Science Education as a Civil Right: Urban Schools and Opportunity-to-Learn Considerations

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Received 2 May 2001; accepted 6 July 2001

Abstract: In this article I make the case that urban science education is a civil rights issue and that to effectively address it as such we must shift from arguments for civil rights as shared physical space in schools to demands for high-quality academic preparation that includes the opportunity to learn science. The argument is organized into two sections: first, a review of the school desegregation literature to make the case that urban science education for all is a civil rights issue; and second, an examination and critique of opportunity-to-learn literature, including an analysis of three opportunity-to-learn constructs to illustrate their potential as civil rights tools in science education. © 2001 John Wiley & Sons, Inc. J Res Sci Teach 38: 1015–1028, 2001

Introduction

> Today, I want to argue, the most urgent social issue affecting poor people and people of color is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math literacy in urban and rural communities throughout this country is an issue as urgent as the lack of registered Black voters in Mississippi was in 1961. (Moses and Cobb, 2001, p. 5)

As a former civil rights activist who is now president of the Algebra Project, Robert Moses believes the opportunity to learn mathematics and science is consonant with ethical correctness and civil rights. The rights a person has because of national citizenship, which are enforceable by law and can be redressed by civil action, are civil rights. Such rights include the right to own property, to marry, to make a contract, and to have a trial by jury, and especially to the right of personal liberty as guaranteed by the 13th and 14th amendments to the U.S. Constitution and various acts of Congress. Framing the opportunity to learn mathematics and science in urban schools as a civil right is a departure from the traditional perspectives of school desegregation

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law and other school-related civil rights initiatives (Bell, 1987). A brief review of this literature reveals that many civil rights challenges to inequality in schooling have focused on students of color winning the right to share the same "educational space" with White students. The purpose of this article is to discuss how education-related civil rights discourse is shifting from arguments for shared physical space in schools to demands for high-quality academic preparation, which includes the opportunity to learn science. I believe this shift in discourse is an open invitation to the science education community to engage in social justice issues and to treat the opportunity to learn science as a civil rights construct.

This article is organized into two major sections. The first section is a brief review of the school desegregation literature, which will illustrate how historically the focus of civil rights as it relates to urban school questions and litigation has been on shared school space, not a direct call for opportunity to learn.[1] Yet recent tracking litigation, calls for standards and accountability in education, and demographic changes have combined to shift political discourse from equating access and opportunity with students sharing space in schools to demands for shared knowledge of rigorous academic content. The second section examines the opportunity-to-learn concept, focusing on science. I argue that the opportunity-to-learn literature provides science educators with the theoretical perspective necessary for viewing school science as a social justice construct. An analysis of three opportunity-to-learn constructs will illustrate their potential as civil rights tools in science education.

From Shared Space To Shared Knowledge

Segregation in public education has a long legal history in the United States. In one of the earliest cases, *Roberts* v. *City of Boston* (1850), the plaintiff sought to desegregate Boston's public schools in order to achieve access to the all-White schools of the city. This suit was rejected by the Supreme Court of Massachusetts, but Black leaders lobbied the legislature for a law against segregated schools and succeeded in acquiring a law prohibiting segregation. Over the next 100 years few school systems made the effort to desegregate; instead, most continued to operate segregated schools until and even after the *Brown* v. *Board of Education* (1954) decision, in which the U.S. Supreme Court determined that in the field of public education the doctrine of "separate but equal" was unconstitutional. It said that maintaining segregated schools districts violated the equal protection clause of the 14th amendment. As a matter of law with respect to public education, the court changed the accepted doctrine of "separate but equal" to "equal opportunity for all." However, the Supreme Court's decision did not result in equal opportunity in urban school districts.

The 1960s and 1970s witnessed a gradual erosion of public support for the desegregation process (Green, 1999). However, there were a series of legal challenges to the practices of tracking and ability grouping on the grounds that they resulted in intraschool segregation and thus produced differential learning opportunities. Initially, two cases, *Hobson* v. *Hansen* (1967) and *Moses* v. *Washington Parish School Board* (1972), produced rulings that prohibited tracking. These decisions were built on two major findings: first, African American students were consistently assigned to the lower track at a greater rate than were Whites, thus segregating the student body; and second, the lower track provided inferior learning opportunities in comparison to the academic track.

The litigation on tracking in the 1980s and early '90s was strongly influenced by a neoconservative judicial perspective. In a critique of this philosophy Crenshaw (1988) succinctly captured the neoconservative perspective:

> Neoconservative doctrine singles out race-specific civil rights policies as one of the most significant threats to the democratic political system. Emphasizing the need for strictly color-blind policies, this view calls for the repeal of affirmative action and other race-specific remedial policies, urges the end of class-based remedies, and calls for the Administration to limit remedies to what it calls "actual victims" of discrimination. (p. 1337)

During this time (1980–1992), the federal courts often deferred to those school districts using organizational practices and pedagogical policies such as tracking and ability grouping (see e.g., *Quarles* v. *Municipal Separate School*, 1989; *Montgomery* v. *Starkville*, 1987). In his historical analysis of tracking, Green (1999) noted that the judicial retreat from equal access and equal educational opportunity ended with the election of President William Clinton in 1992. He observed that the Clinton-era Justice Department decided that tracking was the segregation mechanism of the 1990s, and thus the department sought to challenge many of the policies and practices of tracking and ability grouping. In particular, four cases — *People Who Care* v. *Rockford Board of Education* (1994), *Vasquez* v. *San Jose Unified School District* (1994), *Simmons on Behalf of Simmons* v. *Hooks* (1994), and *Coalition to Save Our Children* v. *State Board of Education* (1995) — produced rulings in favor of detracking school districts. These four cases reflect an important shift in direction for civil rights litigation from strictly macrolevel arguments, which challenged segregation in school districts, to microlevel challenges, which looked to create an intellectual space for all students within every school across demanding content domains.

These legal victories in the battle for opportunity to learn occurred in a political era during which both Democratic and Republican policymakers and civil rights organizations called for and continue to call for high standards and accountability in public education (Bush, 2001; NGA, 1993). Since the 1983 publication of *A Nation at Risk* the educational literature and educational efforts have shifted from a view of equality as shared school space, that is, desegregation, to opportunity-to-learn arguments, with an increased focus on academic excellence for all by: (a) adding the "new" basics, which has come to mean more reading, science, math, computer instruction, and technology in the curriculum; (b) calling for the increased knowledge and qualifications of those charged with teaching the new basics; and (c) declaring — but not attempting to make happen — true opportunity to learn for all students, especially those in our nation's urban centers (Tate, Ladson-Billings, & Grant, 1993). The challenge, of course, is to move beyond mere declarations to systemic changes in urban schools. To meet this challenge requires recognizing that demographic changes present new problems and opportunities for urban school districts.

There is ample evidence that U.S. central cities suffer from significant concentrations of poverty, high rates of student mobility, and inadequate fiscal support (Kozol, 1991; Linden, 1995; Rury & Mirel, 1997). These problems are serious and longstanding. Yet another demographic trend is changing the urban landscape — technoburbs.

Technoburbs, or boomburgs, are defined as suburban cities that have at least 100,000 people and have experienced double-digit growth every decade since they had a population of at least 2,500 (El Nasser, 2001). Four technoburbs have populations that exceed 300,000 — Mesa, Arizona; Santa Ana, Califoria; Arlington, Texas; and Anaheim, California — each surpassing the populations of Tampa, Raleigh, Buffalo, and Newark. More than a quarter of the cities in the United States with populations of between 100,000 and 400,000 — are suburbs. They represent half the population growth in the nation's 199 biggest cities.

Many of the new urban cities were not directly a part of desegregation litigation. Largely in the South and Southwest, these cities face many of the same challenges as megacities — rapid growth in school-age populations, many English-language learners, and shortages of teachers. The fundamental challenge in these largely middle-class communities will not be school segregation. Instead, it will be how to attain high-level academic programs on a large scale.

The national focus on access to high-level content and standards is ever present in education-related civil rights litigation and standards/accountability policy discourse. In addition, the rapid development of suburban/urban cities has produced a new generation of parents and children with access to technology and high expectations for their schools. These legal, political, and social realities reflect the public demand for knowledge access and learning opportunities that science educators face in urban America.

Meeting The Knowledge Demand

Historically, traditional approaches to science education and, more specifically, to the reform of science education have been closely associated with changing views within scientific disciplines and the psychological roots undergirding theories of learning (e.g., Gabel, 1994). This approach to science education has resulted in many important changes related to curriculum, assessment, and teacher education. Despite progress in our understanding of how students learn science, the transfer of this knowledge to urban school systems has been painstakingly slow.

What are some concrete steps that can be taken to establish appropriate interventions and related research on science learning and teaching within the dynamics of urban education? Examining this question is aided by building on the opportunity-to-learn literature for two reasons. First, it provides a theoretical and empirical foundation consistent with scholarship in science education. Thus, the arguments presented in this article build on the strengths in this field yet seek to move beyond the traditional paradigmatic boundaries of science education to provide a more expansive discussion of the research and development possibilities in science, math, engineering, and technology (SMET) education. Second, the opportunity-to-learn concept provides a foundation for discussing science education as a civil right. Most science education reform efforts have been largely associated with macrolevel considerations — that is, the cold war or global economic competition — rather than genuine ethical actions devoted to increasing the scientific competencies of students of color, students acquiring English, and other traditionally underserved urban students. Reframing urban school science as a civil rights initiative grounds this work in a longstanding struggle for quality education for all rather than in the cyclical debates of economic competitiveness and enlightened self-interest that typically are coupled with science and science education.

Opportunity to Learn

A great deal of media debate and policy analysis has focused on international comparisons in science. One important source of data for these debates and analyses has been the IEA (International Association for the Evaluation of Educational Achievement) studies in science. One construct the IEA examined is referred to as "opportunity to learn" (OTL).

Opportunity to learn is an important construct influencing and possibly explaining the impact of the instruction was introduced during the 1960s. Carroll (1963) included OTL as one of five critical constructs in his model of school learning. He defined OTL as the amount of time allocated to the learner for the learning of a specific task. If, for instance, the task assigned to a student is to understand the concept of population density, OTL is simply the amount of time the student has available to learn what population density is.

In Carroll's (1963) model OTL is contrasted with the amount of time the student requires to learn a concept. The latter construct is primarily a function of the student's aptitude in a concept domain. Thus, whereas teachers have some control over the time available for student learning, they have little control over the time required for student learning. Carroll also contrasted OTL with the amount of time the student actually spends engaged in the process of learning. The latter variable, often referred to as time-on-task or engaged time, is thought to be affected by the perseverance of the student, the quality of the pedagogy, and the opportunity to learn. In Carroll's model, opportunity to learn represents the maximum value for engaged time.

In contrast to Carroll, Husén (1967) framed OTL in terms of the relationship between content taught to the learner and content assessed by achievement tests. In Husén's model OTL is the overlap of content taught and content tested. Simply stated, the greater the overlap, the greater is the OTL.

From Carroll's perspective of most important concern is how much time the student has to learn a specific concept. For Husén the concern is whether a student has been provided with quality instruction relative to the concepts included on achievement tests.

Two very important variables that emerge from the OTL literature are *time* and *quality*. The time allocation associated with science instruction and the quality of that instruction are central concerns for the construction of an urban school research agenda in science education. An additional reason time and quality are important is they can be altered with appropriate interventions. Many studies related to urban schools, in particular to those populations traditionally underserved in SMET education, identify variables that are outside the control of educators, such as family socioeconomic status (SES) and parental education levels. Obviously, these are relevant correlates to achievement, yet they provide little or no guidance for optimizing the urban system of learning. Further, the research agenda in science education is not advanced significantly by examining these variables unless very careful interpretations are made. For example, family SES or parents' income level may provide insight into the opportunity for urban students to use technology and scientific equipment both in the home and school.

The role of technology is vitally important to student opportunity-to-learn science. Technology expressed in instrumentation provides a window into the observable natural world. A skilled scientist is one who possesses and masters theory, craft, and technology. Hurd (1997) argued that the paradigmatic boundaries of science are shifting toward a science guided by the coaction of science and technology, perceived as an integrated system. Further, he observed, many in the science community speculate that engineering education may be the best preparation for the natural sciences. This is a provocative point of view worthy of debate. Regardless of one's stance in this debate, there can be little doubt that technology is central to discussions of opportunity-to-learn science.

Following is a discussion of the role of time, quality, and technology and their relation to student OTL in urban school science, as I contend that the appropriate management of these three constructs is central to the improvement of urban science education. Moreover, future research on urban school science should seek to understand how time, quality, and technology influence students' understanding in the domain of science.

Is There Time for Excellence?

Policies and practices that influence content coverage and time-on-task are pivotal to the improvement of student performance in science in urban schools. These opportunity-to-learn variables determine whether students are provided sufficient time to learn the science curriculum expected for their grade level and age.

The science curriculum in many urban school districts is aligned with science standards adopted or derived from state or national curricular frameworks. The standards-based reform of science education is often part of a larger effort at systemic change that includes: academic standards in the core disciplines by grade, holding all students to the same standards, statewide assessments closely linked to the standards, accountability systems with varying levels of consequences for results, computerized feedback systems, and data for continuous improvement. State-level assessment systems and most national testing proposals call for students to be tested in mathematics and reading. This practice has implications for content coverage and time-on-task in science classrooms in urban cities. Perhaps an example will illustrate the point.

Under the Texas accountability system, every year the state categorizes each school district into one of four groups — exemplary, recognized, academically acceptable, and academically unacceptable — and designates individual schools as exemplary, recognized, acceptable, and low performing. The ratings are based on student performance on the state test, the Texas Assessment of Academic Skills (TAAS), the dropout rate, and the attendance rate. The TAAS assessment is given at Grades 3–8 in mathematics, reading, and writing.[2] To receive an "exemplary" or "recognized" designation, a district or a school must have not only a high overall passing rate on the TAAS, a low overall dropout rate, and a high overall attendance rate, but it must also have rates for specific demographic groups — African Americans, Hispanics, Whites, and low SES — that exceed the standard for each category. The Texas accountability system is viewed by some as a model for the nation, using the rationale that the system provides disaggregate data to ensure schools will be accountable for the progress of all children, especially those with the greatest need — in particular, urban students. This aspect of the accountability system has the potential to provide support for the teaching and learning of mathematics, reading, and writing. It definitely assumes an overlap of content taught and content assessed, a central opportunity-to-learn construct. However, no accountability system exists for elementary science instruction. The public pressure to achieve exemplary or recognized school or district-level status is clearly focused on mathematics, reading, and writing, as is the focus of teacher and administrators. There is actually a disincentive to engage in science instruction. This is clearly an area that requires further study by science educators interested in the nexus of accountability, time, and the science achievement of urban school students (e.g., Shepard & Dougherty, 1991).

One response to the question of accountability that science educators could make would be a call for students to participate in whatever accountability model that exists in an educational system. Thus, science could become a part of the accountability movement, building on the assumption that if science is tested, it will be taught. However, there are important lessons to be learned from research on high-stakes testing in mathematics. I submit that building a science accountability model focused strictly on the overlap of content taught and content tested ignores the role assessment has played in creating low-level curriculum opportunities for students in urban school settings who are African American, Hispanic or acquiring English. For example, in a comparison of teachers with high and low percentages of African American students, those with high percentages reported significantly more often that test scores were "very" or "extremely" important for evaluating student progress, placing students in special services, planning curriculum and instruction, and recommending textbooks (Madaus, West, Harmon, Lomax, & Viator, 1992; Strickland & Ascher, 1992). They also indicated they had greater incorporation of test-oriented pedagogical strategies and were pressured more often by their administrations to increase test scores. About 60% of teachers whose classes had a high number of minorities indicated going over test-taking skills, teaching topics known to be on the assessment, emphasizing tested content, and beginning test preparation more than a month before the assessment (Madaus et al.). These practices were reported significantly less often in classes with few minorities. There are several problems with these practices. First, many students are subjected to instruction largely based on test preparation activities rather than on a coherent implemented curriculum. Second, many teachers do not have the time necessary to teach more advanced mathematical concepts, so for the bulk of their instruction they review low-level, decontextualized skills (Madaus et al.).

This practice has serious implications for student proficiency and achievement in school science. First, high-stakes accountability examinations in mathematics (and reading) create a culture that inhibits allocating time to science. Schools become places where test preparation is the mission of the education process. Second, it is not at all clear that including science as a part of the accountability model will result in greater student opportunity to learn key science concepts and skills. Teachers and administrators find it challenging enough to improve student proficiency in mathematics and reading in the current situation, when instruction time is largely devoted to these subjects. Adding science to this time equation will further complicate the process. This is not an argument that science be excluded from the school curriculum, but to point out the difficulty teachers already are having with time-on-task with only three subject domains — reading, writing, and mathematics, a problem that many high-stakes accountability policies and practices don't take into consideration.

Accountability models are policy instruments typically defined as mandates. Mandates are rules governing the action of individuals and agencies and are intended to produce compliance. There are two costs associated with mandates: compliance and avoidance. States with accountability models, such as Texas, assume that schools and school districts will operate in good faith — that is, school district administrators and teachers will ensure all students have access to a high-quality curriculum that is in line with state standards and goals. However, empirical evidence suggests that only in certain dimensions is considerable alignment between the state's intended curriculum and the implemented curriculum (Grant, 1998; Madaus et al., 1992). It is possible for the school district to comply with state curriculum guidelines on low-level curricular objectives yet avoid teaching or lack the teacher expertise to implement more rigorous content objectives. It is apparent that high-performing urban schools have leadership that finds a way to create additional time for instruction, both during the regular school day and outside traditional school hours (e.g., Johnson & Asera, 1999). This is an area that is ripe for additional research in urban school science education. Yet even with additional time many teachers and administrators may lack the tools to teach high-level skills or implement appropriate innovations to support this kind of teaching. This latter phenomenon is an issue of quality.

Where Is the Quality?

Although the opportunity-to-learn literature, typically defines quality of instructional delivery as a set of psychometric variables that focus on how classroom pedagogical strategies influence students' academic achievement, this article includes organizational and fiscal issues that influence the quality of school science instruction, rather than strict focus on the psychometric perspective.

There is one organizational feature of urban schooling that has had a significant influence on student opportunity-to-learn science–curriculum differentiation. One form of curriculum differentiation is tracking. Course-taking opportunities are often subject to two forms of tracking — curricular and ability. To understand this, it is important to examine the literature in mathematics and science together. Often, the mathematics placement will ‘‘drive’’ the course-taking opportunities in science. For example, many school districts require algebra II as a prerequisite or corequisite course for chemistry. And, clearly, opportunities to learn physics are linked to a mathematics background. There have been many important studies of tracking and voluminous reviews of the subject (e.g., Oakes, 1990; Oakes, Gamoran, & Page, 1992). It is not my intention here to review this literature, but to state the facts: the organizational technology of tracking exists in urban schools and has been shown to limit the quality of science instruction for many students. Thus, a central question for those interested in urban school reform is how school systems can increase access to rigorous high-quality science courses.

The case of one successful project in the Dallas Independent School District illustrates how to accomplish this objective. This example is important because the intervention was successful in both mathematics and science. In 1996 the O’Donnell Foundation funded an advance placement (AP) incentive program in nine Dallas high schools. The results of the program were immediate and impressive. The data in Figure 1 provides results of the program in three subject areas—mathematics, science, and English. The range for passing scores on the AP examination is 3–5.

In 1995 the passing-score rate for the AP mathematics, science, and English examinations in the United States and Texas were 44 per 1,000 Juniors and Seniors and 46 per 1,000 Juniors and Seniors, respectively.[3] The rate in the nine Dallas schools was 21 per 1,000 Juniors and Seniors in these content domains. In 1999 the passing-score rate per 1,000 Juniors and Seniors in the United States, Texas, and the nine Dallas Schools was 64, 65, and 100, respectively. This partnership between the school district and a private donor includes several components:

- Lead teachers to support classroom instruction;
- Vertical teams of middle school and high school faculty;
- AP and pre-AP teacher professional development for faculty in each school;
- Teacher bonuses and performance incentives linked to student pass rates; and
- Professional management of the program to ensure quality across grade levels.

A fundamental question to ask about this program, as it should be asked about all programs, is: Can the O’Donnell program be scaled up to support 15, 20, 30, or more high schools? The

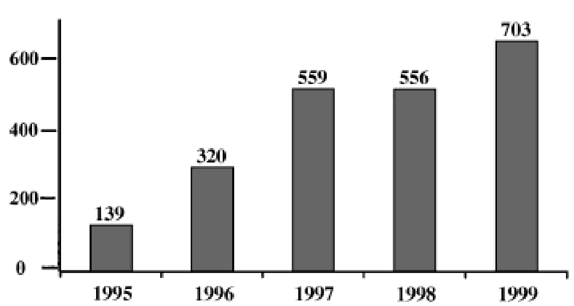

Figure 1. Math, Science, English AP exams passed in the nine DISD program school.

O'Donnell program is important because its existence is proof of documented success in an urban context. The program directly addresses several shortcomings of the urban school context — teacher quality (across grade levels) and fiscal adequacy.

Teacher quality is often associated with subject-matter knowledge, pedagogical knowledge, years of experience, behaviors and practices, knowledge of learning, and/or certification status. The literature on teacher quality (see Darling-Hammond, 1999) will not be reviewed here, except to state the obvious: teacher quality influences student opportunity-to-learn science, mathematics, engineering and technology (SMET) concepts and ultimately affects student achievement. This is not a debatable remark. Yet the issue of teacher quality appears to be an unsolvable problem in urban schools across the United States. This article outlines two recommendations to address the specific problems of teacher quality faced by urban schools. The first is designed to address the shortage of certified secondary SMET teachers in urban schools. Having a teacher who is certified strongly correlates with student achievement (Darling-Hammond, 1999). Certification status is a quality measure that combines aspects of knowledge about SMET and about teaching and learning. In many large urban cities the rate of retiring and relocating certified mathematics and science teachers is growing at a pace that far exceeds the production of graduates in SMET education. Moreover, these graduates have many options, including suburban schools and private industry, employment in both of which usually provides a distinct economic advantage over urban schools. This must be addressed — there is a price for quality. At the national level both the Democratic and Republican platforms on education include proposals to address the teacher quality problem in urban education (Walters, 2000). The Democrats propose:

- That teachers who commit to teach in a school system that requires their services would get financial assistance for college tuition or student loans or a hiring bonus for those who opt to switch careers;
- That alternative certification programs be in place so those opting to switch careers don't have to start their education all over again; and
- That there be expanded education of teachers on Internet use.

The Republicans propose:

- That incentives be created to attract science, math, and engineering graduates to low-income schools and areas with shortages of those teachers;
- That there be increased benefits for college students taking challenging coursework in these fields;
- That school district partnerships with colleges and universities be formed to improve science and mathematics education.

What is wrong with these recommendations from the two major party platforms? From my perspective these recommendations don't begin to provide the level of federal intervention required to improve urban SMET education. Both platforms discuss fiscal incentives to entice SMET graduates into the teaching field. However, I contend that the problem of teacher shortages requires a more targeted and radical effort that provides significant economic incentive to join the urban teaching ranks. For example, as a kind of bonus, first-year certified SMET teachers in urban school districts could be exempted from paying federal income tax. Further, an urban school teaching career incentive model that relates years of service to federal income tax forgiveness is worth investigating. Of course, states and local municipalities could develop similar policies to support competitive salaries for teachers. This proposal only deals with one aspect of the teacher quality problem—the supply and demand issue.

Two other challenges to high-quality SMET education that require rethinking of resource allocations are sustained professional development and adequate resources to support best practices in SMET education. These two challenges are directly related to each other. If a teacher is provided one but not the other, quality instruction is not the likely result. Rather, the resulting instruction is compromised because system goals that typically support teacher learning opportunities are not aligned with the resource allocation process. This problem is compounded if the system only provides professional development for teachers. Linking administrative and teacher professional development to the resource allocation process is a vital component of any effort to provide quality SMET education. Obviously, many urban districts fail in this effort. A finding found in the evaluation of a large urban school system's science program may help to illustrate the point:

> According to personnel from the DPS budget office, the science budget for the DPS schools was not separately identified within each school's general operating funds at any administrative level. Budgets across academic disciplines were commingled at the district, area and campus levels. Thus, definitive discussions of science budgets as a unique entity and as associated with specific classroom services and equipment were not possible. In addition to general operating funds, each campus received supplementary monies intended to enhance science instruction. These funds were expended at the discretion of school administrators. Supplementary funds were provided to individual campuses at the rate of \$1.50 for each enrolled elementary school student and \$2.00 for each middle and high school science student. According to information provided by the budget office, discretionary funds for science were commingled with discretionary funds for other purposes and are therefore not distinctly visible. (DPS, 2000, p. 19)

This is not just an example of a very small investment in science—it is quite possible that with limited resources devoted to science, another more pressing instructional issue (tested curriculum) or a noninstructional matter could be tackled. The alignment of district curriculum goals, professional development opportunities, and campus-level resources to science is an area worthy of study in urban school districts. Providing teachers with appropriate classroom resources combined with professional learning opportunities is essential to the process of improving teacher quality. My second recommendation is that urban schools have a strategic science plan that clearly delineates how science curriculum goals, professional development, and the resource allocation process for the school system inform and support each other. Without such a plan it is hard to imagine a technology-rich science learning experience uniformly distributed across a large urban environment.

Is There a Place for Technology?

Technology has subtly undergirded a significant portion of this article. Accountability systems, assessments, and tracking are all technologies that influence the amount of time devoted to school science and the quality of science instruction in urban schools. How educators manage these technologies is central to student opportunity to learn. Another technology that is associated with science is the equipment used to support hands-on inquiry. For 9-year-old students, the *NAEP 1999 Trends in Academic Progress* found a positive relationship between using scientific equipment and science assessment score. For each type of equipment (e.g., scale, meter stick, telescope, compass), students who had used that item scored higher on average than did students who had not used that item (Campbell, Hombo, & Mazzeo, 2000). There was also a positive relationship for 17- and 13-year-olds between the 1999 NAEP mathematics long-term trend assessment results and the availability and use of computer. It is clear that technologies, specifically devices that help us objectify the observed world, are also learning tools that improve the quality of SMET instruction. Ironically, the very best technology-rich science experiences may occur outside the time allocated for the school day.

Many students extend the time and quality of their school science experience in extracurricular activities such as the Robotics Club or Odyssey of the Mind competitions, where high school students design and test inventions. Many urban school districts have science and engineering magnet schools designed to provide "gifted" students with opportunities to engage in a technology-based engineering experience. These are excellent opportunities to learn, but they are typically limited to just a few students who excel at mathematics and/or science. Many technology and engineering magnet programs represent efforts by urban school administrators to court White middle-class families, and more recently with the changing demographics of urban cities, other middle-class families. Often these programs are not considered for inclusion as part of a comprehensive high school curriculum or experience.

A Southern Methodist University electrical engineering professor made a strong case for engineering education in a comprehensive high school writing:

> Today, courses in engineering and technology often are seen as too advanced for most elementary and secondary school students. Yet many subjects taught in college first are introduced at the elementary and secondary levels in age-appropriate curricula that stress the basics. Biology, chemistry, English, history and physics come to mind. Why save engineering and technology for college-only course? Even the youngest children today are more comfortable and interested in technology than any generation before. Theirs is a world of cell phones, DVD players, Internet access and laptops. Adding engineering and technology to core curricula of elementary and secondary schools will open opportunities to all students and in turn reduce the growing digital divide in our society. (Orsak, 2000, p. 13A)

Southern Methodist University and Texas Instruments have entered a partnership with the Dallas and Houston school districts to introduce digital signal processing (multimedia engineering) to secondary school students. The students must have completed Algebra II and one laboratory science course to be eligible for admission to the program. The INFINITY Project is an effort to provide secondary students access to a high quality curriculum constructed by leading engineers. The INFINITY engineering and technology curriculum has been constructed to engage students in many important, relevant, and interesting ideas of modern engineering and technology related to the information and communication age. Students learn and design new Internet technologies involving images, video, and audio and learn to analyze and understand how digital information is collected, stored, processed, and moved (see www.infinity-project.org). The engineering perspective differs from the traditional scientific perspective in at least one important way. Typically, scientists build in order to learn about the physical word whereas engineers generally learn in order to build. This difference is made clear by experiencing both the laboratory science experience and engineering education in a comprehensive high school setting.

I will not spend a great deal of time reviewing the project here. Instead, I refer the reader to the INFINITY Web site. However, I do want to say that this kind of effort is needed in urban school science. Moreover, there is a need for additional research and development devoted to secondary engineering education. There are clear structural barriers to quality engineering education in urban schools — teacher shortages, accountability models, and fiscal constraints. Again, issues of time and quality play a role in opportunity-to-learn SMET concepts.

Coda

The scientific promise of urban school students depends on how well we — educators, policymakers, and researchers — manage time, quality, and technology. Many have associated the reform of urban schools with accountability models, assessments, and standards. These policy instruments are having an effect on urban schooling. The fundamental question is whether these change mechanisms are producing the desired effect in science education. If they are not, then it is time to challenge them as obstacles to urban school students' opportunity to learn science, and ultimately to their civil rights. However, the science education community will be the final judge on the relevancy of this question. Simply stated: If you won't examine this question, who will?

The author is indebted to the editors (Angela Calabrese Barton and Ken Tobin) and to the reviewers for providing constructive comments on various drafts of this article.

Notes

[1]The rationale for this strategy is well documented yet beyond the scope of this article (see Hill and Jones, 1993).

[2]There are science assessments administered for eighth-grade and for biology students. In addition, there are an algebra test and a high school exit examination that includes algebra concepts. A recently passed law calls for a statewide high school exit examination that includes algebra, geometry, biology, and physical science.

[3]One issue for reporting AP participation is the numerical unit of analysis. I am reporting AP performance in terms of the number of AP examinees with scores of 3 to 5 per 1,000 Juniors and Seniors.

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