Urban Secondary Science Teachers and Special Education Students: A Theoretical Framework for Preparing Science Teachers to Meet the Needs of All Students

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Implicit in all US science education reform efforts in the past, is equal access and opportunity to learn science for all students regardless of their background and status. However, most science teacher preparation programs (with some exceptions, i.e., those that offer dual endorsement/certification), do not have the capacity or resources to prepare teachers to serve special education students. The paper examines the relationship between urban secondary science teachers and special education students. It interrogates the notion of "Highly Qualified Teacher" (HQT), by comparing a sample of science teacher preparation programs in the Greater New York City area, the standards for science teacher preparation and the needs and requirements for serving students with special needs in the science classroom. Using teacher preparation program data published on institutional websites, cross-referenced with data published on the New York State Education Department website, the paper reviews thirteen secondary science teacher preparation programs based on four criteria relating to science content and pedagogical content knowledge, special education courses/practicum offered, multicultural pedagogy and preparation in action research and reflection. The paper demonstrates that despite best efforts, there is a misalignment between the preparation of urban science teachers and the needs and requirements of the special education students they serve. To meet the needs of all learners in the science classroom, including special education students, the paper proposes that urban science teachers must demonstrate knowledge and competencies in planning, implementing and evaluating project-based science instruction. A framework for accomplishing this is discussed, including assumptions, limitations and policy implications.

Keywords: **Highly Qualified Teacher, Urban Teachers, Secondary Science Teachers, Teacher Preparation, Special Education Students, Project-Based Science**

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Introduction

In the past quarter century, the preparation of science teachers in the US has been subjected to various reforms thanks to the introduction of federal legislation, national and state standards. For instance, the National Commission on Excellence in Education (1983) issued a report titled *A Nation at Risk: The Imperative for Educational Reform*. In that report, the Commission presented findings in four areas of education, namely content, expectations, time and teaching. Speaking about teaching, the Commission "found that not enough of the academically able students are being attracted to teaching; that teacher preparation programs need substantial improvement; that the professional working life of teachers is on the whole unacceptable; and that a serious shortage of teachers exists in key fields" (p. 20). In response to *A Nation at Risk*, the American Association for the Advancement of Science or AAAA (1990), released a publication titled *Project 2061: Science for All Americans*. According to the Association,

> Although creative ideas for reforming education come from many sources, only teachers can provide the insights that emerge from intensive, direct experience in the classroom itself. They bring to the task of reform a knowledge of students, craft, and school culture that others cannot. Moreover, reform cannot be imposed on teachers from the top down or the outside in. If teachers are not convinced of the merit of proposed changes, they are unlikely to implement them energetically. If they do not understand fully what is called for or have not been sufficiently well prepared to introduce new content and ways of teaching, reform measures will founder. In either case, the more teachers share in shaping reform measures and the more help they are given in implementing agreed-upon changes, the greater the probability that they will be able to make those improvements stick (http://www.project2061.org/publications/sfaa/online/chap14.htm).

Similarly, the National Research Council (NRC) (1996) released the National Science Education Standards (NSES), which presented a vision for science education in the 21st Century. The standards focused on all the things students and teachers should know, understand and be able to do, and covered science content, science teaching, assessment, science education programs, professional development and the science education system. The release of Project 2061 and the NSES provided a new framework for science teaching and learning. In addition, it created new opportunities and challenges for preparing science teachers.

Since the introduction of *A Nation at Risk*, many states have developed and implemented their own learning standards, which are aligned to national and professional standards. Schools have planned and implemented professional development to help teachers prepare students to meet state and nationals standards. Teacher education programs have also made changes and improvements in their programs to address the standards at the entry, internship and graduation levels. However, despite all the standards and efforts, there is a view among some policymakers, business leaders and in the general public that our public schools, particularly those located in inner cities are not doing a good job in preparing students to function in a knowledge-based, technology-driven and globalized society. The *No Child Left Behind Act* (NCLB) (Senate and House of Representative of the United States of America, 2002) was intended to address the chronic disparities in student achievement and failing public schools. The *Act* included eight titles, but the one that people associate with the most is *Title I*, which focuses on improvement of the academic achievement of disadvantaged students. According to the *Act*, the "purpose of this title is to ensure that all children have a fair, equal, and significant opportunity to obtain a high-quality education and reach, at a minimum, proficiency on challenging state academic achievement standards and state academic assessments" (Title I-Section 1001). To achieve this purpose, the *Act* provides several goals or expectations including the use of state-wide assessment, teacher training and professional development, holding school and education authorities accountable, targeting of resources and parental choice to name a few. It is beyond the scope of this paper to discuss the *Act* in detail. However, it is important to note that the *Act* has been controversial, with proponents claiming that for the first time in the history of United Sates education reform, the focus is on narrowing the student achievement gap and holding teachers and schools accountable. Opponents argued that it relies too much on accountability tools such as standardized tests to measure teacher performance and students' success. According to Koretz (2017), "Our heavy-handed use of tests for accountability has undermined precisely the function that testing is best designed to serve: providing trustworthy information about student achievement" (p. 23). Cochran-Smith et al. (2018) provided an in-depth examination and critique of the accountability movement, and its limitations. They offered a new approach to understanding accountability which they called "democratic accountability" (p. 153). They exposed the so-called "failure narratives" about teacher education constructed and peddled by spokespersons and representatives from the "U.S. Department of Education (USDOE), conservative think tanks, private advocacy and philanthropic organizations, leaders from the business community, emerging educational entrepreneurs and reformers, and some education scholars and professionals" (p. 20). According to the researchers, accountability is not a "new phenomenon in education" and it is not necessarily a good or bad thing. It depends on the "larger agendas to which it is attached and the underlying assumptions it makes about who is to be held accountable for what, to whom, under what conditions, with what consequences, and for what purposes" (p. 5).

In 2013, a new set of science learning standards called the Next Generation Science Standards (NGSS) were released. The NGSS were developed in partnership with the NRC, the National Science Teaching Association (NSTA), the American Association for the Advancement of Science (AAAS), Achieve, an independent, bipartisan education reform group, and 26 lead states (Next Generation Science Standards Lead States, 2013; also see www.nextgenscience.org/lead-state-partners). Instead of viewing science teaching and learning in one dimension (i.e. teaching science content and the application), the NGSS requires science educators to view their practice in three dimensions: teaching science content, enacting scientific and engineering practices and identifying and emphasizing cross-cutting science concepts. The release of the NGSS has huge implications for science teacher preparation programs. One key implication is that course work and clinical practice will have to be modified/changed to reflect the NGSS. At the program level, this means that how we prepare pre-service science teachers in curriculum design, instructional planning and implementation, student assessment, and use of scientific tools and technology will also have to be aligned with the NGSS. At the school district level, professional development for in-service science teachers on how to plan and implement the NGSS in their classrooms will be needed if we are to see the benefits of this new reform.

Purpose of Study

The purpose of this paper is to show that implicit in all of the above science education reform efforts, is equal access and opportunity to learn science for all students regardless of their background and status (i.e. race, ethnicity, gender identity, disability, religion, language, sexual orientation and nationality). However, secondary science teacher preparation programs (with the exceptions of programs where dual certification/endorsement in a science content area and special education is an option), do not have the capacity or resources to prepare teachers to serve special education students. Similarly, most urban schools do not have adequate and qualified teachers and/or resources to serve special education students. We propose that to meet the need of all learners, including special education students, urban secondary science teachers must demonstrate knowledge and competencies in planning, implementing and evaluating project-based science instruction.

We begin the paper with a discussion of the knowledge, skills and dispositions required to become a highly qualified science teacher (HQT). Then we review a sample of science teacher preparation programs leading to initial certification in secondary science education (grades 7-12) in the Greater New York City area. We identify and discuss the misalignment between the knowledge, skills and dispositions required to become a HQT, the standards for science teacher preparation and the requirements for serving students with special needs in the science classroom.

Students with disabilities or special needs come from different racial, ethnic, national and religious backgrounds, and represent all classes, genders and identities. However, in urban science classrooms some groups, particularly African American and Hispanic/Latino males are generally overrepresented. The causes and consequences of this overrepresentation have been discussed extensively in the literature (Ajayi, 2019; Artiles, 2003; Bal, Betters-Bubon & Fish, 2017; Blanchett, 2010; Donovan & Cross, 2002; Gotttlieb, et al., 1994; National Center for Learning Disabilities, 2020; Robinson & Norton, 2019; U.S. Commission on Civil Rights, 2009; Zhang and Katsiyannis, 2002). In this paper, we identify and describe not only the groups of students with special needs most frequently served in science classrooms, but also the types of disability, their characteristics and manifestations in the science classroom and offer suggestions for best teaching practices for these students. We believe that all secondary science teachers should demonstrate knowledge and skills in matching instructional methods/strategies in science teaching with best practice instructional supports in special education. Finally, we propose a framework for preparing secondary science teachers in urban special education that is grounded on the project-based approach. We end the paper with a discussion of the framework, its assumptions, limitations and implications for policy and practice.

Knowledge, Skills and Dispositions Required for Becoming a Highly Qualified Secondary Science Teacher

A discussion of the knowledge, skills and dispositions required to become a highly qualified secondary science teacher cannot be conducted without a review of the origin of the concept. The term "highly qualified teacher' (HQT) means different things to different stakeholders and has existed in the education lingua franca but did not get much attention until when it became part of the NCLB. In a report titled "Meeting the Highly Qualified Teachers (HQT) Challenge: The Secretary's Annual Report on Teacher Quality", the USDOE (2002) defines 'a highly qualified teacher' as follows:

> The term 'highly qualified'— (A) when used with respect to any public elementary school or secondary school teacher teaching in a State, means that— (i) the teacher has obtained full State certification as a teacher (including certification obtained through alternative routes to certification) or passed the State teacher licensing examination, and holds a license to teach in

> such State, except that when used with respect to any teacher teaching in a public charter school, the term means that the teacher meets the requirements set forth in the State's public charter school law; and (ii) the teacher has not had certification or licensure requirements waived on an emergency, temporary, or provisional basis; Therefore, except for charter school teachers, all teachers of core academic subjects must have full state certification or licensure to be considered "highly qualified." (p. 4)

The report also added that "The term 'highly qualified' when used with respect to—

> (ii) a middle or secondary school teacher who is new to the profession, means that the teacher holds at least a bachelor's degree and has demonstrated a high level of competency in each of the academic subjects in which the teacher teaches by— (I) passing a rigorous State academic subject test in each of the academic subjects in which the teacher teaches (which may consist of a passing level of performance on a State-required certification or licensing test or tests in each of the academic subjects in which the teacher teaches); or (II) successful completion, in each of the academic subjects in which the teacher teaches, of an academic major, a graduate degree, coursework equivalent to an undergraduate academic major, or advanced certification or credentialing. (p. 5)

According to the Secretary's Annual Report, "the best available research shows that solid verbal ability and content knowledge are what matters most…" (p. 9) hence why the above definition is driven by teacher content knowledge. Although teacher content knowledge is important, putting less emphasis on other important variables such as pedagogical content knowledge, teacher disposition, how students learn, the social and cultural background of students and the political economy of schools makes the definition problematic to many educators. For instance, Cochran-Smith and Lytle (2006) noted that the notion of teacher education inherent in the USDOE's definition of HQT is a by-product of the past research conducted in the 1960's and 70's when teaching was regarded as a technical occupation and teacher behavior was related to students' test scores. This simplistic and linear thinking about teacher education, according to Cochran-Smith and Lytle (2006), is designed to "maintain control over teachers and surveillance over teachers' instruction" and "dramatically narrows the purposes of education and advances an impoverished view of teaching, learning, curriculum and schooling" (p. 689).

A similar voice was echoed by Darling-Hammond (2006) who pointed out that the Department's definition of HQT when implemented will undo some of the hard work done to create small high performing, community oriented high schools. She proposed that we work towards a definition of HQT that is based on what we know about successful high schools. Successful schools have well qualified teachers who are supported by high quality professional development, where instruction is conducted by teams of teachers and students working together (personalization), where there is a focus on core curriculum and clearly defined performance assessments and where there is support provided to students lagging behind through supplemental and afterschool programs.

The National Board for Professional Teaching Standards (2006) also expressed concern about the USDOE's definition of HQT and issued a statement in which they noted that such a definition was too narrow. They offered their definition which includes the following criteria: (a) teachers are committed to their students and their learning, (b) teachers know the subject they teach and how to teach those subjects to their students, (c) teachers are responsible for managing student learning, (d) teachers think systematically about their practice and learn from experience, and (e) teachers are members of a learning community. The American Association of Colleges of Teacher Education (2007) also added its voice. In a press release titled: *AACTE Commends Commission on No Child Left Behind*, the Association noted "AACTE maintains that the current definition in NCLB of "highly qualified teacher" (HQT) is limited in its breadth and does not ensure that teachers are effective. The current definition requires that teachers have met credentialing requirements and are competent in their content areas, but it does not ensure that teachers are able to effectively teach their content to students. The Commission's proposed Highly Qualified and Effective Teacher status would measure a teacher's effectiveness through student learning gains as well as through principal and peer evaluations" (https://aacte.org/2007/02/aacte-commends-commission-on-no-child-left-behind/).

After receiving several complaints and comments from teachers, school districts and state education authorities about the difficulty in implementing the HQT provisions of the NCLB, the USDOE (2004) decided to revise the definition of HQT. The new definition states that

> Science teachers, like rural teachers, are often needed to teach in more than one field of science. Some states allow such science teachers to be certified under a general science certification, while others require a subject-specific certification (such as physics, biology or chemistry). In science, where demand for teachers is so high, the Department is issuing additional flexibility for teachers to demonstrate that they are highly qualified. Now, states may determine—based on their current certification requirements—to allow science teachers to demonstrate

> that they are highly qualified either in "broad field" science or individual fields of science (such as physics, biology or chemistry). (No. II, p. 1-Fact Sheet)

It is clear from the above discussion that the definition of a HQT by the USDOE focuses on very narrow criteria. However, in order to qualify for the NCLB funding, states are required to meet the federal government's definition of HQT. It is therefore not surprising to see that most states incorporate competency in science content knowledge as a key element of their definition of HQT. Unlike states, the definition of a HQT in science teacher preparation programs is driven more by accreditation and professional standards set by the Council for the Accreditation of Educator Preparation (CAEP) and the National Science Teaching Association (NSTA). The NSTA is the specialized professional association (SPA) recognized by CAEP for reviewing science teacher education programs for accreditation.

Over the past two to three decades, the NSTA has been engaged in a process of development, review, revision and refinement of a set of standards for science teacher preparation. The most comprehensive and earliest standards were released in 2003 and used by most science teacher education programs seeking recognition. According to the NSTA (2003), the development of the standards was informed by not only the research literature, but also the national science education standards (NRC, 1996), standards set by the Interstate New Teacher Assessment and Support Consortium (INTASC) and by the National Board for Professional Teaching Standards. It is important to note that the standards for science teacher preparation were developed with input from the several science educators and professional associations such as the American Association of Physics Teachers, the American Chemical Society, the National Association of Biology Teachers and the National Earth Science Teachers Association.

The 2003 standards focused on the following ten standards: (a) knowledge and understanding of science content, (b) knowledge and understanding of the nature of science, (c) skills in engaging students in different methods of scientific inquiry and in active learning about science, (d) demonstrate skills in engaging students in learning about socially relevant issues in science and technology, (e) demonstrate general science pedagogical skills to serve the needs of diverse learners, (f) demonstrate competency in planning and implementing curriculum that addresses the national science education standards, (g) able to connect science to the community and engage stakeholders and utilize community resources in the teaching and learning of science, (h) demonstrate competency in developing and implementing fair and effective assessments, and are able to use assessment data to inform their instruction, (i) demonstrate knowledge and understanding of safety issues in the classroom and able to conduct science in a safe and ethical environment, (j) are able to continuous engage in professional development and life-long learning in science teaching and learning (NSTA, 2003).

In response to feedback from the science education community and changes in accreditation policies at the national level, the NSTA revised the standards for science teacher preparation in 2012. According to the NSTA (2017), "NSTA supports teacher preparation aligned with the goals and guidance provided by *A Framework for K–12 Science Educati*on: *Practices, crosscutting concepts and core ideas* (NRC, 2012),…and is committed to increasing the numbers of highly qualified science teachers by ensuring that all those entering the profession demonstrate a deep understanding of pure and applied science and have the knowledge and skills required to teach students science in age-appropriate, meaningful ways" (p. 1). The 2012 standards for science teacher preparation addressed six areas of science teacher preparation such as (1) content knowledge, (2) content pedagogy, (3) learning environments, (4) safety, (5) impact on student learning, and (6) professional knowledge and skills. Each standard contains two to three elements or components which further deconstruct the standards. In addition, each standard is aligned to a specific assessment or assessments that are required for NSTA national recognition.

As a results of the release of the NGSS, NSTA in partnership with the Association for Science Teacher Education (ASTE) revised the 2012 standards in 2020 and renamed them *2020 NSTA and ASTE Standards for Science Teacher Preparation* (NSTA and ASTE, 2020). The overview to the new standards stated "These standards are intended to be used by science teacher preparation programs in preparing for accreditation or program design. These standards can also serve as a guide for state agencies developing licensure standards for science teacher preparation. Any new efforts should reflect the NSTA and ASTE 2020 Science Standards for Teacher Preparation, as the 2012 Standards have now been superseded by the 2020 NSTA and ASTE Standards" (p.n.a). The framework for the 2020 standards is similar to the 2012 standards in the sense that the 2020 standards still contain the six standards and elements. However, the main difference is that in the 2020 standards, the emphasis on the application of the NGSS, culturally relevant pedagogy and inclusion or engagement of "all students" is clearly evident across all standards.

As can be seen from the above standards for science teacher preparation, to become a HQT is much more complex than demonstrating "a high level of competency in each of the academic subjects in which the teacher teaches by (I) passing a rigorous State academic subject test in each of the academic subjects."

Review of Secondary Science Teacher Preparation Programs in New York City Area

In preparing this paper, we looked at a sample of science teacher education programs in the Greater New York City area to learn about how teacher candidates from these programs are being prepared to serve students with special needs in the science classroom. We reviewed thirteen secondary science teacher education programs leading to initial certification using data published on institutional websites, cross-referenced with the Inventory of Registered Programs published on the New York State Education Department website. Programs were compared on four criteria such as (1) how much science content and pedagogical content knowledge do they offer to candidates both at the undergraduate and graduate levels? (2) Are there special education courses/practicum and if so how many credits do candidates earn? (3) Do they offer courses in multicultural pedagogy or courses leading to cultural competency? (4) How much intensive action research, reflection, and writing do they require of their candidates? Our rationale for looking at courses in multicultural pedagogy or courses leading to cultural competency was based on the assumption that these courses usually cover issues of diversity, equity, inclusivity and social justice, and therefore, it is conceivable that teacher candidates are likely to learn about issues of students with special needs or students with learning disabilities. Similarly, we were interested in question (4) because science teachers are expected to teach science using different types of inquiry-based teaching strategies, and we wanted to compare preparation programs in terms of how much training teacher candidates receive in research methods.

Our review showed that there is great variability in the number of undergraduate credits, number of graduate credits, special education credits and action research credits across teacher education programs. For instance, with regard to undergraduate programs, almost all offer education as a minor and require candidates to major in a science subject or certification area. The number of credits required for an education minor ranges from 21-37 credits. For graduate programs, the number of education credits that candidates are required to take varies from 21 to 53 credits, with some programs having multiple routes for initial certification (i.e. traditional and Transitional B certification: certification through an alternative program). With regard to science content, about half of the graduate programs do not offer science content and for those graduate programs that offer science content, the number of credits ranges from 6-12 credits. Out of the 13 graduate programs reviewed, 10 require a special education course of some sort, while three had none. The special education credits range from 3-6 credits. Although course titles and descriptions are not a true representation of the actual content taught in a particular course, the presence or absence of a particular course is indicative of what is and is not covered in a program. With the exception of two of the programs reviewed, none of the programs offer courses that specifically addressed diversity and multiculturalism or cultural competencies. This is a surprising finding since all these programs take place in an urban setting and most of their candidates are being prepared to teach in diverse, inclusive science classrooms. Although it is possible that these issues are embedded in other educational foundation courses. Only seven programs require an action research project as part of course work, while the remaining require a capstone project, comprehensive examination and/or a portfolio. Out of the 13, only two programs require candidates to take course work in intensive writing and communication.

From the above review, one can notice that there are similarities and differences as well as strengths and limitations in this sample of secondary science teacher preparation programs. All of the 13 programs are registered with New York State, have national recognition by NSTA and are all accredited. So it is safe to assume that the graduates of these programs will meet expectations and requirements of becoming a HQT. However, it is also clear that these programs are not designed to prepare teachers to meet the needs of special education students. A caveat is in order here and that is the above review is only an exploratory one and is by no means exhaustive or conclusive.

Who are the Students With Disabilities in the Secondary Science Classroom?

Special education can be conceptualized as a complex system of procedures designed to support students with disabilities. At the core of the special education philosophy, is the concept of identifying the strengths and needs of individual students and creating a plan of instruction, with all the needed supports, to educate that individual student. Teachers in urban settings rarely have the luxury of devoting time or resources to planning for individual students. Large class sizes, highly mobile student and staff populations, scarcity of resources, and the significant needs of urban students create a situation where many educators often are quickly persuaded to do their very best for groups of students. The fundamental principle of special education, addressing the needs of the individual student, becomes lost in the multiple demands for teacher time and resources.

This is not a condemnation of urban teachers who are unable to plan for individual students in the way special education was conceptualized, but rather an acknowledgement of the real demands on our education system. Urban science teachers can make a positive impact on students with special needs, both identified as with disabilities and those without, with a studied regard to marrying the best of science teaching methods with known special education techniques and strategies. To begin we will identify the groups of students with special needs most frequently served in science classrooms. This will be followed by a discussion of merging best practice science teaching methods with special education supports.

While there are currently thirteen recognized disability categories under the Individuals Disability Education Act (IDEA), three are considered high incidence in adolescents (USDOE, 2011). Those disabilities: learning disability (LD) intellectual disability (ID), and emotional/behavior disorders (EBD) will be the main focus of this paper. Of note, students with challenges focusing and or maintaining attention, often diagnosed with attention deficit disorder (ADD) or attention deficit hyperactivity disorder (ADHD), present considerable challenges for urban teachers. Often this group is represented in the special education category of other health impaired (OHI). This group, OHI, is represented in large numbers, however the disaggregate percentage limited to only ADD or ADHD students is not represented in national data sets. Modifications for this group will be noted. Finally, a growing challenge for secondary science teachers is to appropriately instruct students with autism spectrum disorder (ASD). Modifications for these students will be noted as well.

At the risk of violating a fundamental underpinning of special education, always planning for the individual; we would posit that for secondary science teachers planning for group characteristics that challenge students may be a first step toward quality instruction. While the definitions of disability are by no means exhaustive, Table 1 presents types of disability with examples of characteristics and manifestations.

As mentioned previously a pillar of special education is the focus on planning for the individual and subsequently providing individualized instruction. Equally important foundations in special education are the concepts of least restrictive environment (LRE) and the continuum of placements. The concept of LRE is that a student should always be educated in the environment, including both school and classroom that most closely resembles where students without disabilities are being educated, while providing the intensity of services the student with disability needs. Thus, the continuum of placements can be thought of as a hierarchy of settings. At one end of the continuum is the general education classroom. The opposite end of the continuum is a highly restrictive environment. Examples would be locked facilities such as a juvenile detention center or a mental health hospital.

Table 1. ***Definition of Disability by Type, Characteristics and Manifestation in the Classroom***

Type of disability	Characteristics	Manifestation in classroom
LD	Uneven pattern of learning May experience significant frustration Organizational difficulty Disability (e.g., reading) will be pervasive across all content areas	May exhibit anxiety, learned helplessness, or attitude of defeat by middle or high school Appears to lose papers, work, and ideas Poor time management Misses deadlines Often must work 2x or 3x as long as others to complete a task or project
ID	Lower cognitive functioning than typical peers Slower learning across all content areas May have delays in social maturation and have interests more similar to younger students Will not have the same higher level language ability as typical peers and may not understand humor, sarcasm, and social conventions	Significantly behind peers in all areas of instruction May be a target for bullying or isolation Needs support in social integration Unable to complete workload and content the same as typical peers

Table 1. ***Definition of Disability by Type, Characteristics and Manifestation in the Classroom (continued)***

Type of disability	Characteristics	Manifestation in classroom
EBD	Average or above intelligence Difficulty with social relationships May be characterized as internalizing (e.g., depression, anxiety, fears or phobias) or externalizing (e.g., aggression, hostility, belligerence) May have gender identity or adjustment issues High risk for self-injurious and suicidal behavior May be involved with mental health services, juvenile justice, or foster care at higher rates than other students	Doesn't bond with peers or teachers May exhibit a high need to control the classroom or others Poor attendance Rule infractions Requires extra teacher time and attention May seek a negative leadership role in the class May be a loner and rarely engage with peers or activities May come to class under the influence of illegal substances May have side effects from prescribed medication
ADD/ ADHD	All levels of cognitive functioning Has difficulty maintaining attention May be highly distractible May display behavior similar to students with EBD both internalizing (ADD) and externalizing (ADHD)	Has difficulty initiating tasks Has difficulty completing assignments May have difficulty maintaining friendships Has difficulty modulating voice Poor organization High rates of frustration High rates of off task behavior

Table 1. ***Definition of Disability by Type, Characteristics and Manifestation in the Classroom (continued)***

Type of disability	Characteristics	Manifestation in classroom
ASD	Significant variability in cognitive ability Topics of fascination Difficulty assessing others' moods or emotional state including facial cues Difficulty understanding humor and sarcasm Difficulty bonding with peers and teachers	Perseveration on topics of interest coupled with disinterest in class content Uneven pattern of performance May be hyper sensitive to schedules and routines and show inflexibility in change May have poor time management Social skill deficits May be emotionally labile and evidence mood swings May have frustration responses that are not age appropriate

Placements are positively skewed toward the general education classroom end of the continuum. For instance, in 2019, the most recent data available, 65% of school age students receiving special education were in the general classroom 80% or more of their school day. An additional 18% of students received special education services in the general classroom 40-79% of the school day (USDOE, 2021). Special education can be provided in the general classroom by "adding on" services for the students with disabilities. This could include modifications in the classroom, consultation with a special educator, and a special educator being assigned as a co-teacher in the class. For a large number of students with LD, CI or EBD the general education classroom with special education supports is their LRE and subsequently the locus of their schooling. Further students with ADD and ADHD who often do not receive special education are in the general classroom. And, increasingly, students with ASD are in general classrooms.

For those students in an LRE, which requires more intensive services, science learning may occur outside of the general classroom. A variety of increasingly supportive settings may include: small class resource rooms, self-contained classes where a small group of students will stay together throughout the day either with one or a small group of teachers, classes offered in a segregated school designed for students with disabilities and so on. It is the position of the authors that irrespective of the setting, science learning develops a mode of thinking and understanding of the natural world that is of great importance to all students. As we continue the discussion on science teaching methods and modifications for students with special needs, the reader is reminded that the recommendations for teaching are meant for all students enrolled in science classes no matter where that class falls on the special education continuum of placements.

In addition to considering disability status and placement for services, we also need to examine two important concepts such as risk index and risk ratio. The former refers to the percentage of the overall school age population of an ethnic group who qualify for special education services, while the latter indicates how likely a student is to receive special education compared to students of all other racial ethnic groups combined. The USDOE (2020) determines the risk index by "dividing the number of students ages 6 through 21 served under IDEA, Part B, in all of the other racial/ethnic groups by the estimated United States resident population ages 6 through 21 in all of the other racial/ethnic groups, then multiplying the result by 100" (p. 48). Viewing data from a national perspective, the overall risk index is highest for American Indian and Alaskan Natives at 15.1 across all disability categories. This is followed by Native Hawaiian and Other Pacific Islander with an index of 13.9, Black or African American students with 12.2, Hispanic/Latino students with 9.6, students identifying with two or more races with an index of 9.2, White students with 8.6, and Asian students with an index of 4.4.

The risk ratio is "calculated by dividing the risk index for the racial/ethnic group by the risk index for all the other racial/ethnic groups combined" (p. 48). According to the USDOE (2020) "In 2017, for all disabilities, American Indian or Alaska Native students, Black or African American students, Hispanic/Latino students, and Native Hawaiian or Other Pacific Islander students ages 6 through 21, with risk ratios of 1.6, 1.4, 1.1, and 1.5, respectively, were more likely to be served under IDEA, Part B, than were students ages 6 through 21 in all other racial/ethnic groups combined" (p. 48). In addition, the US Department of Education also indicated that in 2017, LD was the most common type of disability and in terms of race/ethnicity, this disability was distributed as follows: American Indian or Alaska Native students 44.3%, Asian students represented 23.7%, Black or African American students 39.8%, Hispanic/Latino students 45.7, Native Hawaiian or Other Pacific Islander students 50.2%, White students 34%, and students who identified with two or more racial/ethnic groups 34% (USDOE, 2020).

Table 2. ***Percentage of Students with Individualized Educations Programs (IEP) by Race/Ethnicity in the Nations Four Largest Urban School Districts***

Race/Ethnicity	Chicago	Los Angeles	New York City	Philadelphia
Asian	1.6	1.8	7.6	3.0
Black/African American	43.1	9.1	28.0	53.0
Hispanic/Latino	45.5	75.2	49.0	21.0
White	8.4	8.4	13.0	13.0
Others	1.4	5.5	2.0	11.0

Sources:

a. Illinois Board of Education (http://webprod1.isbe.net/LEAProfile/SearchCriteria1.aspx).

b. Los Angeles Unified School District Division of Special Education (https://achieve.lausd.net/Page/16734).

c. New York City Department of Education (https://infohub.nyced.org/docs/default-source/default-document-library/annual-special-education-data-report-sy18-1960b79998ec27487584b9fedec3fac29c.pdf).

d. School District of Philadelphia (https://www.philasd.org/research/wp-content/uploads/sites/90/2020/04/Special-Education-in-SDP-2018-19-Data-Brief-April-2020.pdf).

Table 2 above shows the percentage of students with Individualized Educations Programs (IEP) or classified as "students with disabilities" by race/ethnicity in the nations four largest urban school districts. The data sources were official websites from the Illinois Board of Education, Los Angeles Unified School District, New York City Department of Education and the School District of Philadelphia. It is important to note that although each education authority reported IEP/disability data by race/ethnicity, not everyone disaggregated the category "Others." In this article "Others" is used to refer to the following race/ethnic groups: Native American, Pacific Islanders/Native Hawaiian and Multiracial or mixed race students. An examination of the table shows that Hispanic/Latino students (followed by Black/African American students) make up the majority of students with IEP's or classified as students with disabilities in the cities of Chicago, Los Angeles and New York, while Black/African American students represented the largest group in Philadelphia. New York City reported the largest number of Asian students classified as students with disabilities. Philadelphia reported the most students with disabilities categorized as "Others." New

York City and Philadelphia have similar percentages of White students with disabilities. While it would be misleading to estimate the number of students with disabilities in urban districts based on these data, we can extrapolate and say that there are greater numbers of students of color in these urban districts than found in the general population.

Proposed Framework

In this paper we have shown that special education is a complex concept that requires an understanding of the diversity of students with disabilities, different types of high incidence disability in urban classrooms, and the disability characteristics and manifestations in the classroom. In addition, we have demonstrated that in certain urban settings, such as New York City, there is a great variability in secondary science teacher preparation programs and that some programs are not preparing teachers to serve all students, particularly those with special needs. We have shown that there is a misalignment between the rhetoric of HQT and the reality of some science teacher preparation programs for initial certification in urban settings.

To address these challenges and to ensure that all students including students in special education are truly served in the science classroom, we propose a framework for preparing secondary science teachers in urban special education that is grounded in the following principles: (1) that to achieve scientific literacy for all students regardless of background, secondary science teachers must know and be able to practice project-based science teaching because this approach can accommodate both individual and team learning, and it mirrors closely how science is conducted in the real world, (2) that secondary science teachers must know and be able to apply the NGSS standards in diverse urban classrooms, (3) that special education is a civil and human rights issue not only about providing special educational services, (4) that to serve students in inclusive and diverse urban classrooms, secondary science teachers must understand the socio-cultural and economic context in which their students come from, and (5) that secondary science teachers teaching science in inclusive and diverse urban classrooms must demonstrate knowledge and understanding of how students learn, the theories and best practices in performance-based assessment, and the use of educational and assistive technologies to enhance instruction.

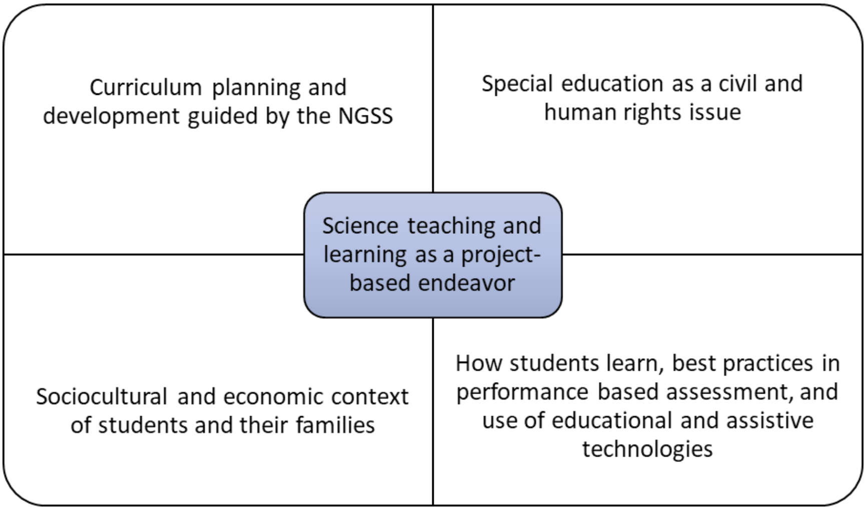

***Figure 1.* Proposed Framework for Preparing Secondary Science Teachers in Urban Special Education**

Figure 1 shows a graphical representation of the proposed framework. The components of the framework are as follows:

- Science teaching and learning as a project-based endeavor
- Curriculum planning and development guided by the NGSS
- Special education as a civil and human rights issue
- Socio-cultural and economic contexts of students and their families
- How students learn, best practices in performance based assessment, and use of educational and assistive technologies

Science Teaching and Learning as a Project-Based Endeavor

The anchor and driving force for the framework is the core principle of project-based science teaching and learning (the rectangle at the center) supported by the four other principles each represented by a quadrant. The framework shows an overlapping relationship not only between the center rectangle and the four quadrants, but also within quadrants. The term project-based science teaching and learning is used here to mean teaching and learning of science that is purposeful and driven by student generated questions. In a project-based science classroom, teachers act as facilitators and students are allowed to take responsibility for their own learning. A key characteristic of project-based learning is student-to-student collaboration, student-to-scientist collaboration and the use of scientific tools and technologies. Project-based science teaching is chosen as an anchor because studies of urban systemic science education reform has shown that those students who take part in project-based science learning activities develop better understanding of science and perform better on curriculum-based assessments (Colley & Pitts, 2010; Colley, 2016; Duncan and Tseng, 2011; Krajcik & Czerniak, 2018; Marx et al., 2004; Polman, 2000; Sola & Ojo, 2007; Tal, Krajcik & Blumenfeld, 2006).

Curriculum Planning and Development Guided by the NGSS

According to the NRC (2012) "Curriculum refers to the knowledge and practices in subject matter areas that teachers teach and that students are supposed to learn. A curriculum generally consists of a scope, or breadth of content, in a given subject area and of a sequence of concepts and activities for learning. While standards typically outline the goals of learning, curricula set forth the more specific means—materials, tasks, discussions, representations—to be used to achieve those goals" (p. 246). One of the major challenges facing science educators relating to curriculum planning and development to address the NGSS is how to design science units and lesson plans to teach the three dimensions of the NGSS (science and engineering practices, crosscutting concepts and disciplinary core). The NRC (2012) suggests that one of the goals of curriculum development on the NGSS must be to develop understanding of at least one disciplinary core idea in the subject area at the appropriate grade level. Science educators or curriculum developers can then identify and address the crosscutting concepts relating to the core idea. Opportunities to engage in science projects to gain experience in scientific and engineering practices should also be provided. Curriculum development should not only focus on creating units and lesson plans that are NGSS compliant, but also include opportunities for students to engage in "…discussion and reflection, students can come to realize that scientific inquiry embodies a set of values. These values include respect for the importance of logical thinking, precision, open-mindedness, objectivity, skepticism, and a requirement for transparent research procedures and honest reporting of findings" (p. 248). Because the NGSS is currently at the center of the reform in science education, it is imperative that all science teachers be competent in its application in the classroom. Similarly, our proposed model requires secondary science teachers to develop knowledge and skills in analyzing, interpreting and applying the NGSS in curriculum development and implementation.

Special Education as a Civil and Human Rights Issue

Until 1975 when the Education for all Handicapped Children Act was passed, the rights of people with disabilities were not well protected and students with disabilities and their families were for the most part responsible for providing their own educational services. Since the inception of the Act in 1975, this law has been continuously reauthorized to provide the legal and educational framework to address the needs of individuals with disabilities and their families within the education system and protect them from discrimination. The current iteration of the Act, the Individuals with Disability Education Improvement Act (IDEA-2004) outlines the policies, procedures and protections for students receiving special education. Most advocates of disability rights welcome the reauthorization of IDEA, but as the Act went through the implementation process, they discovered that there were many unintended outcomes and discrepancies, which led Beratan (2006) to conclude:

> We have heard for the last thirty years that IDEA is civil rights legislation intended to fight discrimination. While the sincerity of this claim is not in question, I contend that ableism is deeply ingrained within IDEA. Covert forms of discrimination, such as institutional ableism and racism, are far more insidious than more overt discrimination because they are so difficult to question. IDEA's attempts to address disproportionality are perfect examples. The stated purpose of the clause indicates an anti-discriminatory intent, but the mechanism the clause creates to achieve this end is designed in a way that is most likely to cultivate the very outcome it intends to eradicate. (p. 11)

Because disproportionality and structural racism exist within the implementation of IDEA, secondary science teachers must develop an awareness of it, understand its manifestations and be able to address it in the science classroom. Because they are in the forefront and usually the first port of call, teachers can play a vital role in bridging the gap between families and service providers. Secondary science teachers should not only be required to take courses in special education, but also must be exposed to the historical, legal, political and sociological dimensions of the subject of disability. It is imperative that special education courses for these teachers address and be taught from civil and human rights perspective or at lease include a requirement that relates to this perspective (Cowger, 2017).

Socio-Cultural, Economic and Political Context of Students and Their Families

Urban science classrooms are very diverse in terms of their student populations, although this is not true for the teachers and administrators who run them. This lack of diversity in the teaching workforce has implications for policy and practice (Albert Shanker Institute, 2015; USDOE, 2016). Studies of urban science classrooms (Calabrese Barton & Schenkel, 2020; McLaughlin, 2014), have shown that they are not always conducive to science teaching and learning because of challenges such as power relationships between different actors and stakeholders, issues of economic inequality and social justice. To create a conducive and better environment for science teaching and learning, we suggest that secondary science teacher education programs should include experiences that allow candidates to develop knowledge and understanding of the social, cultural, economic and political contexts of their students. This requires candidates to immerse themselves in the communities that they serve through conducting sociological studies, doing community service and working on special projects that involve students and their parents. This idea is based on the principle that to serve one, you must know and understand one. Although most science teacher preparation programs already include some form of clinical experience or internship in a school setting, experience in non-school settings should also be encouraged.

How Students Learn, Best Practices in Performance-Based Assessment, and Use of Educational and Assistive Technologies

In the past two to three decades, educators have gained better understanding of how students learn, including the most effective way to assess learning and what technologies to use to support learning for all students, thanks to the research on how people learn (National Academies of Sciences, Engineering, and Medicine, 2018). However, this understanding is not translated into tangible student outcomes in most urban science classrooms because secondary science teachers often base their understanding of how students learn on narrow notions of adolescent development and cognitive abilities learned in their educational psychology courses. To meet the need of all students in the urban science classroom, secondary science teachers must understand that,

> Learning is a dynamic, ongoing process that is simultaneously biological and cultural. Each individual learner functions within a complex developmental, cognitive, physical, social, and cultural system. Factors that are relevant to learning include influences from the microscopic level to the characteristics of the learner's neighborhood, community, and the time period in which he lives. Further, even at the most basic individual level, evidence shows that brain development and cognition (and the connectivity between cortical areas) are influenced and organized by cultural, social, emotional, and physiological experiences that contribute to both age-related and individual variability in learning. (Academies of Sciences, Engineering, and Medicine, 2018, p. 225)

We now know that students come to the classroom with their own preconceptions or 'alternative theories' of how the universe works, and unless teachers examine, challenge and/or address these alternative theories they are likely to interfere with learning (Blown & Bryce, 2006; Driver, Guesne & Tiberghien, 1985; Harvard-Smithsonian Center for Astrophysics, 1987). We also know that in order for students to develop a deep understanding of scientific inquiry, they must demonstrate factual disciplinary knowledge and have a framework for organizing, accessing and applying that knowledge. In addition, we know that all learning takes place within a context and to be meaningful, it must be connected or related to the students' community, social and cultural values. Our proposed framework will draw on this evidence-based knowledge about how people learn.

According to Driver et al. (1994), learning science "requires more than challenging learners' prior ideas through discrepant events. Learning science involves young people entering into a different way of thinking about and explaining the natural world; becoming socialized to a greater or lesser extent into the practices of the scientific community with its particular purposes, ways of seeing, and ways of supporting its knowledge claims. Before this can happen, however, individuals must engage in a process of personal construction and meaning making." (p. 8). This constructivist approach to science teaching has been discussed extensively in the science education literature (Mintzes, Wandersee & Novak, 1998; Yager, 1991; Yore, 2001), yet the way science is conducted in most urban schools is dominated by "chalk-and-talk" and "lecture-and-lab." The work of Tobin, Elmesky and Seiler (2005) on urban science education demonstrated that using a socio-cultural and symbolic approach can help students and their teachers in urban settings "talk and do science in ways that enable social networks to be formed as resources for building a better life" (p. 310). We agree with the constructivist approach to science teaching that incorporates a socio-cultural and symbolic worldview.

It is generally true that we live in a society where testing and assessment is very pervasive in the education system. However, authentic performance-based assessment is not commonly practiced in science classrooms. The reasons vary and have to do with training, funding and culture surrounding assessment. In addition, many secondary science teachers are trained to view assessment as a measure of achievement rather than a process to determining student learning based on multiple sources of evidence. With appropriate training, funding and a change in culture, performance-based assessment could serve as a powerful teaching tool for secondary science teachers. Our view is that assessment that is performance-based is consistent with the way science is conducted in the real world. The preparation of science teachers for urban classrooms must arm candidates with the knowledge, skills and dispositions to implement performance-based science assessments for all students, including special needs students.

We subscribe to the view that regardless of type, all educational technologies, including assistive technologies, when closely examined will show both beneficial uses and potential for misuses. Educational and assistive technologies must be evaluated for appropriateness and practical benefits to students prior to widespread application in the inclusive science classroom. Our framework assumes that assistive technologies will be implemented in inclusive science classroom not as an "add-on" but as part of an integrated system of curriculum, teaching, learning and assessment of science. It draws on the works Linn

(2003), Songer, Lee and Kam (2002) and Edelson (2001). The central question that should drive the use of educational and assistive technologies in the science classroom is: Is it a means or an end? When used as standalone, educational and assistive technologies must serve as means to enhance and support teaching and learning of science for all students.

Assumptions and Limitations

Like most proposed frameworks, they come with assumptions and limitations. Our proposed framework assumes that there are challenges and opportunities to redesign and/or invent new science teacher preparation programs that will address that needs of all students, particularly those with special needs. We also assume that the capacity exists in most science teacher preparation programs to redesign and/or invent programs that will prepare candidates to serve all students. It is beyond the scope of this paper to discuss in detail program redesign and/or invention. Therefore, we intend this framework to be a guide to thinking about program redesign and invention. In this regard, we assume that there is a need for fresh thinking or "thinking outside the box" in order to craft science teacher preparation programs that prepare candidates to meet the needs of all students regardless of background. We are also assuming that regardless of the goals and context, that all science teacher preparation programs have a field experience component (may be called clinical experience, internship, student teaching or practicum), which may vary from a semester to one year. Our proposed framework is limited in that it does not include all the possible components that we or other stakeholders may deem critically important for any science teacher preparation program to have. Because of space constraints, we are also not able to discuss the amount, types and distribution of course work in science content, science education and special education that would prepare candidates to be able to teach science to all students. In addition, our proposed framework focuses on adolescent science teacher preparation programs leading to initial certification for grade 7-12 in urban settings and is therefore limited in audience and context.

Implications for Policy and Practice

Our proposed framework for preparing secondary science teachers for urban special education has implications for policy and practice. The implications will be examined in terms of federal government action, the role of colleges of teacher education, school district partnerships and opportunities for clinically rich, field experience for candidates.

Because our framework views special education as a civil and human rights issue, this issue requires serious attention from those in our national government responsible for education policy and funding. We therefore recommend that the USDOE as part of its funding for the mathematics and science partnerships and special education programs, provide a modest amount of funding to science teacher preparation programs for faculty work teams to explore and/or redesign curriculum for science teacher preparation that is aligned with the needs of all learners. The science teacher preparation curriculum for the 21st Century must take into account the forces of urbanization, human diversity, demographic shifts in the student population, globalization of the world economy, advances in science and technology, and how young people learn and use information technologies.

Although there is interdisciplinary teaching in most colleges of education, these practices are, for the most part, the exception and not the rule. Not enough interdisciplinary teaching is modeled in science teacher preparation programs to create an impact on science teacher candidates' disposition towards interdisciplinary teaching. Colleges of Education/Schools of Education could play a leading role in promoting the preparation of secondary science teachers for urban special education by implementing internal structures that would support interdisciplinary teaching. For instance, modifying faculty course loads or providing incentive so that faculty from education and faculty from the sciences co-teach a course, work together to improve a course or develop a new course to meet the needs of all learners. Other options could be faculty from special education and faculty from science education partnering or having a collaborative interdisciplinary teaching by a scientist, a science educator and a special educator.

In addition to interdisciplinary teaching, our framework implies that science teacher preparation programs will implement clinically rich field experiences where candidates will work in diverse, inclusive classroom using project-based teaching strategies, supported by caring and highly experienced mentor teachers. It is important to note that a field experience should not only be confined to the classroom, but to the community as well. This means that candidates also be provided with the opportunity to engage in community service or projects that address a felt need or leads to empowerment of students and their families.

Implementation of our framework is incomplete without taking into consideration the role of stakeholders, such as school districts and strategic partnerships with local not-for-profit organizations or local businesses. A commitment from local school districts for supporting and implementing inclusive science education reform in their schools is one important step. However, strategic partnerships should also be formed between universities and local school districts or between universities, local school districts and local non-profit organizations and businesses to implement inclusive science education reform. Such reform will provide opportunities for clinically rich field placements for candidates preparing to become secondary science teachers for all students.

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