ChemForAll:

Radicalizing STEM career access through transformative 5-12+ Chemistry Curriculum

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I. Introduction

Dispersal of knowledge in America is highly controlled throughout education history. The battle between democratic ideals and class-based social hierarchy determines which citizens, (and non-citizens) are allowed to enjoy American standards of success. Higher education has evolved into the most powerful tool in building the country's wealth for the wealthy, and alienating the working and middle classes from similar wealth building. This is the result of inadequate K-12 preparatory work in low-income urban schools where students of color predominate (Fabricant, Brier p.112). Alternatively, systems of resistance born in working and middle class communities continue to confront inequities in public education, by empowering students through community colleges, mentoring and scholarship opportunities, and out-of-school support programs supplementing deficits in public classrooms. In both instances, federal and state policies dictate requirements and mandates that must be manifested in order to receive vital funding for all public schools.

In New York City and State, New York State Legislation continues to debate the quality of educational access available to students, particularly through Gifted and Talented programs, specialized high school entrance and matriculation, and subsequent entrance to STEM related undergraduate programs. As New York City prepares to welcome incoming Mayor Eric Adams and his newly appointed administration, students, parents and teachers from the nation's largest public school system anticipate change that will hopefully lead to more equitable distribution of funds that will benefit communities in need of improved access to STEM and other career-building pathways. This paper outlines recommendations for foundational understandings

of science, through Chemistry curricula taught from 5-12+ in all elementary, middle, high and alternative schools across the city.

II. Statement of the Problem

Foundations in science are required to build critical navigational and problem solving skills in crisis. If human survival is dependent on the ability to preserve one's own health, then human survival depends on the environment that influences personal health. coupled with one's ability to adapt to our rapidly evolving environment that is under stress due to increased population, scarcity of natural resources and an increase in man-made and natural disasters around the globe. Without the necessary content knowledge and ability through acquired skills to directly address problems affecting personal and community health, populations suffer enormous loss and disadvantage. Particularly in low-income neighborhoods and among disenfranchised groups, this suffering can be alleviated by investing in building equitable platforms for young people to enter STEM fields of study, so that they may extend from their home communities to spread their expertise to the world, armed with the tools necessary for building a better future. However, in the United States, these same disadvantaged communities are most likely to have no access to appropriate STEM studies during early childhood education and in advanced science coursework at the high school level.

According to The Brookings Institute 2013 report *The Hidden STEM Economy*, Jonathan Rothwell draws correlation between STEM education and employment in the American workforce. The report claims that workers in STEM fields play a direct role in driving economic

growth. Drawing distinctions between 2-year and 4-year colleges methods in preparing students to participate in the national economy. Rothwell claims that policy makers and political leaders can do more to facilitate development of STEM knowledge and educational access to the U.S. workforce and its regional economies. According to Rothwell,

> "The overemphasis on four-year and higher degrees as the only route to a STEM career has neglected cheaper and more widely available pathways through community colleges and even technical high schools. This neglect is all the more nonsensical given that roughly half of students who earn four-year STEM degrees start their education at community colleges" (Rothwell 22).

The study concludes that a hidden economy exists for STEM community college graduates, that is neglected and even denied to students seeking employment and participation in meritocracy through invention and scientific research.

For New York City students graduating from public and charter schools, the need to excel in foundational science courses is essential to begin undergraduate studies toward Bachelor and Associate degrees in STEM careers. Freshman year coursework generally begins with Biology 101, where the chemistry of molecular biology lays the foundation for all science coursework moving forward. Students beginning bachelor of science programs at the undergraduate level are expected to have completed one-year courses in Biology, Chemistry and Physics, along with an equivalent course of Advanced Placement (AP) or Honors level Biology or Chemistry, in order to be successful in introductory Biology courses. However, all too often, struggling schools lack competent, qualified science teaching staff, inefficient or no laboratory access, and few pathways to master the required foundational skills and coursework needed to succeed in STEM college

pathways. Jim Dwyer writes in the New York times article, *Decades Ago, New York Dug A Moat Around It's Specialized School*, explaining,

> Most city students never come near a physics classroom. Although it is the keystone discipline of modern science and technology, the subject is barely taught in the public high schools, outside a select few programs such as those at the specialized schools and elsewhere.

The deficiency created by this manifestation hits low-income schools where Black and Latino students are highly affected. Angela Kelly, a professor of science education at Stony Brook University explains the ramifications of this lost science curriculum stating,

> If a student wants to pursue a college major in life science, engineering, or health, physics is really a gateway course for being able to succeed. Having limited opportunity to learn physics has many social and economic ramifications (NYTimes 2018).

This same logic applies even more significantly to limited access to Chemistry courses throughout the city as well. The best STEM performing schools continue to be the top 3 specialized science high schools: Bronx High School of Science, Stuyvesant High School and Brooklyn Tech. Other top-ranked STEM schools are dominated exclusively by private, high tuition, independent schools in the city. In the public sector, these specialized science high schools are accessible, still, through the standardized admissions 8th grade SHSAT test. Despite Mayor de Blasio's efforts to reform the status quo of admissions to these schools, New York State legislation trumps out city efforts to reform the admissions process. According to the Riverdale Press article *Long Road Still Ahead for Specialized High School Reform*, Rose Brennan outlines the history of legislation that led to the current Hecht-Calandra Legislation that states,

> Admissions to The Bronx High School of Science, Stuyvesant High School and Brooklyn Technical High School and such similar further special high schools which may be

> established shall be solely and exclusively by taking a competitive, objective and scholastic achievement examination, which shall be open to each and every child in the City of New York in the eighth or ninth year of study, in accordance with the rules promulgated by the N.Y.C. Board of Education, without regard to any school district wherein the child may reside. No candidate may be admitted to a special high school unless he has successfully achieved a score above the cut-off score for the openings in the school for which he has taken the examination.

Such legislation limits what the incoming Mayor Eric Adams can propose toward reforming admissions to these schools. Since Hecht-Calandra is a state law, Adams has little power to repeal the restrictions. Brennan suggests that the incoming administration can make sure to state their position about the law clearly to state legislators.

Repealing the law is one direction. Alternatively, other advocates for STEM equity, support bridging the gap in access through supporting disenfranchised students through alternative supports to mastering the SHSAT, after school STEM classes and supporting teacher professional development. . But one thing they can do is make their position on its repeal clear to today's state lawmakers. City officials can also begin to explore alternative pathways for disenfranchised students to perform well on the SHSAT by supplementing test prep through after school programs, and re-vamping STEM curricula from elementary school through grades 12+ in districts. Brennan writes,

> Still, it's no easy task for a law to be repealed by both the state senate and Assembly. And if there's no support among those lawmakers, any effort to repeal Hecht-Calandra could be dead in the water regardless of who the new mayor is.

Earlier this week, New York State Department of Education canceled the January 2022 Regents'Exams, due to rising concerns about the spread of Omicron variant of the coronavirus, throughout all five boroughs and New York State. According to the December 21, 2021 report,

"Due to the cancellation of the January 2022 Regents Examinations, the Department will ask the Board of Regents to approve modifications to the assessment requirements that students must meet to earn high school diplomas, credentials, and endorsements…….NYSED is developing additional guidance in the form of an FAQ and will issue that guidance in early January 2022 to address topics such as safety net options, mastery, honors, and technical endorsements so that schools may determine which diplomas to grant to their graduates" (NYSED).

This extended policy from January 2021 due to the ongoing pandemic launches a moment of reform in New York State for graduating seniors who would otherwise be held back if they do not pass their Regent's requirements for high school graduation. Parallel to this departure from standardized graduation norms are alternative assessment campaigns and new policy initiatives that can be hastened to support graduating seniors as they enter either the work force or 2 and 4 year college and university programs. This is also a time when alternatives to high school graduation requirements on the path to college and work readiness present valuable options for post high school students to participate in economic and academic success.

Reform versus Remediation

In establishing remedial programs like SEEK and Discovery for entering Black and Puerto Rican students, a two-tiered system was put into place, based on one's identity, immediately separating Black and Brown students from the majority of Jewish students at that time. Perhaps an alternative approach of strengthening the city's K-12 foundations would have been a better route for guaranteeing success for entering freshmen. To begin undergraduate studies with a deficit-centered approach to learning, students were faced with challenges at the brink of their academic explorations. FIfty years after the birth of Open Admissions policies, students entering CUNY programs with a deficit in foundation courses greatly limits their ability to thrive. In my twenty-seven years of teaching high school science, I rarely graduated students

who were prepared to take freshman Science courses for Bachelor of Science degrees. Instead, I was responsible for teaching students how to pass two Regents Science exams, usually in Living Environment and Earth Science. Neither of these courses prepare students for undergraduate study in science. Often, students spend their first 2 years of college taking remedial introductory chemistry, biology and physics courses that are foundational to their understanding of college science curricula. A former student of mine who graduated from New York's public school system called me this week. Four years after her acceptance to CUNY, she will begin her Bachelor of Science studies, on her path to enter Dental School. She spent these past four years taking remedial science courses, and earning her two-year associates degree en route to her dentistry dreams. During her high school study, my student passed 2 required Regents science exams in Living Environment and Earth Science. In order to enroll in a four-year program, she needed Biology and Chemistry in her high school transcript. We did not offer either course in that high school, forced to accommodate state guidelines to pass at least 2 science Regents exams. Four years have passed, and when this student called this week, I promised to share whatever resources I had, mainly textbooks in Biology and Chemistry, and moral support, to support her journey. Despite this student's drive and ambition to prepare for her career after high school, her experience at CUNY displays a slow and difficult journey from secondary school to higher education. The school where we met at that time had no labs, no curricula other than teaching to pass the test, and no windows! We were housed in a former bread factory in East New York, and were advised to paint murals of windows in our classrooms.

Perhaps a different approach to supporting students with incoming academic deficits would be to improve the foundations of public school education in New York City's most disenfranchised communities as the better route to post graduation success. By setting up

programs like SEEK and Discovery for remedial support instead of strengthening K-12 curricula to meet college requirements, caste distinctions are again reinforced.

IV. Local Impact of No Child Left Behind in New York City

In semi-post-covid New York City, mayoral elections present an opportunity for a new interpretation of post-colonial education in America. The former narrative of American manifest destiny of the white male manifestation no longer holds fortitude in New York City. Since the No Child Left Behind Act was embraced in New York in 2002, there has been a decrease and weakening of science and arts education in urban districts. In his book Urban Science Education for the Hip-Hop generation, Education scholar Professor Christopher Emdin describes the masking of the American narrative regarding urban people of color being marginalized by federal policies like NCLB. By cloaking such policies as an effort to relieve the plight or lower-income students, these regulations contribute to the erasure of the "after effects of slavery and institutionalized racism" (p. 24) that perpetuates as achievement gaps and roadblocks to higher education. In New York City, NCLB requirements rapidly changed the landscape of learning to ELA and Math testing criteria as sole indicators of school and student achievement. Subsequently, progressive public schools deviated from traditional curricula that included science, social studies, music and art to focus on reading and math scores for funding. Successful small-schools like Central Park East Secondary School (CPESS) were suddenly pressured to sacrifice proven pedagogic reforms and curricula that included, "whole language, authentic assessment, integrated curriculum, and multi-cultural education," (Semel 2008) to adjust to challenges posed by NCLB like standards-based assessment and high-stakes testing.

In New York State where public school students are required to pass at least two Regents Science courses for a standard diploma, many predominantly urban Title I schools have resorted to Earth Science and Living Environment tests. Courses in Chemistry and Physics are absent due to lack of instructors and students' ability to access content due to minimal science education at the middle school level where standardized Math and English scores are the focus for curriculum. Thus, these high school students are ill-prepared for undergraduate studies in science, particularly since a working knowledge of Chemistry is required for the most basic Biology undergraduate introductory course. This lack of ability to succeed at the beginning stages of their college career removes any agency to apply scientific content knowledge to activism, or any professional dreams a student may have in their chosen field of scientific study. Emdin suggests changing the narrative of deficiency and exclusion experienced by urban students of color, by embracing a new pedagogy towards a culturally rich science curriculum that fosters the critical exchange of ideas and skills necessary to improve minority-occupied communities. New and established policies that work to empower all public school students across this country, with a focus on high population density urban districts will prove better to the national economy and prosperity for all learners.

V. Policy Recommendations for CHEMFORALL in New York City

As Eric Adams enters New York City's mayoral office, it is important to improve access to STEM careers and college success for young people across the five boroughs. The following recommendations are based on a strategy to integrate Chemistry coursework into schools, at all levels of learning. Making science class more culturally relevant is just one of the strategies K-12 science teachers are using to better engage students of color at a time when Black and Hispanic

people remain underrepresented in science, technology, engineering, and math careers and national discussions continue on how to make education overall more equitable.

A. Elementary School Recommendations

- Since elementary school teachers are not required to have college science credits for teaching certification, ChemForAll can provide professional development for k-5 teachers to integrate Chemistry concepts to children at an earlier age.
- Develop and implement k-5 Chemistry Curriculum

B. Middle School Recommendations

- Chemistry Curriculum 6-8
- Chemistry Labs in Middle Schools
- Introduce Biochemistry foundations in middle school science so that Living Environment and Chemistry courses are accessible to entering 9th graders.

C. High School Recommendations

- Access to 2-year Chemistry track of Introductory Chemistry and Advanced Placement or Honors Chemistry for year 2, in all high schools for students interested in pursuing 2 or 4-year STEM studies after high school.
- If high schools cannot provide this 2-year Chemistry track, then after school and Saturday school programs should supplement this deficiency, for those students who show interest or aptitude in Science.
- Train and retain Chemistry teachers for high school courses. For students interested in STEM careers, ChemForAll is imperative to undergraduate success

If teacher supply is limited, then the NYCDOE must incentivise Math and other content-area teachers to take on the Chemistry coursework.

- Professional Development for teachers interested in teaching Chemistry.

D. Post-secondary Recommendations

- Provide ChemForAll classes to students who have already graduated and are in need of the 2-year Chemistry Track required for undergraduate STEM studies
- Examine and re-structure 'remedial' learning in CUNY systems to acknowledge that Chemistry is seldom mastered in New York City schools, and create access to Chemistry courses for entering freshmen who may lack previous exposure to the topic.

IV. The Need for ChemForAll

Despite the significant growth in the number of STEM graduates from U.S. colleges and universities at all degree levels since 2010, increased diversity in science-related jobs shows little progress. In the United States, public and private educational systems are the primary source of STEM labor within our nation (Gonzalez, Kuenzi, 2012). Unfortunately, STEM education that leads to employment and wealth production through STEM-related careers only occurs in select communities and schools that have the most funding and resources. This opportunity gap minimizes the benefits of having a STEM literate society and workforce because it excludes a significant portion of the population. Across the US, students from low socioeconomic communities and schools continue to lack the opportunity to engage in advanced STEM studies that lead to employment and substantial contribution to the nation's economy.

Subsequently, disparities in education access limits minority and low-income students from entering college and university studies with proficiency in foundational science coursework that leads to successful graduation and entrance into STEM career pathways.

Since the domination of industrialization and technology in American economics, social hierarchies are intentionally built through job placement and contribution to the market economy. Increasingly, STEM jobs significantly contribute to the nation's economy, dependent on college graduates with bachelor of science degrees, or similar programs intended to develop scientific literacy and skills. The U.S. Department of Labor reports,

> "Nearly all of the 10 fastest growing STEM occupations that require a bachelor's or higher degree for entry are in the computer and mathematics groups. Statisticians are projected to grow fastest from 2014 to 2024 with a growth rate of 33.8 percent. Biomedical engineers is projected to be the fastest growing engineering occupation at 23.1 percent."

Though funding and investment in STEM from federal policy continues to grow, successful matriculation through 2-year and 4-year colleges and universities evades populations from urban school districts. Foundations in science are required to build critical navigational and problem solving skills in crisis. Without the necessary knowledge and ability to directly address problems affecting personal and community health, populations suffer enormous loss and disadvantage. Particularly in low-income neighborhoods and among disenfranchised groups, this suffering can be alleviated by investing in building equitable platforms for young people to enter STEM fields of study, so that they may remain in their own communities or spread their expertise to the world, armed with the tools necessary for building a better future. However, in the United States, these same disadvantaged communities are most likely to have no access to appropriate STEM studies during early childhood education and in advanced science coursework at the high

school level. Despite growing STEM-related jobs in urban areas, Black and Hispanic young adults are underrepresented among STEM graduates (Frye 2021). Subsequently, higher-paying science-related jobs are occupied by graduates from non-urban communities and institutions, displacing minority students from their own potential working community. According to The Brookings Institute 2013 report *The Hidden STEM Economy*, Jonathan Rothwell draws correlation between STEM education and employment in the American workforce in major U.S. metropolitan spaces, often identified as urban school districts. The report claims,

> Because they foster specialization and trade, metropolitan areas are disproportionately home to inventive activity and highly educated workers. Yet large metropolitan areas are similar to smaller metropolitan and nonmetropolitan areas in the intensity of STEM knowledge embodied in the work- force (Rothwell p.12 2013).

This disproportionate supply of educated STEM graduates entering urban work spaces, and the subsequent displacement of urban students from being competitive in the STEM workplace places urban students of color at a disadvantage to compete with their peers. Rothwell claims that policy makers and political leaders can do more to facilitate development of STEM knowledge and educational access to the U.S. workforce and its regional economies.

According to The National Association of Manufacturing and Deloitte 2018 study, by 2025 there will be over 3 million STEM jobs to be filled in the United States. It is also estimated that 2 million of those jobs will remain unoccupied . The report suggests that industry leaders should explore ways to increase exposure to computer programming and engineering to primary school students. Given that graduates in STEM disciplines will undoubtedly play a critical role in addressing local, national and global challenges, framing the purpose of STEM education has serious implications for equity in American society. Federal policies that invest and promote

STEM education must be rooted in equity, for all learners to access tools and critical thinking skills for social justice based scientific solutions. Access to this higher education status begins in k-12 education systems.

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In order to improve equitable access to science education in early childhood and secondary public schools, many federal, state, and regional educational policies are implemented to improve STEM access throughout urban educational spaces. Still, many marginalized students continue to experience low quality science education. Laura Betancour et al examine disparities in science education between different social classes in America, in their 2018 study, *Socioeconomic Gaps in Science Achievement.* Students from low-income communities are often caught between multiple systems of oppression as they face overarching political and economic constraints. These challenges include near poverty wages for parents, lack of educational support

resources in the community, and limited access to healthcare that continuously challenge student success. Students also face barriers from within the school like high stakes standardized tests that reinforce the systemic inequities that keep them from succeeding in science coursework leading to STEM careers.

New York City public education middle and high school students experienced a radical shift in admissions policies six months ago, when according to the New York Times:

> "The city will eliminate all admissions screening for the schools for at least one year…. In doing this, Mr. de Blasio is essentially piloting an experiment that, if deemed successful, could permanently end the city's academically selective middle schools, which tend to be much whiter than the district overall," (Shapiro 2020).

This recent change during the covid-19 crisis that challenges this year's application process to specialized city schools follow up on the mayor's 2018 commitment to provide more equitable access to minority and low-income students who rarely get a chance to compete with white and Asian counterparts from more affluent and middle class districts in the city. The elimination of exam-based admissions to the top eight high schools of New York's public school system appears to be a major change in the institutional tracking present in America's largest public school district. While tracking in classrooms continues across integrated school systems in America, this most recent reform by mayor Di Blasio symbolizes a major return to the de-tracking debate examined by Jeannie Oakes in her commentary *Keeping Track: Structuring Equality and Inequality*, she states:

> "Low-income students and students of color suffer disproportionately from these negative effects, both because they are tracked disproportionately into the lowest classes in racially mixed schools and because they are more likely to attend racially isolated schools where lower level classes predominate. Through tracking, schools continue to replicate existing inequality along lines of race and social class and contribute to the intergenerational transmission of social and economic inequality" (2008 p 705).

By removing this major testing barrier that isolates low-income students into schools ill-prepared to prepare 7th and 8th grade students to be successful in these tests due to a variety of barriers including lack of funding for labs, unqualified teachers, tracking based on ELA and MATH scores remnant from the No Child Left Behind legislation. As an alternative to strict determination of a child's ability through stringent testing of ELA and Math standards acquisition, a return to development of multiple intelligences of all children through providing access to advanced learning designed to develop skill, interest and talent through a variety of curricular discourse and methodology, can improve the equity landscape of education.

A more radical approach to improving STEM education in urban areas could be to remove Regent's State testing in science content, replaced with portfolio-based assessments. This would allow for more hands-on participatory social justice projects aligned to learning fundamental science content in Physics, Chemistry, Biology and Environmental Science. Returning to progressive, small-school movement practices of early child-centered schools would alleviate the demoralizing effects of failing to meet Regent's standardized testing requirements in the public sector (Semel, 2008).

V. Reform versus Remediation

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brink of their academic explorations. FIfty years after the birth of Open Admissions policies, students entering CUNY programs with a deficit in foundation courses greatly limits their ability to thrive. In my twenty-seven years of teaching high school science, I rarely graduated students who were prepared to take freshman Science courses for Bachelor of Science degrees. Instead, I was responsible for teaching students how to pass two Regents Science exams, usually in Living Environment and Earth Science. Neither of these courses prepare students for undergraduate study in science. Often, students spend their first 2 years of college taking remedial introductory chemistry, biology and physics courses that are foundational to their understanding of college science curricula. A former student of mine who graduated from New York's public school system called me this week. Four years after her acceptance to CUNY, she will begin her Bachelor of Science studies, on her path to enter Dental School. She spent these past four years taking remedial science courses, and earning her two-year associates degree en route to her dentistry dreams. During her high school study, my student passed 2 required Regents science exams in Living Environment and Earth Science. In order to enroll in a four-year program, she needed Biology and Chemistry in her high school transcript. We did not offer either course in that high school, forced to accommodate state guidelines to pass at least 2 science Regents exams. Four years have passed, and when this student called this week, I promised to share whatever resources I had, mainly textbooks in Biology and Chemistry, and moral support, to support her journey. Despite this student's drive and ambition to prepare for her career after high school, her experience at CUNY displays a slow and difficult journey from secondary school to higher education. The school where we met at that time had no labs, no curricula other than teaching to pass the test, and no windows! We were housed in a former bread factory in East New York, and were advised to paint murals of windows in our classrooms.

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VI. Conclusion

Nations that invest in STEM education become leaders in solving our most imminent challenges, evidenced by covid-19 response and solutions, use of technology, and space/earth exploration for resources. Policymakers, educators, and business/industry are of the mindset that strengthening STEM education and the future talent pipeline will enable the United States to remain a leader in innovation and global leadership. Ironically, populations that could benefit highly from specialized STEM studies in problem-solving environmental and health challenges faced in local communities, are least likely to receive public education access to such courses. Selective methods, along with traditional schools, often fail to provide access and opportunity for students from underrepresented backgrounds, as students particularly from urban schools become disenfranchised. When systemic racist policies are juxtaposed against the social class structure that has evolved in meritocratic America, the urban communities of this country are often aligned to racial disparities. And in the evolution of public classrooms in America, urban, often black and brown communities receive inadequate access to STEM education through policies like No Child Left Behind.

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