	35.7%	$16,907	2.0%
12	66.7%	$18,907	1.9%
13	35.0%	$16,655	0.4%
14	43.9%	$17,625	1.6%
15	36.2%	$17,258	3.1%
16	46.1%	$18,167	1.0%
17	37.8%	$17,580	2.9%
18	34.3%	$17,357	3.2%
19	50.5%	$17,337	1.5%
20	45.9%	$15,276	0.8%
21	45.1%	$16,367	1.1%
22	32.9%	$15,517	0.5%
23	51.9%	$18,334	1.5%
24	36.5%	$15,208	1.2%
25	33.3%	$16,070	0.8%
26	17.7%	$14,052	0.8%
27	35.6%	$15,511	2.1%
28	20.7%	$15,218	1.0%
29	29.7%	$15,779	1.9%
30	33.5%	$16,108	1.0%
31	9.8%	$16,692	1.1%
32	51.6%	$17,681	2.4%

It was seen that there is a significant and positive correlation between per student expenditure and the district poverty level. This correlation is at the (p<0.01) level, indication that as the poverty level in a district increases, the per student expenditure also increases. The correlation is .505 at ($p<0.01$) which indicates that the possible of change occurrence is minimal. There are several theories as to why this is occurring and they will be further examined in the final chapter. The second and more readily understandable relationship is that of per student expenditure and the student to lab ratio. As the ratio of student to laboratory facilities increases, or, as there are more chemistry students using Chemistry labs in the schools in a district, the per student cost decreases. This would seem likely because with more students using the same facilities or more students per Chemistry class, the cost per pupil would decrease. However, the cost per pupil is the overall cost and does not specify the delineation of the student expenditures.

School Size: Chemistry Access and Enrollment

The data relating to school size was an anomaly in this study as this could not be taken per district. No consistency was found in the school sizes in each of the districts and the variable of school size impacted with Chemistry types offered in the school did not lend itself to this degree of analysis. Table 15 contains the numbers of schools and their sizes, the types of Chemistry offered in each of the school sizes and the percentage of high school population that is enrolled in the levels of Chemistry in each. A cursory view of the values indicates that small high schools offer the largest percentage of non-regents Chemistry. In addition, it can be seen that there are many more small schools not offering Regents Chemistry to their students than in medium sized or large sized high schools.

Table 15 - School Size and Access & Enrollment in High School Chemistry Courses (New York City Department of Education), http://schools.nyc.gov/default.htm

	Non-Regents			
	School	Chemistry Students	Total	% students
Small	76	5,326	30,276	17.6%
Medium	15	921	11,228	8.2%
Large	40	7,550	102,110	7.3%
	Regents			
	Schools	Chemistry Students	Total	% students
Small	134	5,308	83,101	6.3%
Medium	30	6,696	69,029	9.7%
Large	43	11,808	124,365	9.5%
	Advanced Placement			
	Schools	Chemistry Students	Total	% students
Small	10	175	4,077	4.3%
Medium	4	89	3,052	2.9%
Large	21	1,316	54,845	2.4%
	No Regents Chemistry			
	School	Chemistry Students	Total	% students
Small	79	0	26,074	0
Medium	6	0	3,898	0
Large	2	0	3,217	0

A correlation was generated to analyze the percentage of Chemistry offered in all three types of schools in New York City (Figure 14). It can be seen that there is no significant correlation between school size and the percentage of students in any of the three types of Chemistry analyzed. Although the correlations in this matrix are not measured at the significant level, it is important to note that the larger high schools have an inverse correlation to non-Regents chemistry and Advance Placement Chemistry but a positive correlation to Regents Chemistry. Although the magnitude is not seen as being significant, of note is the direction of the correlation.

Figure 14 – School Size and Access to High School Chemistry

Correlations					
		School Size	% Non-Regents Chemistry	%Regents Chemistry	% A.P. Chemistry
School Size	Pearson Correlation	1	-.903	.839	-.965
	Sig. (2-tailed)		.283	.367	.170
	N	3	3	3	3
% Non-Regents Chemistry	Pearson Correlation	-.903	1	-.991	.984
	Sig. (2-tailed)	.283		.084	.113
	N	3	3	3	3
% Regents Chemistry	Pearson Correlation	.839	-.991	1	-.953
	Sig. (2-tailed)	.367	.084		.197
	N	3	3	3	3
% A.P. Chemistry	Pearson Correlation	-.965	.984	-.953	1
	Sig. (2-tailed)	.170	.113	.197	
	N	3	3	3	3

Socioeconomic and Racial Composition Factors

The socioeconomic factors that were analyzed in this study include pupil demographics, percentage of students receiving free lunch, percentage of students who are classified as being English Language Learners and the poverty level of the districts in which these students attend school. (See Tables 15, 17) The variable of access and entrance to high school Chemistry was expanded for this section of the study. It was felt that a more comprehensive overview of the students' access would be seen if the correlations were done on four levels: Any Chemistry (Figure 5); Advanced Placement Chemistry (Figure 16); Regents Chemistry (Figure 17) and Non-Regents Chemistry (Figure 18). Although several of the variables in the matrices will remain constant, the access to the different types of Chemistry as it relates to the poverty level of the district is the focus of this section.

Figure 15 – District Socioeconomic factors and Enrollment in **any type of Chemistry**

Correlations

		Any Chemistry	District Poverty	Free Lunch	ELL	Asian	Black	Hisp.	White	Minority
Any Chemistry	Pearson Correlation	1	-.222	**-.388***	-.162	.281	.017	-.315	.280	-.287
	Sig. (2-tailed)		.221	.028	.376	.119	.928	.079	.121	.111
	N	32	32	32	32	32	32	32	32	32
District Poverty	Pearson Correlation	-.222	1	**.818****	.340	**-.448***	.090	**.432***	**-.557****	**.518****
	Sig. (2-tailed)	.221		.000	.057	.010	.624	.013	.001	.002
	N	32	32	32	32	32	32	32	32	32
Free Lunch	Pearson Correlation	**-.388***	**.818****	1	**.368***	**-.667****	.229	**.493****	**-.787****	**.727****
	Sig. (2-tailed)	.028	.000		.038	.000	.207	.004	.000	.000
	N	32	32	32	32	32	32	32	32	32
ELL	Pearson Correlation	-.162	.340	**.368***	1	-.007	**-.673****	**.738****	-.076	-.005
	Sig. (2-tailed)	.376	.057	.038		.970	.000	.000	.680	.979
	N	32	32	32	32	32	32	32	32	32
Asian	Pearson Correlation	.281	**-.448***	**-.667****	-.007	1	**-.418***	-.320	**.461****	**-.759****
	Sig. (2-tailed)	.119	.010	.000	.970		.017	.074	.008	.000
	N	32	32	32	32	32	32	32	32	32
Black	Pearson Correlation	.017	.090	.229	**-.673****	**-.418***	1	**-.528****	**-.486****	**.557****
	Sig. (2-tailed)	.928	.624	.207	.000	.017		.002	.005	.001
	N	32	32	32	32	32	32	32	32	32
Hispanic	Pearson Correlation	-.315	.432*	**.493****	**.738****	-.320	**-.528****	1	-.264	**.411***
	Sig. (2-tailed)	.079	.013	.004	.000	.074	.002		.144	.019
	N	32	32	32	32	32	32	32	32	32
White	Pearson Correlation	.280	**-.557****	**-.787****	-.076	**.461****	**-.486****	-.264	1	**-.782****
	Sig. (2-tailed)	.121	.001	.000	.680	.008	.005	.144		.000
	N	32	32	32	32	32	32	32	32	32
Minority	Pearson Correlation	-.287	**.518****	**.727****	-.005	**-.759****	**.557****	**.411***	**-.782****	1
	Sig. (2-tailed)	.111	.002	.000	.979	.000	.001	.019	.000	
	N	32	32	32	32	32	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Figure 16 – District Socioeconomic factors and Enrollment in **Advanced Placement Chemistry**

Correlations

		District Poverty	Free Lunch	ELL	Asian	Black	Hisp.	White	Minority	AP Chem.
District Poverty	Pearson Correlation	1	.818**	.340	-.448*	.090	.432*	-.557**	.518**	-.386*
	Sig. (2-tailed)		.000	.057	.010	.624	.013	.001	.002	.029
	N	32	32	32	32	32	32	32	32	32
Free Lunch	Pearson Correlation	.818**	1	.368*	-.667**	.229	.493**	-.787**	.727**	-.414*
	Sig. (2-tailed)	.000		.038	.000	.207	.004	.000	.000	.019
	N	32	32	32	32	32	32	32	32	32
ELL	Pearson Correlation	.340	.368*	1	-.007	-.673**	.738**	-.076	-.005	-.105
	Sig. (2-tailed)	.057	.038		.970	.000	.000	.680	.979	.567
	N	32	32	32	32	32	32	32	32	32
Asian	Pearson Correlation	-.448*	-.667**	-.007	1	-.418*	-.320	.461**	-.759**	.124
	Sig. (2-tailed)	.010	.000	.970		.017	.074	.008	.000	.501
	N	32	32	32	32	32	32	32	32	32
Black	Pearson Correlation	.090	.229	-.673**	-.418*	1	-.528**	-.486**	.557**	-.116
	Sig. (2-tailed)	.624	.207	.000	.017		.002	.005	.001	.527
	N	32	32	32	32	32	32	32	32	32
Hispanic	Pearson Correlation	.432*	.493**	.738**	-.320	-.528**	1	-.264	.411*	-.093
	Sig. (2-tailed)	.013	.004	.000	.074	.002		.144	.019	.613
	N	32	32	32	32	32	32	32	32	32
White	Pearson Correlation	-.557**	-.787**	-.076	.461**	-.486**	-.264	1	-.782**	.418*
	Sig. (2-tailed)	.001	.000	.680	.008	.005	.144		.000	.017
	N	32	32	32	32	32	32	32	32	32
Minority	Pearson Correlation	.518**	.727**	-.005	-.759**	.557**	.411*	-.782**	1	-.217
	Sig. (2-tailed)	.002	.000	.979	.000	.001	.019	.000		.234
	N	32	32	32	32	32	32	32	32	32
AP. Chemistry	Pearson Correlation	-.386*	-.414*	-.105	.124	-.116	-.093	.418*	-.217	1
	Sig. (2-tailed)	.029	.019	.567	.501	.527	.613	.017	.234	
	N	32	32	32	32	32	32	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).

Figure 17 – District Socioeconomic factors and Enrollment in **Regents Chemistry**

Correlations

		District Poverty	Free Lunch	ELL	Asian	Black	Hispanic	White	Minority	Regents Chemistry
District Poverty	Pearson Correlation	1	**.818****	.340	**-.448***	.090	**.432***	**-.557****	**.518****	-.304
	Sig. (2-tailed)		.000	.057	.010	.624	.013	.001	.002	.091
	N	32	32	32	32	32	32	32	32	32
Free Lunch	Pearson Correlation	**.818****	1	**.368***	**-.667****	.229	**.493****	**-.787****	**.727****	**-.437***
	Sig. (2-tailed)	.000		.038	.000	.207	.004	.000	.000	.012
	N	32	32	32	32	32	32	32	32	32
ELL	Pearson Correlation	.340	**.368***	1	-.007	**-.673****	**.738****	-.076	-.005	-.041
	Sig. (2-tailed)	.057	.038		.970	.000	.000	.680	.979	.825
	N	32	32	32	32	32	32	32	32	32
Asian	Pearson Correlation	**-.448***	**-.667****	-.007	1	**-.418***	-.320	**.461****	**-.759****	**.386***
	Sig. (2-tailed)	.010	.000	.970		.017	.074	.008	.000	.029
	N	32	32	32	32	32	32	32	32	32
Black	Pearson Correlation	.090	.229	**-.673****	**-.418***	1	**-.528****	**-.486****	**.557****	-.210
	Sig. (2-tailed)	.624	.207	.000	.017		.002	.005	.001	.248
	N	32	32	32	32	32	32	32	32	32
Hispanic	Pearson Correlation	**.432***	**.493****	**.738****	-.320	**-.528****	1	-.264	**.411***	-.167
	Sig. (2-tailed)	.013	.004	.000	.074	.002		.144	.019	.360
	N	32	32	32	32	32	32	32	32	32
White	Pearson Correlation	**-.557****	**-.787****	-.076	**.461****	**-.486****	-.264	1	**-.782****	.330
	Sig. (2-tailed)	.001	.000	.680	.008	.005	.144		.000	.065
	N	32	32	32	32	32	32	32	32	32
Minority	Pearson Correlation	**.518****	**.727****	-.005	**-.759****	**.557****	**.411***	**-.782****	1	**-.388***
	Sig. (2-tailed)	.002	.000	.979	.000	.001	.019	.000		.028
	N	32	32	32	32	32	32	32	32	32
Regents Chemistry	Pearson Correlation	-.304	**-.437***	-.041	**.386***	-.210	-.167	.330	**-.388***	1
	Sig. (2-tailed)	.091	.012	.825	.029	.248	.360	.065	.028	
	N	32	32	32	32	32	32	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 18 – District Socioeconomic factors and Enrollment in **Non-Regents Chemistry**

Correlations

		District Poverty	Free Lunch	ELL	Asian	Black	Hisp.	White	Minority	Non Regents
District Poverty	Pearson Correlation	1	.818**	.340	-.448*	.090	.432*	-.557**	.518**	.089
	Sig. (2-tailed)		.000	.057	.010	.624	.013	.001	.002	.629
	N	32	32	32	32	32	32	32	32	32
Free Lunch	Pearson Correlation	.818**	1	.368*	-.667**	.229	.493**	-.787**	.727**	.000
	Sig. (2-tailed)	.000		.038	.000	.207	.004	.000	.000	.999
	N	32	32	32	32	32	32	32	32	32
ELL	Pearson Correlation	.340	.368*	1	-.007	-.673**	.738**	-.076	-.005	-.193
	Sig. (2-tailed)	.057	.038		.970	.000	.000	.680	.979	.291
	N	32	32	32	32	32	32	32	32	32
Asian	Pearson Correlation	-.448*	-.667**	-.007	1	-.418*	-.320	.461**	-.759**	-.063
	Sig. (2-tailed)	.010	.000	.970		.017	.074	.008	.000	.731
	N	32	32	32	32	32	32	32	32	32
Black	Pearson Correlation	.090	.229	-.673**	-.418*	1	-.528**	-.486**	.557**	.312
	Sig. (2-tailed)	.624	.207	.000	.017		.002	.005	.001	.082
	N	32	32	32	32	32	32	32	32	32
Hispanic	Pearson Correlation	.432*	.493**	.738**	-.320	-.528**	1	-.264	.411*	-.277
	Sig. (2-tailed)	.013	.004	.000	.074	.002		.144	.019	.126
	N	32	32	32	32	32	32	32	32	32
White	Pearson Correlation	-.557**	-.787**	-.076	.461**	-.486**	-.264	1	-.782**	-.032
	Sig. (2-tailed)	.001	.000	.680	.008	.005	.144		.000	.863
	N	32	32	32	32	32	32	32	32	32
Minority	Pearson Correlation	.518**	.727**	-.005	-.759**	.557**	.411*	-.782**	1	.068
	Sig. (2-tailed)	.002	.000	.979	.000	.001	.019	.000		.713
	N	32	32	32	32	32	32	32	32	32
Non Regents	Pearson Correlation	.089	.000	-.193	-.063	.312	-.277	-.032	.068	1
	Sig. (2-tailed)	.629	.999	.291	.731	.082	.126	.863	.713	
	N	32	32	32	32	32	32	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 16 - Demographics of the Five Boroughs of New York City Census, 2010, http://www.census.gov

Borough	Asian	Black	Hispanic	White	Other	Minority *
Manhattan	11.4%	12.9%	25.4%	48.0%	2.3%	40.6%
Bronx	3.7%	34.2%	51.1%	10.9%	0.1%	85.4%
Brooklyn	6.6%	34.3%	19.8%	35.7%	3.6%	57.7%
Queens	23.3%	17.7%	27.5%	27.6%	3.9%	49.1%
Staten Island	4.1%	9.5%	19.8%	64.0%	2.6%	31.9%

*Minority is defined as underrepresented populations in the area of Science, Technology, Engineering and Mathematics for the purpose of this study.

Table 17 - Demographic Factors of the School Districts in NYC
New York City Department of Education, http://schools.nyc.gov/default.htm

D	Poverty	Chemistry	Free Lunch	ELL	Asian	Black	Hisp.	White	Minority
1	50.0%	25.5%	61.0%	12.0%	21.0%	18.0%	45.0%	15.0%	64.0%
2	8.9%	19.6%	53.0%	12.0%	22.0%	20.0%	37.0%	20.0%	58.0%
3	12.0%	13.0%	48.0%	9.0%	7.0%	31.0%	36.0%	25.0%	67.0%
4	46.5%	18.6%	83.0%	13.0%	5.0%	30.0%	62.0%	2.0%	93.0%
5	43.3%	24.1%	72.0%	11.0%	2.0%	57.0%	38.0%	2.0%	95.0%
6	40.9%	14.3%	85.0%	36.0%	1.0%	8.0%	89.0%	3.0%	97.0%
7	65.0%	8.4%	86.0%	19.0%	1.0%	29.0%	69.0%	1.0%	98.0%
8	42.2%	4.8%	77.0%	12.0%	4.0%	27.0%	63.0%	6.0%	90.0%
9	59.7%	15.5%	87.0%	25.0%	1.0%	33.0%	64.0%	1.0%	97.0%
10	49.0%	21.1%	78.0%	22.0%	7.0%	20.0%	67.0%	6.0%	87.0%
11	35.7%	11.2%	68.0%	11.0%	6.0%	45.0%	41.0%	7.0%	87.0%
12	66.7%	16.0%	88.0%	19.0%	2.0%	29.0%	68.0%	1.0%	98.0%
13	35.0%	21.8%	63.0%	4.0%	16.0%	61.0%	15.0%	8.0%	77.0%
14	43.9%	16.2%	81.0%	13.0%	3.0%	29.0%	5.0%	8.0%	34.0%
15	36.2%	14.5%	60.0%	16.0%	12.0%	23.0%	44.0%	21.0%	67.0%
16	46.1%	7.4%	76.0%	3.0%	1.0%	84.0%	14.0%	1.0%	99.0%
17	37.8%	14.0%	80.0%	9.0%	2.0%	85.0%	11.0%	1.0%	96.0%
18	34.3%	19.2%	68.0%	5.0%	1.0%	91.0%	7.0%	1.0%	98.0%
19	50.5%	12.0%	83.0%	13.0%	6.0%	53.0%	40.0%	1.0%	94.0%
20	45.9%	12.4%	66.0%	26.0%	38.0%	4.0%	28.0%	21.0%	32.0%
21	45.1%	19.7%	61.0%	16.0%	25.0%	21.0%	22.0%	31.0%	43.0%
22	32.9%	28.4%	56.0%	10.0%	16.0%	43.0%	14.0%	27.0%	57.0%
23	51.9%	17.3%	80.0%	4.0%	1.0%	81.0%	17.0%	1.0%	98.0%
24	36.5%	14.0%	68.0%	26.0%	1.0%	4.0%	62.0%	15.0%	66.0%
25	33.3%	19.2%	56.0%	19.0%	43.0%	11.0%	29.0%	17.0%	40.0%
26	17.7%	19.1%	35.0%	8.0%	50.0%	15.0%	16.0%	19.0%	31.0%
27	35.6%	9.2%	68.0%	10.0%	24.0%	30.0%	36.0%	10.0%	66.0%
28	20.7%	20.0%	59.0%	11.0%	30.0%	30.0%	24.0%	16.0%	55.0%
29	29.7%	18.7%	64.0%	7.0%	14.0%	71.0%	13.0%	2.0%	85.0%
30	33.5%	14.9%	69.0%	23.0%	22.0%	8.0%	54.0%	16.0%	62.0%
31	9.8%	17.3%	42.0%	6.0%	8.0%	15.0%	23.0%	53.0%	38.0%
32	51.6%	10.7%	85.0%	19.0%	2.0%	25.0%	72.0%	1.0%	97.0%

When analyzed using access to all chemistry (See Figure 15) , the only demographic group that had an inverse correlation were those students receiving free lunch. This was on the magnitude of ($p<0.05$). Other correlations of interest but that do not effect this study are as follows:

1. An increase in the poverty level of the district significantly increases the percentage of free lunch, Hispanics and minorities. An increase in poverty level in the district also significantly decreased the percentage of Asian and White students attending high school in that district.
2. An increase in the percentage of students receiving free lunch is directly correlated with an increased poverty level in that district, the percentage of English Language Learners who attend high school in that district and an increase in the percentage of Hispanic and minority students who attend high school in that district.

In terms of enrollment in the three variations of high school Chemistry, there is a significant and inverse correlation ($p<0.01$) between district poverty level and the percentage of students enrolled in Advanced Placement Chemistry courses (See Figure 16), so the high schools in the districts with high poverty level have a lower percentage of students taking Advanced Placement Chemistry. The same is true for the students receiving free lunch. There is a significant and inverse correlation between free lunch and Advanced Placement Chemistry ($p<0.01$). Again indicating the students who receive free lunch are less likely to be enrolled in Advanced Placement Chemistry. However, there is a significant ($p<0.01$) and positive correlation to the percentage of white students and percentage of students enrolled in Advanced Placement Chemistry, indicating the White students are more likely to be enrolled in Advanced Chemistry courses.

Looking at the correlation matrix for the relationship between several factors and enrollment in Regents Chemistry courses (See Figure 17), a similar pattern emerges. There is a significant (*p*<0.01) and inverse correlation between enrollment in Regents Chemistry and percentage of student who receive free lunch and the percentage of students who are identified as minorities.

Simply stated, students are less likely to be enrolled in Regents Chemistry courses if they receive free lunch or if they are identified as a minority student. Minority is defined as underrepresented ethnic groups (Black and Hispanic) in the areas of Science, Technology, Engineering and Mathematics. The percentage of Asian students enrolled in Regents Chemistry is a significant positive correlation (*p*<0.01) indicating that an Asian student is more likely to be enrolled in Regents Chemistry than students who identify as White, Black or Hispanic.

Finally when looking at the correlation matrix for Non-Regents Chemistry courses (See Figure 18), there is no significant correlation between enrollments in a Non-Regents Chemistry course and any of the other descriptive factors. The implication is that Non-Regents Chemistry enrollment imposes fewer barriers for access to and enrollment in these courses.

No Access to Regents Chemistry by District Poverty Levels

A separate correlation was done in terms of access to and enrollment in high school Chemistry in New York City. The only data publicly available for this correlation was for Regents Chemistry (See Figure 19). Arguably, Regents Chemistry is seen as the foundational course for high school students. As seen in Table 18, the percentage of students without access to Regents Chemistry was calculated for each of the thirty-two district in New York City.

Table 18 – No Access to Regents Chemistry by District in 2009-2010
(New York State Testing and Accountability Reporting Tool, 2010)
http://www.p12.nysed.gov/irs/pmf/2010-11/home.html)

District	Number of Students in Schools without Regents Chemistry	Total Number of HS Students in District	% of Students without access to Regents Chemistry
1	0	1,847	0.0%
2	6,318	36,105	17.5%
3	1,086	8,556	12.7%
4	1,084	3,088	35.1%
5	708	1,825	38.8%
6	173	4,674	3.7%
7	1,771	6,046	29.3%
8	1,571	9,698	16.2%
9	3,194	6,137	52.0%
10	2,117	16,546	12.8%
11	1,713	9,434	18.2%
12	1,729	4,572	37.8%
13	2,229	11,200	19.9%
14	866	6,464	13.4%
15	1,776	2,624	67.7%
16	101	2,794	3.6%
17	1,152	7,090	16.2%
18	1,006	3,470	29.0%
19	2,570	6,506	39.5%
20	0	12,058	0.0%
21	1,301	12,096	10.8%
22	0	10,410	0.0%
23	0	1,166	0.0%
24	1,194	12,645	9.4%
25	393	8,886	4.4%
26	0	15,887	0.0%
27	446	10,827	4.1%
28	0	11,895	0.0%
29	0	3,034	0.0%
30	0	9,840	0.0%
31	0	16,734	0.0%
32	1,656	3,126	53.0%
Total/Average	36,154	277,280	17.0%

A cursory review of the table points to the discrepancies in access to Regents Chemistry in several of the thirty-two districts in New York City. This was then coupled with the poverty level in each of the districts along with percentage of minority students and percentage of English Language Learners in each district to see if there was any significant correlation. The following matrix contains the findings.

Figure 19 – Access to Regents Chemistry by Poverty Level, Demographic and ELL Percentages

Correlations

		% Students w/o Access to Regents Chemistry	% Poverty Level per District	% Minority Students in District HS	% ELL in District HS
% Students without Access to Regents Chemistry	Pearson Correlation	1	**.404***	**.479****	.097
	Sig. (2-tailed)		.022	.006	.599
	N	32	32	32	32
% Poverty Level in District	Pearson Correlation	**.404***	1	**.568****	.261
	Sig. (2-tailed)	.022		.001	.149
	N	32	32	32	32
% Minority Students in District High Schools	Pearson Correlation	**.479****	**.568****	1	-.143
	Sig. (2-tailed)	.006	.001		.435
	N	32	32	32	32
% ELL Students in District High School	Pearson Correlation	.097	.261	-.143	1
	Sig. (2-tailed)	.599	.149	.435	
	N	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed).

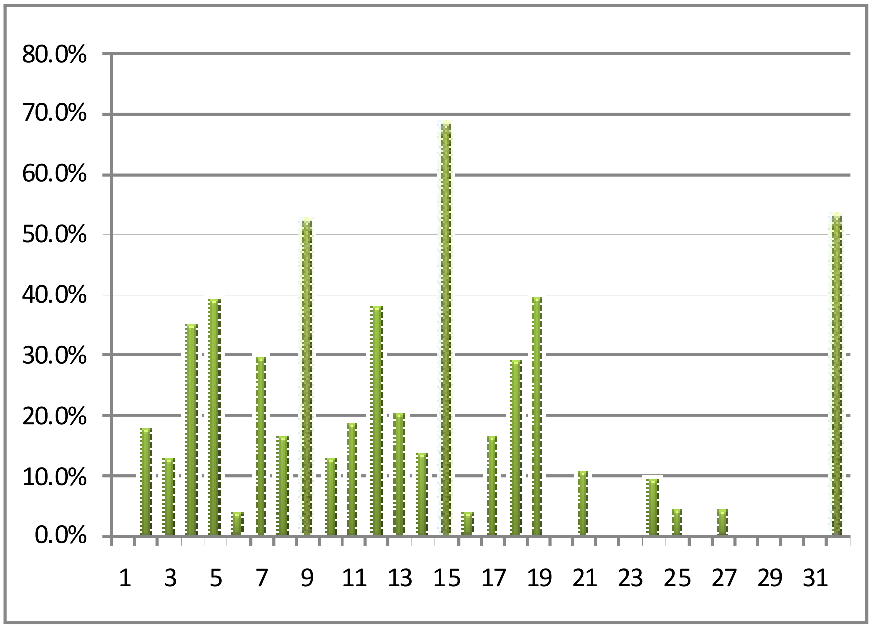
**. Correlation is significant at the 0.01 level (2-tailed).

When reading this correlation matrix (Figure 19), it can be seen that there are three positive or directly proportional relationships with correlations that are deemed significant enough to suggest that these are not random occurrences. The percentage of students who do not have access to Regents Chemistry is directly related to the poverty level of the district in which they attend high school is .404 at the (p<0.05) level. The percentage of students who do not have access to Regents Chemistry is directly related to the percentage of minority students in the district in which they attend high school is .479 at the (p<0.01) level. The percentage of minority students in a district is directly related to the poverty level in the district in which they attend school is .568 at the (p<0.01) level A further finding was that there is no significant relationship between poverty level of a district and the percentage of English Language Learners who attend school in that district.

Table 19 – Chemistry Access by Poverty level, Demographic and ELL Percentages
(New York State Testing and Accountability Reporting Tool, 2010)
http://www.p12.nysed.gov/irs/pmf/2010-11/home.html)

District	% of Students w/o Access	District Poverty Level	Minority	ELL
1	0.0%	50.0%	64.0%	12.0%
2	17.5%	8.9%	58.0%	12.0%
3	12.7%	12.0%	67.0%	9.0%
4	35.1%	45.6%	93.0%	13.0%
5	38.8%	44.3%	95.0%	11.0%
6	3.7%	40.9%	97.0%	36.0%
7	29.3%	65.0%	98.0%	19.0%
8	16.2%	44.2%	90.0%	12.0%
9	52.0%	59.7%	97.0%	25.0%
10	12.8%	49.0%	87.0%	22.0%
11	18.2%	35.7%	87.0%	11.0%
12	37.8%	66.7%	98.0%	19.0%
13	19.9%	35.0%	77.0%	4.0%
14	13.4%	43.9%	34.0%	13.0%
15	67.7%	36.2%	67.0%	16.0%
16	3.6%	46.1%	99.0%	3.0%
17	16.2%	37.8%	96.0%	9.0%
18	29.0%	34.3%	98.0%	5.0%
19	39.5%	50.5%	94.0%	13.0%
20	0.0%	45.9%	32.0%	26.0%
21	10.8%	45.1%	43.0%	16.0%
22	0.0%	32.9%	57.0%	10.0%
23	0.0%	51.9%	98.0%	4.0%
24	9.4%	36.5%	66.0%	26.0%
25	4.4%	33.3%	40.0%	19.0%
26	0.0%	11.7%	31.0%	8.0%
27	4.1%	35.6%	66.0%	10.0%
28	0.0%	20.7%	55.0%	11.0%
29	0.0%	29.7%	85.0%	7.0%
30	0.0%	33.5%	62.0%	23.0%
31	0.0%	9.8%	38.0%	6.0%
32	53.0%	51.6%	97.0%	19.0%

Figure 20 - Percentage of students without access to Regents Chemistry by District



Behavioral Factors

The next sets of data included the percent of students who plan to attend 4-year college, the 4-year high school graduation rate and the following factors: over-aged students in the high schools, the safety index of the school and attendance rates. (See Table 20) These indicators are considered secondary in terms of academics but they help to flesh out the dynamics of the study as many of these factors have the ability to thwart academic growth.

At this point a further explanation of the school safety index is needed. The safety index is a subjective value that can be found on the Learning Environment Survey under the domain titled “Safety and Respect”. This value (which ranges from 0-10, with 10 being the most favorable) is derived from the survey results of parents, teachers and students and measures the degree to which a physically and emotionally secure school environment is perceived. The rationale for this measure is the feeling that students who feel safe are more able to function in this type of academic environment. Answers to survey questions in four general areas (academic expectations, safety and respect, communication and engagement) create the measurement for this domain. Over-aged students are defined as those that are at least one full year behind the other students in their cohort. Many students in urban areas fall into this category for several reasons. These will be discussed at length in the conclusion but some possible reasons are transient populations, recent immigrants, students who have missed extended periods of schooling due to illness or other reasons and lack of credit accumulation in the high school years.

Figure 21 – Chemistry Enrollment by Poverty Level and Behavioral Factors

Correlations

		Dist. Poverty	Chem Enroll	Over Age	Attendance	Safety	Suspension
District Poverty	Pearson Correlation	1	-.222	**.391***	-.184	.085	.137
	Sig. (2-tailed)		.221	.027	.313	.642	.454
	N	32	32	32	32	32	32
Chemistry Enrollment	Pearson Correlation	-.222	1	-.228	.139	-.004	-.162
	Sig. (2-tailed)	.221		.209	.448	.984	.375
	N	32	32	32	32	32	32
Over Aged	Pearson Correlation	**.391***	-.228	1	**-.510****	-.073	**.392***
	Sig. (2-tailed)	.027	.209		.003	.692	.027
	N	32	32	32	32	32	32
Attendance	Pearson Correlation	-.184	.139	**-.510****	1	**.490****	**-.584****
	Sig. (2-tailed)	.313	.448	.003		.004	.000
	N	32	32	32	32	32	32
Safety	Pearson Correlation	.085	-.004	-.073	**.490****	1	**-.356***
	Sig. (2-tailed)	.642	.984	.692	.004		.046
	N	32	32	32	32	32	32
Suspension	Pearson Correlation	.137	-.162	**.392***	**-.584****	**-.356***	1
	Sig. (2-tailed)	.454	.375	.027	.000	.046	
	N	32	32	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

Table 20 – Chemistry Access by District with Poverty levels and Behavioral Factors
New York City Department of Education, http://schools.nyc.gov/default.htm

D	District Poverty Level	Chemistry Enrollment	% Overage	Attendance	Safety	Suspension
1	50.0%	25.5%	5.4%	87.8%	72.0%	8.0%
2	8.9%	19.6%	7.5%	86.7%	75.0%	7.0%
3	12.0%	13.0%	7.3%	85.0%	71.0%	15.0%
4	45.6%	18.6%	6.1%	85.0%	74.0%	9.0%
5	44.3%	24.1%	5.7%	84.6%	70.0%	10.0%
6	40.9%	14.3%	7.9%	89.3%	75.0%	0.0%
7	65.0%	8.4%	9.4%	85.1%	74.0%	11.0%
8	44.2%	4.8%	9.1%	84.0%	71.0%	10.0%
9	59.7%	15.5%	8.4%	85.1%	72.0%	11.0%
10	49.0%	21.1%	11.0%	87.0%	74.0%	8.0%
11	35.7%	11.2%	9.1%	87.8%	71.0%	8.0%
12	66.7%	16.0%	13.5%	82.6%	73.0%	14.0%
13	35.0%	21.8%	5.5%	86.6%	72.0%	6.0%
14	43.9%	16.2%	6.8%	84.1%	72.0%	10.0%
15	36.2%	14.5%	4.9%	84.3%	71.0%	13.0%
16	46.1%	7.4%	7.1%	83.1%	70.0%	14.0%
17	37.8%	14.0%	7.7%	86.2%	70.0%	12.0%
18	34.3%	19.2%	10.1%	83.1%	69.0%	21.0%
19	50.5%	12.0%	9.3%	81.5%	68.0%	8.0%
20	45.9%	12.4%	8.4%	88.9%	76.0%	3.0%
21	45.1%	19.7%	8.2%	85.6%	72.0%	12.0%
22	32.9%	28.4%	3.1%	91.2%	76.0%	3.0%
23	51.9%	17.3%	5.5%	81.9%	69.0%	12.0%
24	36.5%	14.0%	4.4%	90.3%	75.0%	5.0%
25	33.3%	19.2%	2.9%	90.7%	72.0%	6.0%
26	11.7%	19.1%	5.9%	84.4%	71.0%	6.0%
27	35.6%	9.2%	3.0%	90.8%	74.0%	8.0%
28	20.7%	20.0%	5.1%	86.9%	63.0%	8.0%
29	29.7%	18.7%	6.7%	90.9%	78.0%	11.0%
30	33.5%	14.9%	2.5%	89.6%	72.0%	6.0%
31	9.8%	17.3%	6.5%	81.0%	75.0%	9.0%
32	51.6%	10.7%	4.6%	89.4%	78.0%	9.0%

These data sets were examined for statistical correlations to chemistry enrollment at the district level. There are several significant correlations in this matrix (See Figure 21) but unfortunately none of them pertain to the access that students have to high school Chemistry. There is a positive and significant correlation ($p<0.05$) to the district poverty level and the percentage of over-aged high school students and the percentage of suspensions in the high schools in the district. There is a significant and inverse correlation ($p<0.01$) between the percentage of over-aged students and the attendance rate in the schools and the attendance and suspension rate in the schools. There is a significant and inverse correlation ($p<0.05$) between school safety and the suspension rate in the school but a significant and positive correlation between safety and attendance in the schools within the districts. However, no significant correlation can be made for the access to Chemistry that the students have in relation to the other metrics in this matrix.

Chemistry Enrollment and Teacher Certification

In the area of chemistry access, the category was divided into four sections: Any high school Chemistry offering, Advanced Placement Chemistry, Regents Chemistry and Non-Regents Chemistry. (See Tables 21-23) The student teacher ratio was determined by dividing the number of chemistry students by the number of licensed Chemistry teachers in the district. In theory, Regents Chemistry classes are mandated to be taught by Chemistry licensed teachers. It then goes without saying that the Advanced Placement Chemistry courses should also be taught by licensed Chemistry teachers as the students who succeed in this courses will earn college credits for their efforts. In addition, this level of Chemistry is quite rigorous and would need the pedagogical and content knowledge of an expert in the field.

Figure 22 – Chemistry Enrollments by District and Certified Teacher

Correlations

		District Poverty	Any Chemistry	A. P. Chemistry	Regents Chemistry	Non-Regents Chemistry	Teacher Student Ratio
District Poverty	Pearson Correlation	1	-.222	**-.386***	-.304	.089	-.300
	Sig. (2-tailed)		.221	.029	.091	.629	.095
	N	32	32	32	32	32	32
Any Chemistry	Pearson Correlation	-.222	1	**.456****	**.792****	**.519****	**.349***
	Sig. (2-tailed)	.221		.009	.000	.002	.050
	N	32	32	32	32	32	32
A. P. Chemistry	Pearson Correlation	**-.386***	**.456****	1	**.632****	-.220	.052
	Sig. (2-tailed)	.029	.009		.000	.226	.778
	N	32	32	32	32	32	32
Regents Chemistry	Pearson Correlation	-.304	**.792****	**.632****	1	-.107	.252
	Sig. (2-tailed)	.091	.000	.000		.559	.164
	N	32	32	32	32	32	32
Non-Regents Chemistry	Pearson Correlation	.089	**.519****	-.220	-.107	1	.232
	Sig. (2-tailed)	.629	.002	.226	.559		.202
	N	32	32	32	32	32	32
Certified Teacher/ Student Ratio	Pearson Correlation	-.300	**.349***	.052	.252	.232	1
	Sig. (2-tailed)	.095	.050	.778	.164	.202	
	N	32	32	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

It can be seen in the correlation matrix (See Figure 22) that there is no significant correlation between the student teacher ratio in chemistry classes and the poverty level of the district in which the high school are situated. As would be expected as Chemistry access in any of the sub-divisions of Chemistry is increased, so too would any of the subsets of chemistry which exist under this umbrella.

As was stated previously, as the district poverty level increases there is a significant decrease (p<0.01) in the Advanced Placement Chemistry offerings. A point of interest although not at a significant level, is the finding that as the Advanced Placement Chemistry and Regents Chemistry offerings are increasing there is a trend for the non-Regents offerings to decrease. The teacher student ratio is only seen as significant and positive ($p<0.01$) when any Chemistry is offered. (See Figure 22) So it can be said that as the ratio between the number of certified chemistry teachers and the number of chemistry students increases, there is a greater amount of any type of Chemistry offered. This finding would lean toward the fact that there are many cases of chemistry being taught by non-certified teacher.

Table 21 - Total Chemistry Students by Borough (New York State Testing and Accountability Reporting Tool, 2010) http://www.p12.nysed.gov/irs/pmf/2009-10/home.html

	Chemistry Teachers	Regents Chemistry	Non-Regents Chemistry	Advanced Placement Chemistry	Total Chemistry Students	Total High School Population
Manhattan	109	5,827	4,132	410	10,478	56,095
Bronx	90	4,279	2,688	232	7,289	52,433
Brooklyn	124	8,053	5,512	323	14,012	75 878
Queens	96	7,695	4,051	185	12,027	73,014
Staten Island	18	2,051	767	182	3,018	16,734

Table 22 - Total Chemistry Students by Borough – Percentage (New York State Testing and Accountability Reporting Tool, 2010) http://www.p12.nysed.gov/irs/pmf/2009-10/home.html

	Regents Chemistry	Non-Regents Chemistry	Advanced Placement Chemistry	Total Chemistry
Manhattan	9.4%	6.7%	0.07%	17.0%
Bronx	7.2%	4.5%	0.04%	12.2%
Brooklyn	9.1%	6.2%	0.04%	15.8%
Queens	10.0%	5.2%	0.02%	15.6%
Staten Island	11.8%	4.4%	0.01%	17.3%

Table 23 – Chemistry Enrollment with District Poverty Level and Certified Teacher Ratio (New York State Testing and Accountability Reporting Tool, 2010) http://www.p12.nysed.gov/irs/pmf/2009-10/home.html; (New York City Department of City Planning, 2010) http://www.nyc.gov/html/dcp/

District	District Poverty Level	Chemistry Access	A.P. Chemistry	Regents Chemistry	Non-Regents Chemistry	Chemistry Teacher/ Student Ratio
1	50.0%	25.5%	0.0%	15.1%	10.5%	0.6%
2	8.9%	19.6%	0.8%	9.5%	9.4%	0.9%
3	12.0%	13.0%	0.9%	9.3%	2.8%	1.4%
4	45.6%	18.6%	0.0%	15.0%	3.7%	1.0%
5	44.3%	24.1%	1.5%	19.6%	3.1%	1.4%
6	40.9%	14.3%	0.4%	10.6%	3.3%	1.6%
7	65.0%	8.4%	0.3%	6.0%	2.2%	2.0%
8	44.2%	4.8%	0.0%	3.5%	1.3%	2.4%
9	59.7%	15.5%	0.0%	8.7%	6.8%	1.5%
10	49.0%	21.1%	1.1%	12.7%	7.3%	1.0%
11	35.7%	11.2%	0.3%	7.7%	3.1%	1.0%
12	66.7%	16.0%	0.0%	5.0%	11.1%	1.1%
13	35.0%	21.8%	1.2%	15.5%	5.1%	1.3%
14	43.9%	16.2%	0.0%	9.8%	6.5%	1.0%
15	36.2%	14.5%	0.0%	8.0%	6.5%	0.5%
16	46.1%	7.4%	0.0%	1.1%	6.3%	1.0%
17	37.8%	14.0%	0.0%	9.0%	5.1%	1.0%
18	34.3%	19.2%	0.0%	5.7%	13.5%	1.5%
19	50.5%	12.0%	0.0%	4.1%	7.9%	0.9%
20	45.9%	12.4%	0.5%	10.5%	1.5%	0.9%
21	45.1%	19.7%	0.3%	9.0%	10.4%	0.7%
22	32.9%	28.4%	1.0%	17.4%	10.1%	0.6%
23	51.9%	17.3%	0.0%	5.0%	12.3%	1.5%
24	36.5%	14.0%	0.0%	7.1%	6.9%	1.1%
25	33.3%	19.2%	0.0%	12.2%	7.0%	0.6%
26	11.7%	19.1%	0.4%	14.7%	4.0%	0.7%
27	35.6%	9.2%	0.2%	8.2%	0.9%	1.2%
28	20.7%	20.0%	0.5%	11.5%	8.2%	0.4%
29	29.7%	18.7%	0.0%	9.9%	8.8%	1.4%
30	33.5%	14.9%	0.5%	8.4%	6.1%	0.9%
31	9.8%	17.3%	1.1%	11.8%	4.4%	0.6%
32	51.6%	10.7%	0.0%	4.1%	6.6%	0.6%

Survey Results

In interpreting survey results, all sample surveys are subject to possible sampling error; that is, the results of a survey may differ from those which would be obtained if the entire population were interviewed. The size of the sampling error depends upon the total population and the size of samples collected.

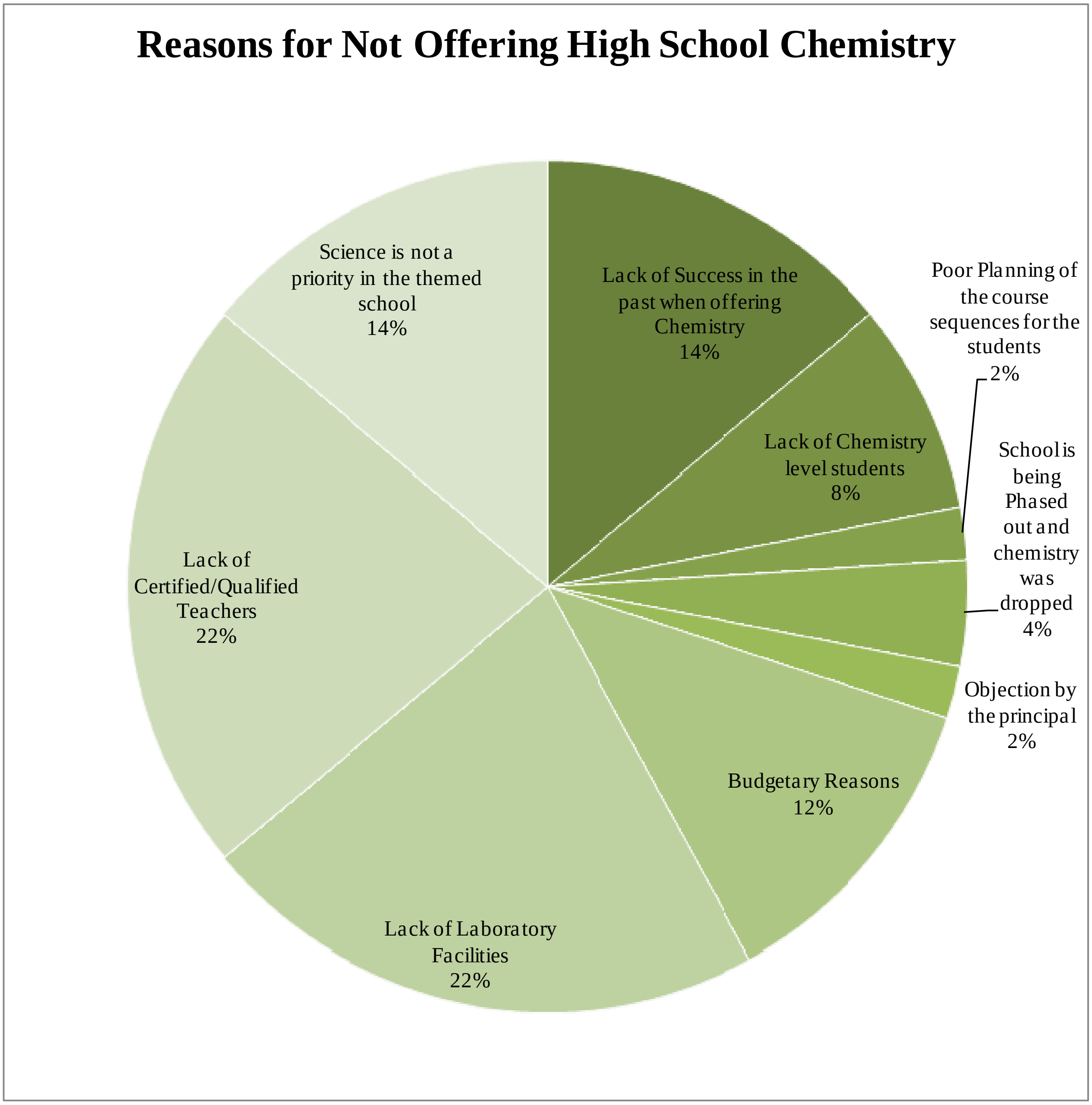
In addition to the statistical data that was collected from the various public websites, a brief survey was sent to the administrators in the high schools in New York City. (See Appendix A) The intended audience was either the principal of the school or the Assistant Principal of Science. In total, there were 128 responses collected. The main focus question of the survey was to determine why chemistry might not be taught in some of the high schools if in fact the school did not offer chemistry. There were 128 collected responses of the possible 358 high schools in New York City that serve the general population. This represents 35.5% of the total. Of the 128 responses, 35 of the administrators of the schools indicated that they did not offer any chemistry. (See Table 24) Based on a review of school websites, 86 high schools in the city do not offer chemistry and so the survey results encompass 41% of those high schools. The breakdown of the responses by borough is as follows: Manhattan (9), Bronx (6), Brooklyn (11), Queens (8) and Staten Island (1). This number represents schools without high school chemistry in any of the three categories (Regents, Non-Regents and/or Advanced Placement Chemistry). The reasons provided for the lack of chemistry in the school surveys can be seen in Table 24.

Table 24 – Survey Results from Schools Not offering high school chemistry

Reason*	Number
Lack of Success in the past when offering Chemistry	7
Lack of Chemistry level students	4
Poor Planning of the course sequences for the students	1
School is being Phased out and chemistry was dropped	2
Objection by the principal	1
Budgetary Reasons	6
Lack of Laboratory Facilities	11
Lack of Certified/Qualified Teachers	11
Science is not a priority in the themed school	7

*Some surveys included more than one reason

Figure 23 - Survey Results for High School Chemistry Access in New York City



The reasons are varied and several of the surveyed schools indicated more than one reason. (See Table 24) However, the consistently repeated responses which bubbled to the surface (See Figure 23) included lack of laboratory facilities (22%), lack of certified/qualified teachers (22%), a lack of success in the school when chemistry was offered in the past (14%) and science being of less priority in the themed schools (14%).

A Pearson Correlation matrix (See Figure 24) was created to determine if the percentage of responses is indicative of the entire city and can be viewed as a fair representation. Eighteen measurements were compared between the total number of participating high schools (358) and the high schools that completed the survey (128), as sub-set of the total participating high schools. (See Table 25).

Table 25 – Eighteen Points of Comparison between All Participating High Schools and the Subset of Participating High Schools that completed the survey

	Surveyed High Schools	All High Schools
Manhattan Schools	35	86
Bronx schools	39	99
Brooklyn Schools	25	107
Queens Schools	21	57
Richmond Schools	8	9
Small Schools	83	236
Medium Schools	26	79
Large Schools	19	43
Minority Total	80567	231197
HS pop Total	113490	288037
M-HS students	21312	57025
X-HS students	23535	56568
K-HS students	23774	81546
Q-HS Students	30270	75734
R-HS Students	14599	17164
Small School Students	35314	96792
Medium School Students	22734	68155
Large School Students	55442	123090
Total High Schools	**128**	**358**

As seen in Figure 24, the correlation coefficient between the surveyed schools and all of the high schools in New York City is positive and equal to .992. The correlation is significant at the alpha = 0.01 level. This can be interpreted at a significance level of 99%. In other words, there is a correlation or relationship between the eighteen measures (N = 18) used to determine if the surveyed schools are a fair representation of all of the high schools asked to complete the survey. As such, it can therefore be assumed that the survey responses are indicative of the city schools as a whole.

Figure 24 – Correlation between all high schools in New York City and the subset of high schools in New York City that returned completed surveys

Correlations

		Surveyed	All High Schools
Surveyed Schools	Pearson Correlation	1	**.992****
	Sig. (2-tailed)		.000
	N	18	18
All High Schools	Pearson Correlation	**.992****	1
	Sig. (2-tailed)	.000	
	N	18	18

**. Correlation is significant at the 0.01 level (2-tailed).

Principals' Interviews

The final section of data that was gathered was through interviewing three New York City public high school principals. (See Appendix C) The criterion for selection of these principals was based on school size and science offerings at the school during the 2009-2010 school year. Each of the three schools falls into a different category based on school size. All of the schools serve the general high school population. All three of the interviews were done on a face to face basis.

1. Large Comprehensive High School

The school is located in midtown Manhattan and had a total population of 2,749 students in 2009-10. The schools population was comprised of 31% Black, 52% Hispanic, 3% White and

14% Asian. Approximately 65% of the families of the students in the school received some form of public assistance and there were 284 students enrolled in Regents Chemistry (10.3%). When asked how the selection was made for the science offerings in the school and more specifically, the Chemistry offerings in the school, the principal explained that this school is not necessarily focused in the sciences but felt that it was important at the high school level to give the students the opportunity to select and pursue science. The criteria for selection for the Regents Chemistry coursework, the only chemistry offering in this school, is done solely by the guidance counselors who are assigned the students in his/her caseload. A major component of whether or not Regents Chemistry is programmed for the child is the prior success in the Living Environment coursework and the Algebra I coursework. It is felt by the principal – and endorsed by the cabinet – that students who excel in the Living Environment coursework have an interest in the sciences. Additionally, it is assumed that students who show competence in mathematics will fare well in Regents Chemistry. Another issue that the principal brought to light was the fact that the school's rating is based on student success on each grade level. Success is defined as taking and completing ten credits of coursework for each school year. This school has received a "C" rating for the last two consecutive years. As a result, the guidance counselors have received training on course assignments for the students in their cohort and must get special sign-off permission from the Assistant Principal of Guidance for courses that are deemed more rigorous than average. Regents Chemistry is one of these courses. The principal indicated that making these decisions is difficult in any climate but especially now that the impacts of the student achievement are directly felt at the school quality level and as such, may influence parents in their decision to send their child to the school.

2. Medium High School

With an enrollment of 1493 students in 2009-10, this high school is located in the southeast section of Manhattan. The school population comprises 24% Black, 51% Hispanic, 5% White and 19% Asian. Approximately 75% of the families of the students in the school received some form of public assistance and there were 458 students enrolled in Regents Chemistry (30.6%). As reported by the then principal, the Advanced Placement Science courses in the school were selected due to the overall popularity of the courses by the students. Fortunately, this is a school with a health care theme. Because of this, there is a larger than average number of science teachers certified in biology, chemistry and physics with a few teachers holding dual certification. In the early spring of the previous year, the guidance department distributes a questionnaire to the members of the junior class after discussing course selection with the school's cabinet. The results of these surveys, along with the individual guidance given to each of the students, helps to shape the course offerings for the senior year. Other areas of focus when offering electives in the senior year are the budget and the number of students in each of the courses. As explained by the principal, the courses are actually in competition with one another and in order for a course to be offered, it must garner a significant number of students. The budget does not pertain so much to supplies for the course as it does for the human capital in the school to offer the course. Since the mandatory science courses must be offered to all of the students in the school, and each full programmed teacher carries five sections of courses, only one Advanced Placement course in science can be offered each year. Historically in this school, A.P. Chemistry and A.P. Biology are offered every other year or stated differently, A.P. Chemistry is offered during the odd numbered school year and A.P. Biology during the even numbered school year.

Advanced Placement Physics and Advanced Placement Environmental Science had never been offered during this principal's tenure.

3. Small High School

The small school selected is in the southwest Bronx and has a total population of 366 students in the 2009-2010 school year. The school population comprises 38% Black, 60% Hispanic, 1% White, and 1% Asian students. The student body includes 13% English language learners and 11% special education students. 73% of the students that attend the school are eligible for free lunch. Chemistry is not offered at this school and the principal mentioned several reasons for this decision. When interviewed, the principal was quite clear about the focus of his school and the reasons behind the programming decisions. He is the founding principal of the school and from its inception, the focus has been on using the arts to enhance the motivational level and thus, their learning. Being a small school, this focus limits the number of mathematics and science courses that are offered to the student body. While the principal feels that these are important for certain populations of students that show interest in science and mathematics, he feels that this is not the type of student who is drawn to his school.

In the students' choice of high schools, the theme of the school is made quite clear to the students and the parents. Through articulation in the neighborhood middle schools and at the High School Fair held at Brooklyn Tech each fall, the messaging about the school is its small size, the community atmosphere that is fostered and the liberal arts focus for the students.

This school is one of several small schools that currently occupied a large school that is slowly being phased out. Another small high school within the building has science and technology as its thematic focus. The principal feels that students who are more prone to this way of thinking and achieving should be guided to the science themes school within the building. In closing the principal did see that in the future some of his students may want to pursue some of the more advanced sciences (currently the school offers, Regents Living Environment, Environmental Science and Forensics) and he hopes to be able to have some cross-over among the schools in the building so that all of the students within this setting will be given opportunities similar to those offered in a larger school site.

Enrollment in Higher Order Science in New York City (2003-2010)

To put this access to the high order sciences in perspective for the city of New York, an overview of Regents Chemistry and Regents Physics was tracked over the course of the last seven school years. (See Table 26) This data was taken from the NY State public website (New York State Testing and Accountability Reporting Tool or nyStart) and sites the number of Chemistry and Physics Regents examinations for each borough. This information does not include the level of success on the Regents examinations for any of the schools or boroughs but is just meant to supply an overview of access for the high school students in New York City. As stated at the onset of this study, the rate of S.T.E.M. related careers opportunities has growth threefold in comparison to other employment opportunities. (See Figure 1) Relatively speaking, the educational system in New York City has not been keeping pace with this growing trend and economic need. A more concerted effort must be initiated in the schools in New York City as well as other urban areas in America to be able to convert this tipping point from negative to positive.

Table 26 – Higher Order Science Regents Totals for New York City (2003-2010) (www.nystart.gov/nystart/ - New York State Testing and Accountability Reporting Tool, 2011)

Borough	Subject	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010
Manhattan	Regents Chemistry	2.1%	9.2%	10.3%	10.9%	10.9%	10.9%	10.4%
	Regents Physics	2.6%	4.3%	4.3%	4.7%	4.4%	4.9%	4.7%
Bronx	Regents Chemistry	6.7%	7.1%	7.0%	7.8%	7.7%	8.3%	8.1%
	Regents Physics	2.7%	2.5%	2.6%	2.9%	2.8%	3.2%	3.3%
Brooklyn	Regents Chemistry	11.6%	10.5%	10.4%	11.6%	11.6%	12.2%	11.9%
	Regents Physics	4.5%	4.2%	4.0%	4.6%	4.6%	4.6%	5.3%
Queens	Regents Chemistry	8.1%	8.9%	9.0%	10.0%	9.6%	10.6%	10.5%
	Regents Physics	3.4%	3.6%	3.8%	3.7%	4.4%	4.3%	4.6%
	Regents Chemistry	11.2%	11.1%	10.5%	12.7%	12.6%	12.6%	12.3%
Richmond	Regents Physics	5.3%	5.5%	5.1%	5.1%	5.3%	5.8%	6.3%

Correlations were done for the five boroughs during the course of the seven years analyzed. The data for Regents Chemistry and Regents Physics was analyzed using the SPSS software. (See Figure 25). As the years increased there was a significant increase in enrollment of chemistry students in both the Bronx and Queens.

Figure 25 – Correlation between the Regents Chemistry enrollments in the boroughs, 2003-10 (www.nystart.gov/nystart/ - New York State Testing and Accountability Reporting Tool, 2011)

Correlations

		YEAR	M Regents Chemistry	X Regents Chemistry	K Regents Chemistry	Q Regents Chemistry	R Regents Chemistry
YEAR	Pearson Correlation	1	.694	**.945****	.625	**.925****	.711
	Sig. (2-tailed)		.084	.001	.134	.003	.073
	N	7	7	7	7	7	7
Manhattan Regents Chemistry	Pearson Correlation	.694	1	.717	.017	.695	.432
	Sig. (2-tailed)	.084		.070	.971	.083	.333
	N	7	7	7	7	7	7
Bronx Regents Chemistry	Pearson Correlation	.945**	.717	1	.683	.995**	.829*
	Sig. (2-tailed)	.001	.070		.091	.000	.021
	N	7	7	7	7	7	7
Brooklyn Regents Chemistry	Pearson Correlation	.625	.017	.683	1	.682	.825*
	Sig. (2-tailed)	.134	.971	.091		.091	.022
	N	7	7	7	7	7	7
Queens Regents Chemistry	Pearson Correlation	.925**	.695	.995**	.682	1	.837*
	Sig. (2-tailed)	.003	.083	.000	.091		.019
	N	7	7	7	7	7	7
Richmond Regents Chemistry	Pearson Correlation	.711	.432	.829*	.825*	.837*	1
	Sig. (2-tailed)	.073	.333	.021	.022	.019	
	N	7	7	7	7	7	7

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 26 – Correlation between the Regents Physics enrollments in the boroughs, 2003-10 (www.nystart.gov/nystart/ - New York State Testing and Accountability Reporting Tool, 2011)

Correlations

		YEAR	M Regents Physics	X Regents Physics	K Regents Physics	Q Regents Physics	R Regents Physics
YEAR	Pearson Correlation	1	-.129	**.872***	.735	**.951****	.660
	Sig. (2-tailed)		.784	.011	.060	.001	.107
	N	7	7	7	7	7	7
Manhattan Regents Physics	Pearson Correlation	-.129	1	-.356	-.562	-.097	-.382
	Sig. (2-tailed)	.784		.433	.190	.836	.398
	N	7	7	7	7	7	7
Bronx Regents Physics	Pearson Correlation	.872*	-.356	1	.890**	.757*	.751
	Sig. (2-tailed)	.011	.433		.007	.049	.052
	N	7	7	7	7	7	7
Brooklyn Regents Physics	Pearson Correlation	.735	-.562	.890**	1	.656	.795*
	Sig. (2-tailed)	.060	.190	.007		.109	.033
	N	7	7	7	7	7	7
Queens Regents Physics	Pearson Correlation	.951**	-.097	.757*	.656	1	.684
	Sig. (2-tailed)	.001	.836	.049	.109		.090
	N	7	7	7	7	7	7
Richmond Regents Physics	Pearson Correlation	.660	-.382	.751	.795*	.684	1
	Sig. (2-tailed)	.107	.398	.052	.033	.090	
	N	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

It can be seen that the only significant correlation between year of the data collection and the geographic area where there is a positive increase in the percentage of students taking Regents Chemistry and Regents Physics is in the boroughs of the Bronx and Queens (See figures 25 and 26). For Regents Chemistry, this correlation is equal to .945 and .925 respectively at the

(p <0.01 level) indication that this association did not occur by happenstance. Stated another way, there is a significant increase in the percentage of students enrolled in Regents Chemistry (See Figure 25), in the boroughs of Queens and the Bronx from the 2003-04 school year through the 2009-10 school year.

Similarly, the increase in the enrollment of Regents Physics (See Figure 26) can be found in the same two boroughs: The Bronx and Queens. The correlation is equal to .872 in the Bronx at the (p <0.05) level and is equal to .951 in Queens at the (p <0.01). Each indicates that the association is high for increased enrollment in these two boroughs.

Chapter 5 – Conclusions, Implications and Future Work

Introduction

This chapter presents the interpretation of the data and a discussion of the implications for future work in this area of research. The purpose of this study was to determine if there were inequities in the access and entrance to high school chemistry in the public high schools in New York City. Also included in this chapter are the embedded inequities pertaining to the field of Science, Technology, Engineering and Mathematics education (S.T.E.M.) and how this impacts educational and employment opportunities.

Significant Findings

Some of the most significant findings in this study are:

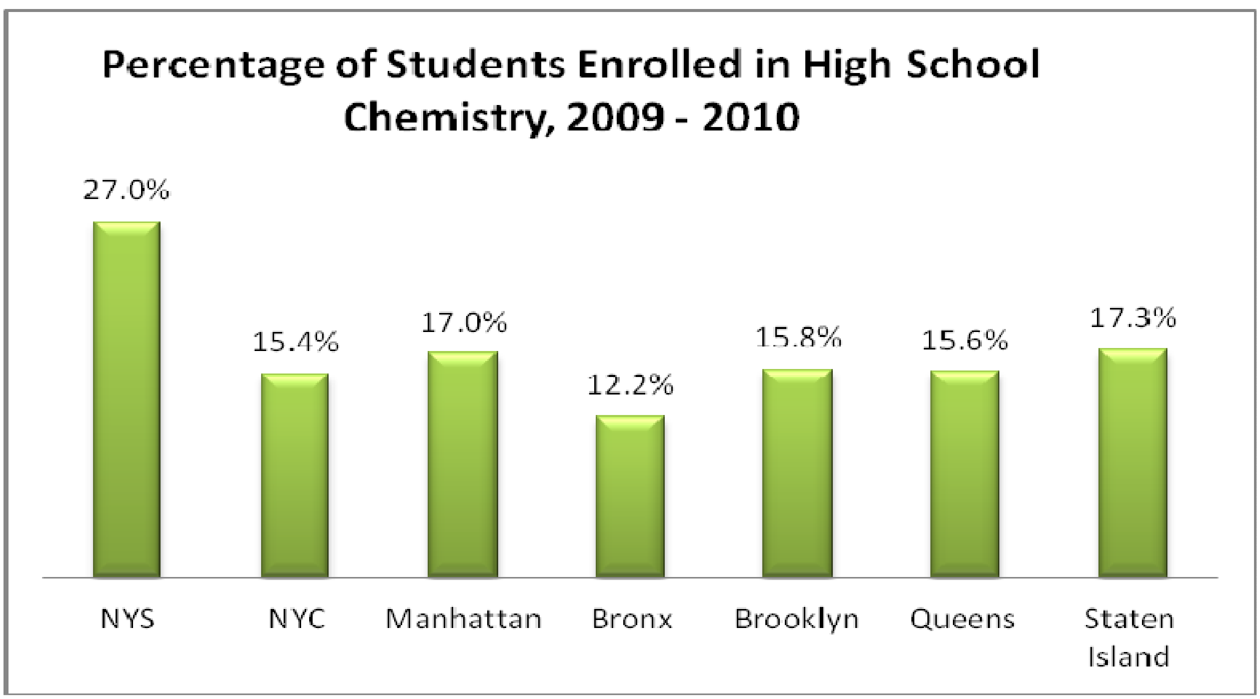
1. There are substantial inequities in the distribution of chemistry offerings in the New York City public high schools. 24% of the high schools included in this study did not offer chemistry. The poverty level of the population in the school district and certain identified characteristics of the students in the schools within the school district strongly correlate to the access to chemistry in that district. (See Table 19)
2. The bulk of the schools that offer no chemistry access (seventy-nine of the eighty-six or 91%) are small schools. However, if chemistry is made available in the small schools, it is most frequently in the form of Non-Regents Chemistry. A sizeable number (134/299 or 45%) of these small schools were launched through the small school movement and served to replace the large comprehensive high schools. (See Table 15)
3. The large, comprehensive high schools that serve the general education population offer scant opportunities for Advance Placement Chemistry but the majority of the Regents Chemistry offerings in the city are in the large high schools. (See Table 15)

4. The poverty level of a geographic area within New York City has a significant correlation to the following student factors in the schools: student demographics, access to chemistry, mathematics achievement, science achievement, four year graduation rate and student socioeconomic level based on free lunch data. (See Tables 13 – 17)
5. The poverty level of a geographic area within New York City had a significant correlation to the following facilities based factors in the schools: access to chemistry courses, access to chemistry labs, student expenditure and access to certified chemistry teachers. (See Table 15)

Examination of the Research

How does chemistry enrollment in New York City, by borough and by district, compare to the state and national enrollments in chemistry?

Figure 27 - Comparisons of High School Chemistry Enrollments (2009-10)
(New York State Testing and Accountability Reporting Tool, 2010)
http://www.p12.nysed.gov/irs/pmf/2010-11/home.html



Access to high school chemistry in the New York City public schools during the 2009-2010 school year was seen to be restricted. (See Figure 27) Although 27.0%of the high school students in the New York State were enrolled in some form of chemistry, the overall enrollment was a scant 15.4% in the City of New York. Each of the boroughs had varying percentages of students enrolled in some type of chemistry (Manhattan, 17.0%, Bronx, 12.2%, Brooklyn, 15.8%, Queens, 15.6% and Staten Island, 17.3%) and the thirty-two districts had a wide-ranging fluctuation in the amount of chemistry offered in the high schools within the district, with School District #8 in the Bronx having 4.8% of its high school students in chemistry classes at the low end and School District #22 in Brooklyn having 28.4% of its students in high school chemistry at the high end of the spectrum. (See Table 23)

The quality of the courses taken in high school is a greater predictor of college success than test scores, class rank or grade point average. (Barth & Haycock, 2004) One of the basic challenges to America's competitiveness in the world economy is based on the preparation of students in STEM education. Some of the most lucrative jobs with the highest paying salaries continue to be found in this field. The average annual wage for all STEM occupations was $77,880 in May 2009, and only 4 of the 97 STEM occupations had mean annual wages below the U.S. average of $43,460. (Cover, et al, 2011). In terms of the global economy, careers that depend on a deep understanding and background in science and mathematics are deemed necessary for economic success and elevation in terms of social capital. In order for this to become a reality for the next generation of our workforce, a greater emphasis should be placed in this area throughout the K-16 education spectrum. It is highly unlikely that a student will select S.T.E.M as an occupational goal let alone succeed, if prior opportunity to access the subject matter is not made available. Students must be given the opportunity to tackle the more rigorous courses in mathematics and science during their high school years for several reasons. These courses are not only necessary for students in terms of bolstering the scientific and technological labor force, the demands of 21st century existence are such that they necessitate a scientifically literacy and informed citizenry. Chemistry is an integral piece of this rigorous educational foundation that is needed by every high school student.

Although research has continually emphasized the need for higher order or more rigorous mathematics and science for American students, the reality of the high school course sequence in the City of New York, its five boroughs, and most significantly, the thirty-two school districts within those boroughs tells a different story.

The socioeconomic status of the city as a whole is seen through its poverty level as compared to the State of New York and the nation (See Table 12). New York City has a poverty level of 20.1% as compare to 15.3% for the state and 15.1% for the nation. (U.S. Census Bureau, 2010) Being the largest urban environment in the United States affords New York City a vastly diverse population with extremes in every social and economic perspective. The five boroughs are even more complex.

New York City's Five Boroughs

Table # 27 - The Boroughs of New York City (New York City Department of City Planning, 2010) http://www.nyc.gov/html/dcp/html/neighbor/neigh.shtml

Borough	Population	Area	Poverty	Number of High Schools*	High School Population	Chemistry Enrollment	% HS Minority
Manhattan	1,585,873	23 mi^2	17.6%	113	56, 095	17.0%	40.6%
Bronx	1,385,108	42mi^2	27.1%	122	52,433	12.2%	85.4%
Brooklyn	2,504,700	71mi^2	21.9%	143	75,878	15.8%	57.7%
Queens	2,230,722	109mi^2	12.0%	68	73,014	15.6%	49.1%
Richmond	468,730	58mi^2	9.8%	10	16,734	17.3%	31.9%

*This number includes general education and specialized high schools

Manhattan is the smallest borough in size and has the highest population density with 68,951 people per square mile. (See Table 27) Its overall poverty level is 17.6% which is the third highest of the boroughs. However, as with all of the boroughs, poverty level will vary from neighborhood to neighborhood within the borough. The highest poverty level in Manhattan is in School District #1 which encompasses the Lower East Side, the Bowery and the East Village. This school district has a large Asian population (21%) (See Table 16) and access to chemistry in high school is the highest for the borough (25.5%). The percentage of public high school students in Manhattan taking some form of Chemistry was 17.0% during the 2009-10 school year. (See Table 22) This represented the 2nd highest percentage of the five boroughs. Chemistry access is directly related to the Asian and White populations in a school district. This will be addressed at length later in this chapter. There are 113 public high schools in the borough and of these, three are specialized high schools which require additional admission qualifications. They are Stuyvesant High School, the High School for Math, Science and Engineering at CCNY and Fiorello LaGuardia High School. Twenty-three percent or 26/113 of the public high schools sprang from the new small school movement.

The Bronx is the poorest borough of the five with an average poverty level of 27.1%, significantly higher than the national poverty rate. (See Table 27) The poorest area in the Bronx is School District # 12 which has an astounding 66.7% poverty rate. The neighborhoods in this area include Castle Hill, Hunts Pont and the South Bronx. There are 32,980 people per square mile and 37.8% of the high school students in this area do not have any access to chemistry. (See Table 22) 98% of the high school population is classified as minority with 29% Black and 68% Hispanic. (See Table 16) Total access to some type of chemistry course in the Bronx is 12.2%, the lowest in the city. There are 122 public high schools in the Bronx with many of these originating through the new small school movement (55/122 or 45%). There are two specialized high school in the Bronx; the Bronx High School of Science and the High School of American Studies at Lehman College. These specialized schools serve the city, not just the Bronx.

Brooklyn is the most populous borough (2,504,700) and has the second highest poverty level, with 21.9% of its residents living in poverty. The poorest geographic area is school district #23 (51.9%) (See Table 12) which slightly edged out school district #32 (51.6%). School District #23 encompasses Brownsville, Bushwick and East New York while School District #32 is concentrated in the remaining section of Bushwick. Because these school districts overlap to some extent and have very similar poverty levels, they will be addressed as one in the section. The high schools in both of these school districts do not offer A.P. Chemistry and Regents Chemistry enrollments in the districts are 4% and 5% respectively. The percentage of minority students in the districts is 98% in District #23 with 81% being Black and 97% in district #32 with 72% being Hispanic. There is a 17.3% chemistry access rate (See Table 17) in the predominantly Black District #23 while there is a 10.7% chemistry access rated in the predominantly Hispanic District #32. The average for the rate of access and enrollment in some form of Chemistry is 15.8% for the borough of Brooklyn. There are 143 public high schools in Brooklyn with approximately one-quarter of these (28%) originating from the new small school movement. There are two specialized high schools in Brooklyn; Brooklyn Technical High School and the Brooklyn Latin School. These specialized schools serve the city, not just Brooklyn.

Queens is the largest borough in area, expanding for 109 square miles. (See Table 27) Queens has the second lowest poverty rate at 12.0%, less than that of the State of New York or the nation. There are 20,465 people per square mile and the public high schools in Queens serving the general population offer 15.6% Chemistry access. This is very similar to the access that the students receive in Brooklyn. However the level of rigor is different with Queens offering Regents Chemistry to more of their students and Brooklyn offering the non-standardized Non-Regents chemistry more often. The most deficit school district in terms of access to chemistry in high school is District #24. It has a poverty rate of 36.5% and the total minority population in the high schools in this district is 66% with 62% being Hispanic. (See Table 17) There is no Advanced Placement Chemistry given in this district for the general high school population. This district borders Bushwick and includes Long Island City, Fresh Pond and Glendale. There are 68 public high schools in Queens and 14 have evolved during the small school movement (21%). The one specialized high school in Queens is the Queens High School of Science at York College.

The fifth and smallest borough in terms of population and population density is Staten Island. There are 468,730 residents in this borough and there are 8,082 people per square mile. (See Table 27) This borough's school district is unique in that the entire borough is defined by one school district. Staten Island has the lowest poverty rate, at 9.8% and is an anomaly due to the fact that its high school population is predominantly in large school settings and none of the large schools on Staten Island have been closed or reorganized. In other words, this school district/borough has not felt any impact from the small school movement. One high school in the borough is designated as specialized, Staten Island Technical High School. All ten high schools on Staten Island offer Regents Chemistry so access to Chemistry in District #31 is 100% when taken at the school level. (See Table 17) The percentage of students enrolled in some form of Chemistry is 17.3%, the highest percentage among the five boroughs.

When focusing on the data available it can be seen that the percentage of high school enrollment in chemistry is unbalanced, with the largest percentage of students enrolled in chemistry in Staten Island, the borough with the smallest minority population and the lowest poverty level. Inversely, the Bronx, the borough with the largest minority population and the highest level of poverty also has the smallest number of students enrolled in high school chemistry. Taken one step further, this inequity is even more dramatic on the district or neighborhood level. The areas of the city with the highest poverty level are located in School Districts 7 and 8 – both located in the Bronx. The geographic area that these districts encompass is the Southwest Bronx and includes the neighborhoods of Mott Haven, Melrose, Morrisania, Hunts Point and Tremont. (See Table 17) Not only do these two adjacent districts have the highest poverty rates, at 65% and 44% respectively, they also have among the highest levels of minority students with a corresponding 98% and 90%. Enrollment in high school chemistry is 8.4% and 4.8% respectively; two of the lowest percentage rates in the city.

In contrast, the two school districts that have the lowest percentage of poverty are District 2 in Manhattan at 8.9% and District 31, which encompasses the borough of Staten Island at 9.8%. Coincidentally, these two areas have a minority student level of 58% and 38% respectively. District 2 encompasses most of Manhattan up to the southern border of Central Park and then is adjacent to the park on the northeast side up to and including East 95th Street. (See Table 17) Enrollment in high school chemistry in District 2 is the highest in the city at 19.6% and 17.3% on Staten Island or District 31. This is a good example when discussing the individual districts rather than taking the borough as a whole. The two highest districts are miles apart and yet have similar enrollment in high school chemistry. This would not have been evident if the analysis was only taken at the borough level.

Are there statistical correlations between chemistry access and racial status (Black, Hispanic, White, Asian/Other); socioeconomic status (percentage of free lunch students); percent English Language Learners?

The correlation between the percentage of students receiving free lunch and their overall access to Chemistry was seen as significant. (See Figure 15) Free Lunch students had lower enrollment levels in high school chemistry and more specifically, in Regents Chemistry and

Advanced Placement Chemistry with a 95% level of correlation confidence. (See Figures 17 and 16, respectively) This finding points to the fact that poor children are less likely to have access to and enrollment in the more rigorous high school chemistry offerings. There was no significant correlation between free lunch student and Non-Regents Chemistry, (See Figure 18) indicating that this type of chemistry course is offered with fewer if any restrictions to the students in the New York City public high schools. There are several possible reasons for this trend including less stringent requirements both by the student and the administration in terms of a licensed teacher and required laboratory seat time. Non-Regents Chemistry courses, like all high school science courses, must offer a laboratory component to the class. However, it is only in the Regents courses that a set time is mandated by the State of New York. Similarly, the Regents or Core science courses requires than the instructor have a certification in that specific science whereas, non-Regents science courses do not carry that particular requirement. Finally, non-Regents courses are not required to include the units that compose the Regents Chemistry coursework. These are quite rigorous and include a heavy mathematics component. Non-Regents Chemistry can avoid this skills area and can focus on a conceptual framework for the course, thus proving less challenging but more inclusive in terms of the general education population.

Districts in the city that offered no access to the more rigorous Regents Chemistry (See Figure 19) were directly correlated at .404 level at the ($p<0.05$) to the poverty level of the district. Also noteworthy was the positive correlation between minority students and no access to Regents Chemistry. This was calculated at the .479 level at the ($p<0.01$) level of confidence making this association a major factor when discussing inequity and social justice. On the other hand and on an equal level of confidence, was the correlation between White and Asian students and access to the higher order offerings in Chemistry: Regent Chemistry and Advanced

Placement Chemistry. (See Figures 17 and 16, respectively) The variation across lines of ethnicity and social status is evident as it pertains to access to more rigorous science coursework. There is a tremendous need to expand our underrepresented Black and Hispanic population in the fields associated with S.T.E.M. careers (National Academies of Science, 2011). The groups of people that have historically been underrepresented in science and mathematics are those that are increasing in the United States at a disproportional rate. Without the inclusion of these Black and Hispanic populations, the United States is excluding an ever increasing and viable portion of its human resources.

As stated in "Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads",

> "The education children receive from preschool through high school is foundational and critical. For S.T.E.M., quality preparation is a prerequisite for later success. There are issues that are specific to underrepresented minorities focused on preparation, access and motivation, financial aid, academic support and social integration."

New York City's educational system, as well as those in other large urban areas in the United States will have to seriously consider major reforms within their systems to ameliorate the current conditions so that our continually growing percentage of poor and minority children will be given an equal opportunity in S.T.E.M. and allow them to partake in the social and economic capital this would afford them.

Are there statistical correlations between chemistry access and systemic factors – school size, per pupil expense, access to lab facilities and licensed chemistry teachers?

There are several school based factors that may have an effect on the access and enrollment of students in the more rigorous courses in high school and more specifically in Chemistry. Given the current emphasis on the smaller school environment as an asset to the students in high school, this will be the first of several elements considered.

The large comprehensive high schools (See Figure 14) were more likely to offer Regents Chemistry to their students. It is noted here that if a school did not offer Regents Chemistry, Advanced Placement Chemistry was also not offered. Of the 87 high schools that do not offer Regents Chemistry (or A.P. Chemistry) to their students, 79 of these were small schools. This represents 91.0% of the schools that do not allow access to the core curriculum material found in Regents Chemistry. Six of the forty-five medium sized schools (enrollments of 500-1499) did not offer Regents Chemistry during the 2009-10 school year representing 7.0% of the total number of high schools not offering Regents Chemistry. The remaining two schools are large schools and this represents 2.0% of the total number of schools that do not offer Regents Chemistry. This represents 4% of the total number of large schools serving the general high school population in New York City. Traditionally, these large schools were designed to offer varied programs to their student population. Due to the size of these schools, the staff and facilities usually were able to accommodate a variety of leveled course work in each of the academic areas. These schools also had their downside in the fact that some were less personal and had poor graduation rates as a whole. However, there are pockets of the city in which these large schools still survive and they are clustered in certain geographic areas in the city. There are six large schools in District #2 and five in District #31. These districts have poverty levels of 8.9% and 9.8% respectively, lower than the poverty rate of the city in general (15.3%) and much lower than many of the other school districts in New York City.

Medium sized schools (See Figure 14) account for 22% of all of the high schools (45/358) and all but six offer Regents Chemistry. Similar to the larger comprehensive high schools, each of these schools has a more diverse course offering due to its larger staff and accommodations. The small schools represent the largest configuration of the high school model with 236 of the 258 schools falling within this category. Of the small schools in the city, 79 do not offer Regents Chemistry or Advanced Placement Chemistry. This number represents 33.5% of all of the small schools. Since small schools represent the majority of the high schools in New York City, it does show an alarming trend in the area of science in general and in chemistry particularly. Reports indicate that the smaller school setting is beneficial to students in many ways including increasing graduation rates, more individualization and safer environments (Bloom, Levy-Thompson, & Unterman, 2010). However, the consequence to this trend is the decreasing science and mathematics coursework that urban students are receiving and the lack of rigor that is represented by these alternative courses.

The per pupil expense correlation to chemistry access (See Figure 13) was not significant but there is a direct correlation to per pupil expense and the district poverty level at the ($p<0.01$) level of certainty. The reason for the increased student expense may vary but services for the more indigent, English-language deficient and special education populations may account for this increased spending. Another interesting correlation was the ratio of chemistry lab access to students and the per pupil expense. As the cost per student increased, there was a decrease in the access to lab facilities in the schools that these students attended. This in turn corresponds to the poverty level of an area of the city. The students who receive more funding from the city are those attending high school located in high poverty areas. In turn, these areas have a dearth of school facilities for the students in attendance there. The reasons for this deficiency may vary but it is worth noting that a lack of facilities to offer a given subject such as chemistry might create a lack of motivation in offering the course in the school.

The teacher student ratio was seen to be significant (See Figure 22) when chemistry was taken as a whole. Enrollment in some type of chemistry did increase with an increased number of chemistry certified teachers. This finding seems to point to the increased access and enrollment to chemistry when licensed chemistry teachers are in the school or the possibility that schools offering chemistry hire certified teachers.

New York State requirements for the Core Curriculum courses in science are quite specific and this is unique to the high school sciences. Whereas in other core curriculum areas of concentration, a mathematics, history or English certified teacher can teach any given course in that content area, science teachers must be licensed in the specific subject to be able to teach this on the Regents and Advanced Placement level. In other words, a Biology licensed teacher is not considered qualified to teach Regents or Advanced Placement Chemistry. This coupled with the No Child Left Behind Act of 2001, requiring highly qualified teachers in every classroom increases the need for a broad range of licensed science teachers, not the least of which is the Chemistry teacher. However, the findings of this study show that there is no significant correlation between the number of licensed chemistry teachers and the number of students in either Regents Chemistry or Advanced Placement Chemistry. While this is clear, it must be remembered that this study is only dealing with the quantity of chemistry and does not touch on the quality in terms of student outcomes.

Are there statistical correlations between chemistry access and student achievement: mathematics achievement, science achievement, four-year graduation rates and 4-year postsecondary enrollments?

There is an increased level of 4-year college enrollment, science achievement and mathematics achievement when there is greater access to chemistry. (See Figure 12) The science and mathematics achievement in each district were determined by the number of students who moved from the mandated and less rigorous Living Environment and Algebra I to the higher order science and mathematics, Chemistry and Geometry, respectively. It was seen that those districts that had higher percentages of these students also had high graduation rates and students whose focus was on attending a four-year postsecondary institution. In contrast, these same high achieving districts were inversely correlated with poverty, indicating that they encompassed the more affluent sections of the city. This was at the ($p<0.05$) level of significance, indicating that the results are related although no causality can be established.

Success on the K-12 level is foundational and crucial. Many factors contribute to the enduring achievement gaps but there is agreement that low expectations, mediocre course offerings and school and community perspective all have an effect on student achievement and efficacy. (National Academy of Sciences, 2011) The challenge in both rural and urban settings is to create an atmosphere of exactitude in which all students are afforded equal opportunity to demanding and thought-provoking content that will enhance their learning experience and set them up for social, educational and vocational opportunities. This will have a two pronged effect on the student as an individual and on society in its entirety.

The enduring struggle for increased student achievement in areas with lower affluence continues in New York City and other urban centers in the United States. Although it is seen that the schools in these districts receive per pupil funding that is equal to or surpasses the average, the fact is that this funding is not making any significant change in the status of the students achievement levels. Access to more rigorous coursework, and increased self-esteem and self-efficacy are seen as possible motivators and agents of change in student success through academic achievement.

Are there statistical correlations between chemistry access and the following behavioral measures which are monitored by the school such as over-aged students, school safety, suspensions and attendance?

The success or failure of a student is dependent on a variety of factors not the least of which is the school environment. One of the factors that help to determine the environment of a school is the perceived safety of the school. When students feel that they are in a safe learning environment, learning becomes the main objective of the school day. Suggested methods of creating a safe environment include open communication. Every student should feel that he or she has a trusting relationship with at least one adult in the school. Another method used to foster safety in the school is making collaborative decisions in which the students are an integral part. Through participation in planning and creating the culture of the school, students will feel empowered and participatory (Stephens, 2004). It is argued that this will have a residual effect on absenteeism, suspension rate and a lowering of the number of over-aged students in the New York City high schools.

When the data was analyzed, it was seen that there was no correlation between access to high school chemistry and any of the behavioral factors used in this analysis.(See Figure 21) However, interesting correlations did occur between the district poverty level and over-aged students and suspensions. The correlation is positive indicating that there are a significant number of suspensions and over-aged high school students in the high schools located in the higher poverty areas in the city. Similarly, there is a lower attendance rate in these schools and the survey results on school safety for these schools are also lower. This points to the fact that students, parents and faculty feel that these schools are less safe than other schools in the city. Research has shown that the school environment has a direct effect on student learning and behavior (Paine, 2006). The findings from this study seem to reinforce this concept. Schools that are perceived to be safer enhance the academic atmosphere of the school and in turn, allow students to concentrate on the purpose for which they attend school.

What are the variables that best predict the characteristics of high schools offering chemistry?

After analyzing all of the variables that define a school and its community, the characteristics that are most favorable for offering chemistry in a New York City high school have been teased out. As predicted, the socioeconomic status of the students of the particular high school and the neighborhood in which the school is located seem to contribute to the access or lack thereof of high school chemistry in the school. (See Figure 18)

It was found that the percentage of minority students in a school has a direct effect on whether or not a school offers high school chemistry. The larger the percentage of minority students in a school district, the lower the proportion enrolled in chemistry for those students attending high school in the district. (See Figure 18) However, when the types of chemistry were analyzed, the results indicated that the Non-Regents Chemistry courses were more prevalent in the geographic areas with lower socioeconomic statistic. (See Figure 18) Unfortunately, these Non-Regents Chemistry courses are more difficult to define in terms of content rigor because there is no set syllabus for Non-Regents Chemistry in the New York City high schools. Descriptively, it can be seen that the variety of Non-Regents Chemistry courses cover a width berth and so it can be assumed that the same goes for the content within those courses. For example, courses named Quantitative Chemistry and Organic Chemistry can be perceived as having a fairly high level of rigor as compared to Chemistry courses titled Chemistry in Society or The Chemistry of Food. For this reason, it is difficult to quantify and qualify the content in the Non-Regents Chemistry courses. The implication is that the students in these schools might not be receiving the foundation in chemistry needed to succeed on the post-secondary level and/or to become truly competent as science literate citizens. However, it can be assumed that some exposure to a subject is better than none and in that context; the Non-Regents Chemistry courses are reaching a larger and more diverse population. The Non-Regents Chemistry courses are most notably offered in the small school setting if the small school offers Chemistry at all. (See Figure 14) As previously noted, small schools have difficulties in both the facilities in which they are housed, and in their ability to offer diverse course selections due to the size and diversity of the faculty.

To increase the impact of the Non-Regents Chemistry courses, it is suggested that teacher choice in the content and the laboratory experiences (Tai, & Sadler, 2007) will greatly influence the rigor of the coursework and further prepare the students for college level chemistry. In addition, because the small school setting does not allow for a content-diverse faculty, online or distance learning is another viable alternative when considering access to the more rigorous math and science coursework (Robinson, 2003). The National Science Teachers Association (NSTA) has been working to create a large Web site that offers highly interactive four-hour engagements with science content designed for the adult novice learner (Tai & Sadler, 2007). This could be a way to fortify the content knowledge of the non-certified chemistry teachers in all schools but specifically in the small schools where there is a scarcity of these trained teachers.

Studies have shown that racial disparities in science, technology, engineering and mathematics (STEM) occur because fewer Blacks and Hispanics are prepared for STEM in high school (Tyson, Lee, Borman & Hanson, 2007). Access to a more rigorous core of science and mathematics coursework is a necessity. High school counselors and teachers must encourage more minority students to take challenging courses in high school. In addition, they must also work with the parents of these children to encourage their children to take more of the pre-requisite courses at the appropriate grade level to ensure success in high school and beyond. As the student enters middle school, if interest in science is not triggered, the student will more than likely choose other content electives during his or her high school years (Osbourne, et al, 2003).

Schools located in the higher socioeconomic areas of the city are seen to offer more advanced courses in science to their students. These students also tend to be White and Asian (See Figure 15) and of higher economic status themselves. Therefore, it is erroneously surmised that these students are more capable when the data is examined in isolation. More correctly, the schools that the socially and economically disadvantaged students attend do not tend to offer these courses and the repercussion is that these students are not exposed to the rigor needed at the secondary level to be able to excel at the post-secondary level. A dynamic is established that is difficult to reverse and without intervention, these students are unknowingly being excluded from a growing and lucrative job market.

Implications and Further Study

An area for further study would be the naming of the high schools in New York City and the location of these themed schools within the city. On a cursory level, it appears that many of the schools with names that connote less challenging coursework are located in the areas containing the students with the greatest need. The list below gives the names and themes of several high schools in the city, the location of the school and the poverty level of the neighborhood in which the school lies. Although not studied in-depth in this thesis, it may be an area of interest for others.

The average poverty level in the city of New York is 20.1%. (See Table 12) A cursory view of the high schools and their themes indicates that schools with less academic monikers are located in areas of the city with greater poverty levels. There are also fewer schools with names that connote academics in their titles. (See Table 28) For a more precise analysis, further research must be conducted.

Table 28 - Themed High Schools in New York City (New York City Department of Education) http://schools.nyc.gov/default.htm

	Name in Title	School District Location	Average
Academic	Academy	9X (6) 10X (4) 11X (3) 12X (7), 13K (2),	43.5%
65 high schools	Collegiate	9X, 15K, 18K, 19K, 23K	46.5%
	Preparatory or	7X (2), 9X (3), 10X (2), 11X (2), 14K (2)	46.9%
Citizenry Themes	Citizenship	17K	37.8%
43 high schools	Civil Rights	12X, 19K	58.6%
	Community	3M (1), 7X (2) 8X (2), 9X (1), 10X (1), 12X	46.1%
	Human Rights	17K	37.8%
	Neighborhood	11X	35.7%
	Public Safety	17K, 28Q, 23K	36.8%
	Justice	3M, 9X, 13K, 14K	37.9%
	Public Service	32K, 2M, 6M	33.8%
	Service	17K, 28Q, 23K	36.8%
	Social Action	5M	43.3%
	Peace	12X, 14K	55.3%
	Social Justice	7X, 32K	58.3%
	Freedom	12X, 13K	50.9%
Cultural Themes	Cultures	12X	66.7%
22 high schools	International	6M (1),7X (1), 9X (1), 10X (4), 13K (1),	40.8%
	Global	11X, 16K, 17K, 30Q	38.3%
	Diversity	12X	66.7%
S.T.E.M. Themes	Science, Math	2M(1),4M (1), 7X (1) 9X(1), 11X (2), 13K	40.2%
21 high schools	Environment	2M (1), 4M (1)	27.7%
	Health, Medical	2M (1), 6M (1), 9X (1), 11X (2) 18K (1),	35.8%
	Engineering	17(K)	37.8%

The larger schools in the city tend to offer more Regents Chemistry coursework. (See Figure 14) This is the foundational course in Chemistry and it is upon this course that all of the subsequent Chemistry coursework will rely. It is recommended that this course become part of the pre-requisite for all high school students and that this also become one of the measures for the post-secondary success indicator on the high school progress report[9]. Once this has been established, its inclusion will be linked to school level achievement. Why not give every child the opportunity to study STEM in the general high schools and bring the ideal of equal opportunity for all into science education in New York City? To ensure that science education in the urban high school is equitable, systemic reform in terms of curriculum and instruction as well as fiscal resources must be as uniform as possible (Holbrook, 2010).

An additional source of information in this study was acquired through the use of a survey. This provided information about the individual schools and the reasons behind some of the choices made in the area of science and specifically chemistry in the high schools. Surveys are one of the most commonly used research tools but they do have drawbacks. Since the survey collects data that are self-reported and may reflect social desirability bias or the

tendency for a person to respond in a way that is socially desirable, but does not necessarily

represent his/her true opinion.

The response rate to the initial distribution to the survey was 92/358 replies. This represented a 25.7% of the disseminated survey and so a re-canvasing was attempted. After the second distribution, there were 127/358 responses (35.5%), which was approximately a 10% higher response rate. The response population was then compared to the total high school population on eighteen contact points (See Table 25) to ensure that this was a reliable representation of all of the high schools in New York City that serve the general population of students.

[9] The College Preparatory Course Certification (CPCC) process recognizes high school courses that build college readiness skills and expands the range of courses for which high schools can earn credit on the College Preparatory Course Index (CPCI), one of the three college-readiness metrics on the high school Progress Report.

Results from the information found in the surveys and the interviews with select principals show some disconnects in the system. Statistically it was seen that there is little connection between the students' access to licensed Chemistry teachers and the amount of Chemistry offered in a district. However, several of the surveyed schools (22%) indicated the reason for not offering Chemistry was the lack of certified/qualified teachers. (See Figure 23) It is true that a certified teacher is a necessity for the Regents and A.P. level Chemistry courses but not for the non-Regents courses. Since these courses do not have a mandated curriculum or a mandated set of laboratory activities, teacher decision is critical to the level of rigor provided to the students. Covering fewer topics with more depth (Robinson, 2005) is sometimes more beneficial than covering the entire content with less understanding. Although the mathematical rigor on some of the non-Regents Chemistry courses is a matter of concern, the fact that the students are receiving some exposure to the subject matter is more helpful than no exposure at all.

Another area that received a high percentage when asked for the reason that chemistry was not offered in the high school was the lack of laboratory facilities.(See Figure 23) This represented 22% of the reasoning behind not offering chemistry. This data did coincide with the statistical findings that there is a lack of laboratory facilities in the schools that do not offer chemistry. The recommendation is for each high school in New York City to have a science laboratory in the school building. This would eliminate the indecision of some administrators about the science program in their schools and help to strengthen the S.T.E.M. foundation in the high school.

At 14% each the third most popular reason for not offering chemistry in high school was the of lack of success when offering chemistry in the past and the lack of priority chemistry represents in some of the high schools. (See Figure 23) The high school rating system is a probable cause for schools to drop Chemistry if they had low success rates in the past. As previously mentioned, the emphasis on high schools is to successfully graduate their students. If offering chemistry to the students thwarts this effort, it becomes an effort without merit in the eyes of some administrators. It is suggested that the non-Regents chemistry courses be a way of "dipping one's toe" in these academic waters. This could be a ninth grade introductory science course which would then lead students to the more rigorous and mathematically based Regents Chemistry course. The students will have completed the Algebra I course simultaneously in the ninth grade and be fully prepared, both mathematically and scientifically for the Regents course. This would also address the issue of students who have a lack of preparation for the coursework.

Principal Interviews

The purpose of the principal interviews (See Appendix C) was to understand from the point of an administrator, the complex and multi-leveled reasoning behind course selection at various schools in the city. Through the epistemology of each of the three principals interviewed, decisions come to light that might not have been evident on the surface. Each of the principals determined the course selection that they felt was right for their population of students, usually in conjunction with others on the administrative or guidance level in the school. The driving force in the decision to include or exclude chemistry form the science program in the schools came down to the same variables that were mentioned in the surveys. The larger schools that offer chemistry limit its access to students that have proven themselves to be more adept in the area of mathematics. So, although the schools do offer chemistry, the selection of the population limits its access to the general student population. This is seen as productive for the school and for the student body as those students who are not proficient in mathematics find chemistry to be frustrating and tend not to pass the course. Similarly, having a school with a liberal arts theme such as the small school that was part of the interview process, it is seen that the students self-select the focus of their education by choosing this school. This opting out of the more rigorous sciences is condoned by both the school and the parents of these children and thus the importance of the sciences is not emphasized or encouraged.

Recommendations for Increasing Access and Enrollment in High School Chemistry

Below are some suggested recommendations for increasing the number of high school students in NYC who earn chemistry credit and thus increase their base knowledge in science. Hopefully this will have implications on the post-secondary career paths of some of the less represented groups within our student body:

1. Begin the emphasis on the sciences and mathematics work early in the academic sequence for children. Enhance the science programs in elementary and middle schools with stronger content and more diverse work in the area of physical science. At present, accelerated middle school courses include Living Environment and Earth Science. Expand this to Chemistry and Physics so that there is a balanced representation of the content areas at the earlier grade levels.
2. Conduct a study of the other urban school districts in the United States to gather data on the various science course-taking patterns around the country. Identify the common problems endemic to large urban areas and form a consortium of science leaders from these cities to tackle the inequities that are surfaced. Funding should be available from the Federal Math Science Partnership Grants.

3. On the state level, incentives should be offered to individuals that chose to teach science in the urban school districts. This can be through tuition reimbursement programs or increased pension benefits such as early retirement incentives.
4. On the city level, each of the school districts should be required to have a minimum percentage of higher order science and mathematics classes offered to all of their students.
5. All high school science courses should be mandated to include the New York State Math, Science and Technology Standards before becoming a part of the course sequence.
6. All guidance counselors should be encouraged to make themselves aware of the current trends in post-secondary education and employment trends in the United States. This would enhance their ability to counsel the students in their caseloads with the most current and realistic opportunities.
7. At the school level, students should be encouraged to form peer study groups in addition to the classroom time on task. Incentives could include service credit for the students as they are helping one another become successful as well as providing a viable workspace and refreshment for the students who stay after class-time to work with their peers.
8. At the community level, leaders in the science community should be encouraged to offer internships to high school students in the summer and after-school. This would expose these youngsters to authentic scientific endeavors and viable possibilities for them in the future.

"Some people view this focus on STEM education as just another passing trend. Instead, it needs to be the cornerstone of a new 21st century American economic resurgence. America's long-term economic future is at stake." ~ Barack Obama, 2010

APENDIX A

Survey of New York City High Schools

Please answer all questions as they relate to the science courses in your school.

NAME OF SCHOOL: ____

SCHOOL NUMBER: ____

ADMINISTRATOR COMPLETING SURVEY: __________________________

TITLE OF ADMINISTRATOR: _______________________________________

1. Please enter the sequence of science courses in your school. Denote each course with a "P" for physical science or an "L" for life science after the name of the science course offering. [e.g. 10^{th} Grade – Genetics (L)]

9^{th} Grade Science Offerings	10^{th} Grade Science Offerings	11^{th} Grade Science Offerings	12^{th} Grade Science Offerings

2. For each of the courses listed above, please give the time allotment for the laboratory section of the course in minutes per week.

   COURSE **LAB TIME PER WEEK**

   a. ____
   b. ____
   c. ____
   d. ____
   e. ____
   f. ____
   g. ____
   h. ____

3. How many teachers of science are in your school? __________________________

4. How many teachers of science are certified in the content area in which they teach? __________

If you answered no to Question #1, could you please give a brief explanation as to why Chemistry is not taught in your school.

____
____
____

APENDIX B

Dear School Administrators,

RE: Science Course Selection in Your School

My name is Denise McNamara and I am a doctoral candidate in Urban Education at the Graduate Center, City University of New York and principal investigator of this project entitled, “Access and Entrance to High School Chemistry in New York City”. This is a research study of high school chemistry enrollments in New York City public high schools. I would like permission to interview you about your experiences and would like you to fill out a one-page survey/questionnaire.

The interview will take approximately 20 minutes and the survey/questionnaire should take fifteen minutes to complete. All of the information will be kept strictly confidential and will be stored in a locked file cabinet, to which only I will have access. At any time you can refuse to answer any questions or end this interview.
The risks from participating in this study are no more than encountered in everyday life. The benefit of your participation is that this may impact the science literacy of the high school students in New York City and have potential to increase post-secondary success for these students. There will be approximately 300 participants taking part in this study.
I may publish results of the study, but names of people, or any identifying characteristics, will not be used in any of the publications. If you would like a copy of the study, please provide me with your address and I will send you a copy in the future.

If you have any questions about this research, you can contact me at (212) 374-0870 or dmcnama@schools.nyc.gov , or my advisor, Dr. Nicholas Michelli at (212) 817-8280 or nmichelli@gc.cuny.edu If you have questions about your rights as a participant in this study, you can contact Kay Powell, IRB Administrator, The Graduate Center/City University of New York, (212) 817-7525, kpowell@gc.cuny.edu .

Thank you for your participation in the study. I will give you a copy of this form to take with you.

Participant’s signature	Date	Investigator’s signature	Date

APENDIX C

Principal Interview Questions

Face- to-Face or telephone interview:

Name of School: ____

School DBN: ____

Name of Principal : _________________________

Number of Students currently enrolled: ____

Do you have a Science Supervisor in the School: ___________________________________

What are the reasons for offering or not offering Chemistry (Regents, Non-Regents, A.P.)?

Do you offer any Advanced Placement Science courses?

If so, please name the A.P. Course(s) in Science: ___________________________________

What are the motivational factors that influence your decisions around the course sequence in science for your students?

What is the state of you lab facilities currently? Does this influence the types of science courses you offer at your school?

To what extent does the Guidance staff at the school influence the course sequencing, if any?

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