Inclusive STEM-focused High Schools:
STEM Education Policy and Opportunity Structures

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Rationale for Studying Inclusive STEM-focused High Schools and Importance to the Field

This paper introduces a pair of relatively new research projects that focus on an innovative type of school that is quietly emerging across the U.S., *Inclusive STEM-focused High Schools (ISHSs)*. Unlike older, highly selective STEM-focused schools that target students already identified as being STEM gifted/talented, the goal of ISHSs is to develop new sources of STEM talent among underrepresented minority students, and provide them with the means to succeed in school and in STEM jobs, college majors, and careers (Means, Confrey, House, & Bhanot, 2008; Scott, 2009). ISHSs have the exciting potential to create entirely new opportunity structures (Roberts, 1968) for students underrepresented in STEM fields because they help connect the dots between K-12 schooling, higher education, and STEM jobs and careers through innovative education programs that are delivered at the school level, but expand the boundaries of the normal school day and year (Carnegie Corporation, 2009). ISHSs blur boundaries between formal and informal education, and can potentially reconfigure relationships among teachers, students, and knowledge (Coburn; 2003; Elmore, 1996). Their innovative school designs are pushing limits for practice by engaging students with their communities, STEM business and industry, and early opportunities for higher education experiences (Means et al., 2008).

Policy Initiatives and ISHSs

In his 2013 *State of the Union* address, President Obama once again signaled his strong support for STEM-focused high schools. The President pointed out the need for high schools that better prepare students for 21st Century jobs that require technical skills, and singled out, "…P-Tech in Brooklyn, a collaboration between New York Public Schools and City University of New York and IBM, students will graduate with a high school diploma and an associate's degree in computers or engineering. We need to give every American student opportunities like this" (2013, para. 42)

This has been a theme in the Obama White House across both of his terms. In September 2010, President Obama issued a challenge to the U.S. educational system to create more than 1000 new STEM-focused schools over the next decade, including 200 high schools. This was stimulated by a report from the President's Council of Advisors on Science and Technology (PCAST): *Prepare and Inspire: K-12 Education in STEM for America's Future.*. The report argues that the success of the U.S. in the 21st century, its wealth and welfare, depends on the ideas and skills of its population. As the world becomes increasingly technological, the value of these assets will be determined by the quality of its STEM education. In order to meet immense challenges in energy, health, the environment and national security, the U.S. will need a greater portion of populace that is better prepared in STEM, and generally more STEM literate. This report points out that the U.S. is not only falling behind in STEM proficiency in its K-12 education system, its students are also falling behind in STEM interest. This is particularly troubling for students who are under-represented in STEM fields: African-Americans, Hispanics, Native Americans and women, who are shut out of opportunities. "The United States cannot remain at the forefront of science and technology if the majority of its students—in particular women and minorities underrepresented in STEM fields—view science and technology as uninteresting, too difficult, or closed off to them." (PCAST, 2010, p. 36). These problems have been documented for decades in policy pieces such as *A Nation at Risk* (NCEE, 1983), *Before It's Too Late* (NCMCT, 2000), *Rising Above the Gathering Storm* (NAS, 2005), *Report of the Academic Competitiveness Council* (USDOE, 2007), *The Opportunity Equation* (Carnegie Corporation, 2009), as well as annual Indicators Reports issued by NSF. Unfortunately, the problem remains, perhaps exacerbated by a widening socio-economic gap.

The push for improved STEM education has come from both sides of the U.S. political aisle. At the request of Virginia Congressman, Representative Frank Wolf (a Republican), the National Science Foundation through the National Research Council convened a panel on the state of STEM education in the U.S.: "Successful K-12 STEM Education" (2012). The document characterizes highly successful STEM education in the U.S., and includes STEM schools as one important strategy.

The PCAST report and President Obama have seen STEM-focused schools not only as an economic priority, but also view them as promising for closing the STEM opportunity to learn and interest gap. These schools have captured the imaginations of policymakers and business/industry as an under-explored potential resource for economic progress as well. The Carnegie Institute's (2009) *Opportunity Equation* states that "*there is much to learn about the most effective school designs* (emphasis ours) for realizing high levels of achievement in science and math by all. New urban schools, charter schools, and specialized schools for STEM, both inclusive and selective, could provide a portfolio of different options from which school districts might select (Carnegie Institute, 2009; PCAST, 2010). Such schools also provide a variety of models for students for new pathways to success. The *Opportunity Equation* argues persuasively "Math-and-science-themed schools have often been highly selective, but a new generation of schools with STEM themes are accepting students regardless of past academic achievement and preparing them for the challenges of the 21st century workplace" (2009, p. 14).

Inclusive STEM schools ISHSs, however, are a new phenomenon and their ability to meet their goals (raising the STEM achievement of underrepresented students and creating new learners ready for college STEM majors and careers) has not been well documented in the research literature (NRC, 2011), although reports of ISHSs can be found in the popular media. Moreover, several states have incorporated ISHSs into their overall state STEM plans, including Ohio, North Carolina, and Texas, and more recently Washington State and Tennessee. In addition, non-profit and for-profit organizations like Edutopia and Pearson have created well-crafted professional videos capturing the essence of some of these schools (found on YouTube). The students and staff at the schools also create YouTube videos to showcase aspects of student work consistent with school missions, as well students having fun.

Despite the spread and enthusiastic response, there appear to be no rigorous*, on-site* published studies of ISHSs designed to make systematic comparisons across ISHS, or between ISHSs and their comprehensive school counterparts. We could find no studies of ISHSs that use a set of common metrics to guide a cohesive research design.

Research Challenges

Clearly, there are at least are two major research problems that need to be addressed immediately, as the ISHS models are propagated across the U.S. and designed into state-level STEM education plans:

1. What exactly are inclusive STEM-focused high schools? How do they work? Who seems to benefit from attending such schools and why? What are the critical components that operate in each school, and across schools? If we could begin to answer these questions, systematically and credibly, then we would be able to define a common model. This would be tremendously helpful as they are propagated and scaled up across the US. Answering these questions is the goal of the NSF funded study, *Opportunity Structures for Preparation and Inspiration (OSPrI)* (Lynch, Behrend, Means, & Peters-Burton,2011).

2. Are ISHSs effective? To answer this question, a much clearer picture of the demographic characteristics of the students who choose to attend ISHSs is needed, as well as insights into why students choose them. To understand the impact of ISHSs, requires a longitudinal study of ISHS students after high school graduation. We need to understand if ISHSs are actually helping to create more STEM majors or to understand other benefits or deficits of students

attending inclusive STEM-focused high schools. This is the goal of the NSF-funded, ISTEM study (Means, Young, House & Lynch, 2011), which is a companion study to the OSPrI study.

The similarities between ISHSs and at charter schools are noteworthy for a number of reasons (some ISHSs are charter schools, but the majority are not), and among them is the element of choice and oftentimes a lottery system that determines admission. Although charter schools in the U.S. have been studied for 20+ years, there is still little sound empirical evidence about their effectiveness. Moreover, for the handful of charter schools that consistently perform well, little is known about their critical components, so there is no well-developed model that allows a clear understanding of how they work. Consequently, policy decisions about scale-up are difficult.

In order to avoid this conundrum, a goal of the two research projects on ISHSs discussed in this paper (OSPrI and ISTEM) is to avoid the research design problems that have plagued the charter school research efforts over the last decade, and rather to build on what is known about stronger research designs. To do this, these companion research projects explore both research areas listed above, simultaneously, one informing the other.

Theoretical Perspective

There is no single theoretical framework that explains why ISHSs might be effective in producing graduates with the confidence and ability to succeed in STEM college majors, jobs, and careers. There are no effectiveness studies on inclusive STEM high schools, with the exception of work done by Young et al., which showed small positive effects, through a study that was limited due to funding restrictions (NRC, 2011).

We hypothesize that successful ISHSs do more than focus on STEM, or incorporate new education technologies. Rather these schools create new *opportunity structures* for their students. This term was first used by Kenneth Roberts (1968) in his work with British youth to describe conditions that could lead a juvenile to criminal activity if pathways to success (such as decent schooling) were blocked. Roberts said "momentum and direction of school leavers' careers are derived from the way in which their job opportunities become cumulatively structured and young people are placed in varying degrees of social proximity, with different ease of access to different types of employment" (1968, p.179). In other words, psychological choice did not govern success so much as the actual physical and social affordances found in some geographic locations, but not others. Determinants of occupational paths include the home; the environment; the school; peer groups; and job opportunities. Roberts (1984) later expanded his opportunity structure model to include factors such as distance to work (or school), job qualifications, informal contacts in business, ethnicity, gender, and cyclical and structural factors operating within the economy that result in a demand for labor with high skill levels (c.f. Wilson, 2009 for a discussion of structural and cultural forces shaping poverty and opportunity in U.S. urban environments). Although "opportunity structure" was used by Roberts to explain how youth chose deviant career paths, it can be adapted to consider what it would take for students underrepresented in STEM—often less affluent, minority students—to move into rewarding STEM fields. ISHSs, either deliberately or intuitively, must create opportunity structures designed to guide and support students for STEM jobs, college majors and careers.

The OSPrI Study: Research Questions and Framework

For the OSPrI study, we ask these research questions:

1. Is there a core set of likely critical components (listed in Exhibit 1) shared by well-established, promising ISHSs? Do other critical components emerge from the study of each school?
2. How are the critical components implemented in each ISHS?
3. What are the contextual affordances and constraints that influence each ISHS's design, implementation and student outcomes, within and across ISHSs?
4. How do ISHS student STEM outcomes compare with school district and state averages (e.g., STEM achievement measures, graduation rates, college intentions)?

Candidate Critical Components

If ISHSs are creating opportunity structures for students' success in STEM, then the question remains, what are their critical components? The literature on ISHSs suggests a set of critical components that may work together to form new opportunity structures for students. However, unlike well-established whole-school reform programs such as the James Comer's School Development Project (Comer, 2009) or Success for All (Success for All Foundation, 2010), ISHSs have not been organized under one umbrella philosophy or organizational structure (c.f. Rowen, Correnti, Miller, & Camburn, 2009). The PCAST Report (2010) notes that most STEM-focused schools are singular creations and there are few attempts to scale the successful ones. Rather, ISHSs may be viewed as a series of related "education experiments" (Bryk & Gomez, 2008; Carnegie Corporation, 2009; PCAST, 2010). ISHSs may share common goals, but there is no single explicit theory of action (Chatterji, 2002) that undergirds how they function; they are too new on the scene and varied in their designs and origins. However, some groupings of ISHSs have defined models such as the High Tech High (Rosenstock, 2008) or the New Tech High Foundation (2010). In the last two or three years, at the state level, more deliberate organization of ISHS school models has occurred in some states. By reviewing the existing literature on both inclusive and selective STEM-focused high schools and analyzing websites of ISHSs, we have identified a candidate set of 10 critical components for ISHSs that forms the basis for our inquiry. We have been unable to find research that shows causal claims or correlational relationships between the presence of each component and student outcomes *in ISHSs*. However, a component such as "Well-Prepared STEM Teaching Staff" has a strong research base in STEM education (Brewer & Goldhaber, 2000; Monk, 1994; Monk & King, 1994; Rowan, Chiang, & Miller, 1997). The 10 critical components in Exhibit 1 form working hypotheses, the basis to develop a theory of action for ISHSs.
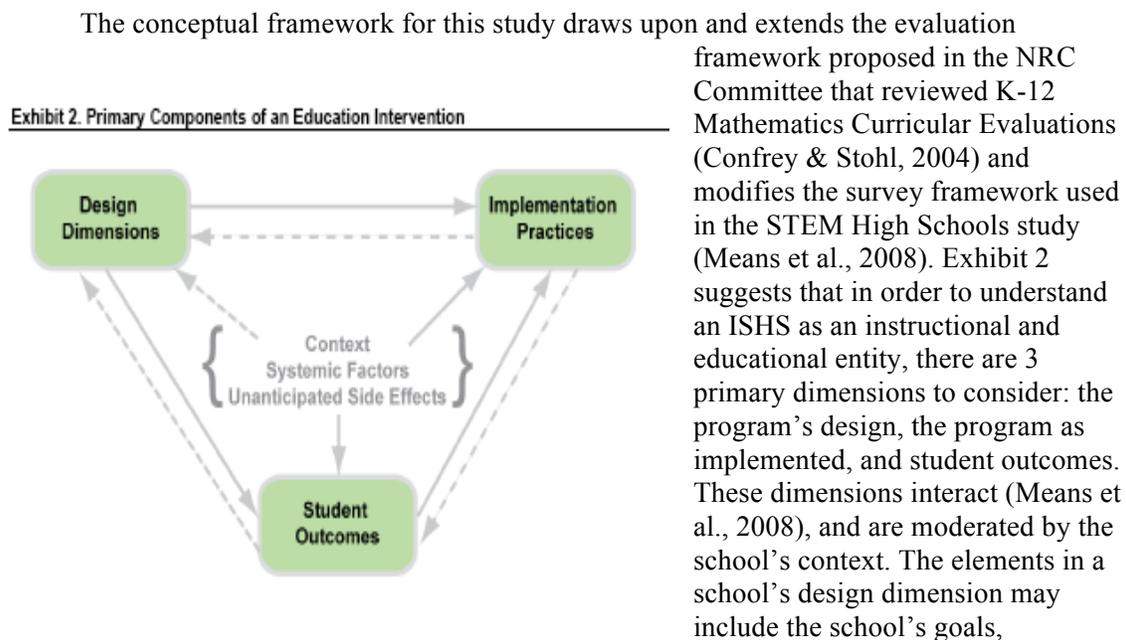
Exhibit 1

Candidate Critical Components (CC)

CC#	Description
1.	***STEM-Focused Curriculum.*** Strong courses in all 4 STEM areas, or, engineering and technology are explicitly, intentionally integrated into STEM subjects and non-STEM subjects (Atkinson, Hugo, Lundgren, Shapiro & Thomas., 2007; Brody, 2006 as cited in Subotnik, Tai, Rickoff, & Almarode, 2010; Kaser, 2006 as cited in Means et al., 2008; Means et al., 2008; Rosenstock, 2008; Scott, 2009).

2. ***Reform Instructional Strategies and Project-Based Learning.*** STEM classes emphasize instructional practices/strategies informed by research found in *Adding It Up* (NRC, 2001), *Taking Science to School*, (NRC, 2007), *Learning Science in Informal Environments* (NRC, 2009), *Restructuring Engineering Education: A Focus on Change* (NSF, 1995), *Fostering Learning in the Networked World* (Borgman, Abelson, Dirks, Johnson, Koedinger, Linn & Szalay, 2008) for active teaching and learning (Lynch, 2008) and immersing students in STEM content, processes, habits of mind and skills (Atkinson et al., 2007; Means et al., 2008; Scott, 2009). Opportunities for project-based learning and student production are encouraged, during and beyond the school day. Students are productive and active in STEM learning, as measured by performance-based assessment practices that have an authentic fit with STEM disciplines (Atkinson et al., 2007; Means et al., 2008; New Tech High, 2010; NRC, 2004, 2005, 2007, 2010; Rosenstock, 2008; Subotnik et al., 2010; Scott, 2009).

3. ***Integrated, Innovative Technology Use.*** Technology connects students with information systems, models, databases, and STEM research; teachers; mentors; and, social networking resources for STEM ideas during and outside the school day (Means et al., 2008; NRC, 1999, 2009; New Tech High, 2010; Rosenstock, 2008). The school's structure and use of technology has the potential to change relationships between students, teachers and knowledge (Borgman et al., 2008; Coburn, 2003; Elmore, 1996; Rosenstock, 2008) and flatten hierarchies (Atkinson et al., 2007; New Tech High, 2010; Scott, 2009).

4. ***Blended Formal/Informal Learning beyond the Typical School Day, Week, or Year:*** Learning opportunities are not bounded, but ubiquitous. Learning spills into areas regarded as "informal STEM education" and includes apprenticeships, mentoring, social networking and doing STEM in locations off of the school site, in the community, museums and STEM centers, and business and industry (NRC, 2009; PCAST, 2010, Rosenstock, 2008). As a result, the relationship between students, teachers and knowledge changes (Coburn, 2003; Elmore, 1996), and hierarchies flatten to "*...substantially alter the traditional roles of learners, teachers, and instructional resources in the learning environment*" (NSF-DR-K12, 2010, p. 7)

5. ***Real-World STEM Partnerships***: Students connect to business/industry/world of work via mentorships, internships, or projects that occur within or outside the normal school day/year (Atkinson et al., 2007; Brody, 2006 in Subotnik et al., 2010; Kaser, 2006 in Means et al., 2008; Kolicant & Pollock in Subotnik et al., 2010; Means et al., 2008; Rosenstock, 2008; Stone III et al., 2006 in Means et al., 2008). This is envisioned in DR-K12 solicitation: *"The responsibilities for meeting the goals of formal education will undoubtedly shift to include a broader community of stakeholders, such as informal institutions, STEM professionals, parents and caregivers"* (NSF DR-K12, 2010 p. 7).

6. ***Early College-Level Coursework***: School schedule is flexible and designed to provide opportunities for students to take classes at institutions of higher education or online (Atkinson, et al., 2007; Martinez & Klopott, 2005; Means et al., 2008; Rosenstock, 2008; Subotnik, Rayback & Edminston, 2006 as cited in Means et al., 2008).

7. ***Well-Prepared STEM Teaching Staff***: Teachers are qualified and have advanced STEM content knowledge and/or practical experience in STEM careers (Means et al., 2008; Subotnik et al., 2010**).**

8. ***Inclusive STEM Mission:*** The school's stated goals are to prepare students for STEM, with emphasis on recruiting students from underrepresented groups (Means et al, 2008; PCAST, 2010; Scott, 2009, Obama, 2010).

9. ***Administrative Structure:*** The administrative structure for inclusive STEM education varies (school-within-a-school, charter school, magnet school, etc.) and is likely affected by the school's age (less than a full set of grade cohorts) and the school's provenance, i.e., whether the school was converted from another model or was created "from scratch" as a STEM school (Means et al., 2008; Scott, 2009).

10. ***Supports for Underrepresented Students:*** Supports such as bridge programs, tutoring programs, extended school day, extended school year, or looping exist to strengthen student transitions to STEM careers. Such supports result in altered, improved opportunity structures, i.e., students are positioned for STEM college majors, careers, and jobs; and student social structures and identities change to accommodate new opportunity structures (Carnegie Corporation, 2009; Lynch, 2000; Means et al., 2008).

Conceptual Framework

The conceptual framework for this study draws upon and extends the evaluation

Exhibit 2. Primary Components of an Education Intervention

framework proposed in the NRC Committee that reviewed K-12 Mathematics Curricular Evaluations (Confrey & Stohl, 2004) and modifies the survey framework used in the STEM High Schools study (Means et al., 2008). Exhibit 2 suggests that in order to understand an ISHS as an instructional and educational entity, there are 3 primary dimensions to consider: the program's design, the program as implemented, and student outcomes. These dimensions interact (Means et al., 2008), and are moderated by the school's context. The elements in a school's design dimension may include the school's goals, governance, or academic structure, student recruiting and selection, curriculum and pedagogy, and outside partnerships (Means et al., 2008). The *OSPrI* study will especially focus on the 10 critical components in Exhibit 1. The implementation dimension includes the extent to which intended design and critical components are put into practice. For instance, a school may have *design goals* for integrated technology throughout the school program or for student participation in business/industry mentorships outside the normal school day. How consistently and in what ways these goals are actualized in a school's *implementation* would vary from school-to-school, and likely affect outcomes, depending on context. Thus, it is important not only to document /describe implementation of critical components, but also to gauge the extent to which the candidate critical components are implemented. Fidelity of implementation of critical components likely moderates important student outcomes (Dane & Schneider, 1998; Dusenbury, Brannigan, Falco, & Hansen, 2003; Lynch, 2008; Lynch et al., 2008; Mowbray, Holter, Teague, & Bybee., 2003; O'Donnell, 2008). For the *student outcomes* dimension, there is overall agreement that ISHSs should improve underrepresented students' preparation in STEM in ways that inspire and provide requisite background knowledge and skills, instilling confidence and
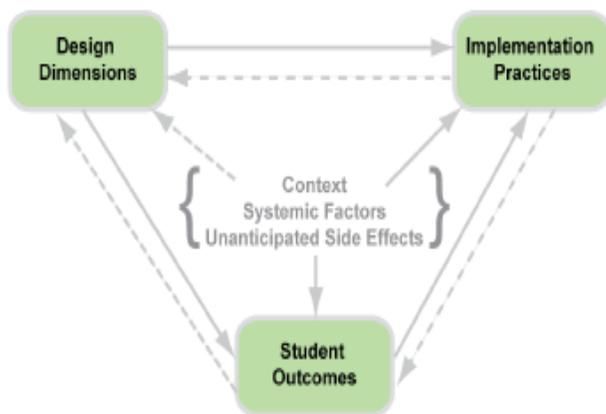
desire to seek more STEM education, jobs, and careers (Means et al., 2008; NRC, 2004). However, other outcome goals may vary by school, some focusing on student products, engineering skills designed for local contexts, or accumulating college credits. Moreover, because publicly funded schools are subject to state-level accountability, ISHSs likely need to show that their students have improved near-term outcomes (assessment data, earned STEM credits, STEM gatekeeper courses taken, prizes and awards), mid-term outcomes (graduation and retention rates , college admissions rates, STEM-intensive jobs), and long-term outcomes (college major, STEM credits, college graduation, and STEM careers). All three dimensions in Exhibit 2 are affected by contextual factors, systemic factors, and unanticipated side effects, including life events, community resources, and environments beyond the typical school day or school building. The study will discusses how these critical attributes are seen in each school's design dimension, and how they are implemented (recorded through on-site visits). It explores contextual factors unique to each school that enhance or inhibit both design and implementation. Using existing databases, it compares ISHS student outcomes with comparable schools within the district and state.

ISTEM Research Questions and Conceptual Framework

The research questions and conceptual framework for the ISTEM study will be discussed in a separate paper. However, the conceptual framework for ISTEM is shown below. See Exhibit C. Note that the central rectangle of the ISTEM conceptual framework in Exhibit C corresponds with OSPrI's critical components.

Goals of the Related Paper Set

The eventual goal of the OSPrI study is to conduct a cross case analysis of 12 ISHSs using a multiple instrumental case study design (Stake, 2006; Yin, 2003); this allows systematic comparisons across schools using descriptive statistics and common rubrics and measures. We hope to build a model that reveals how these successful schools function. In contrast, the goal of the ISTEM study is to provide information on the students who attend ISHSs and compare them to their counterparts across the state and to those who go to other schools. The ISTEM study will eventually follow high school graduates into their first post-high school year to find out if the ISHSs have made a difference in their lives and whether their schools have provided STEM experiences and built opportunity structures that help these students to be successful.

At this time, we are about midway in both projects. This paper set will provide information on two school-level cases of ISHSs for the OSPrI study, and discuss the critical components that were most prevalent. For the ISTEM study, the focus will be on comparing the perceptions and characteristics of students who choose to attend ISHSs with. their counterparts in other schools.

Connections to Policy

The nation's need for STEM competent professionals is great, and economic argument has stimulated relatively heavy private and governmental investment and interest in improved K-12 STEM public education. States and municipalities are banking on their ability to "grow their own" STEM professionals. It is increasingly difficult to import and retain STEM professionals from outside the U.S., and mobility within the U.S. has declined. The STEM education movement is aligned with the desire to have students able to enter the workforce with 21st Century skills ("Partnership for 21st Century Skills," 2012), which in turn, enable innovation.

In addition, for many, the more persuasive argument for improved STEM education is to have more STEM professionals as well as a better educated citizenry who can respond intelligently and think critically about complex issues facing the U,S. and the world, such as energy policy, response to global warming, and the development of a technology infrastructure that can facilitate the pace of research and development. Policymakers, government, and business and industry see investing in education as key to both economic and civic health. The fact that inclusive STEM-focused high schools have been so enthusiastically launched without primary stimulus from the federal government is a testimony to local and municipal needs. This leads to a new notion of what constitutes a "school community." Increasingly, this involves public-private partnerships on a grander scale than in the past, as big business gets involved in stimulating K-16 education systems responsive a global community in the 21st Century.
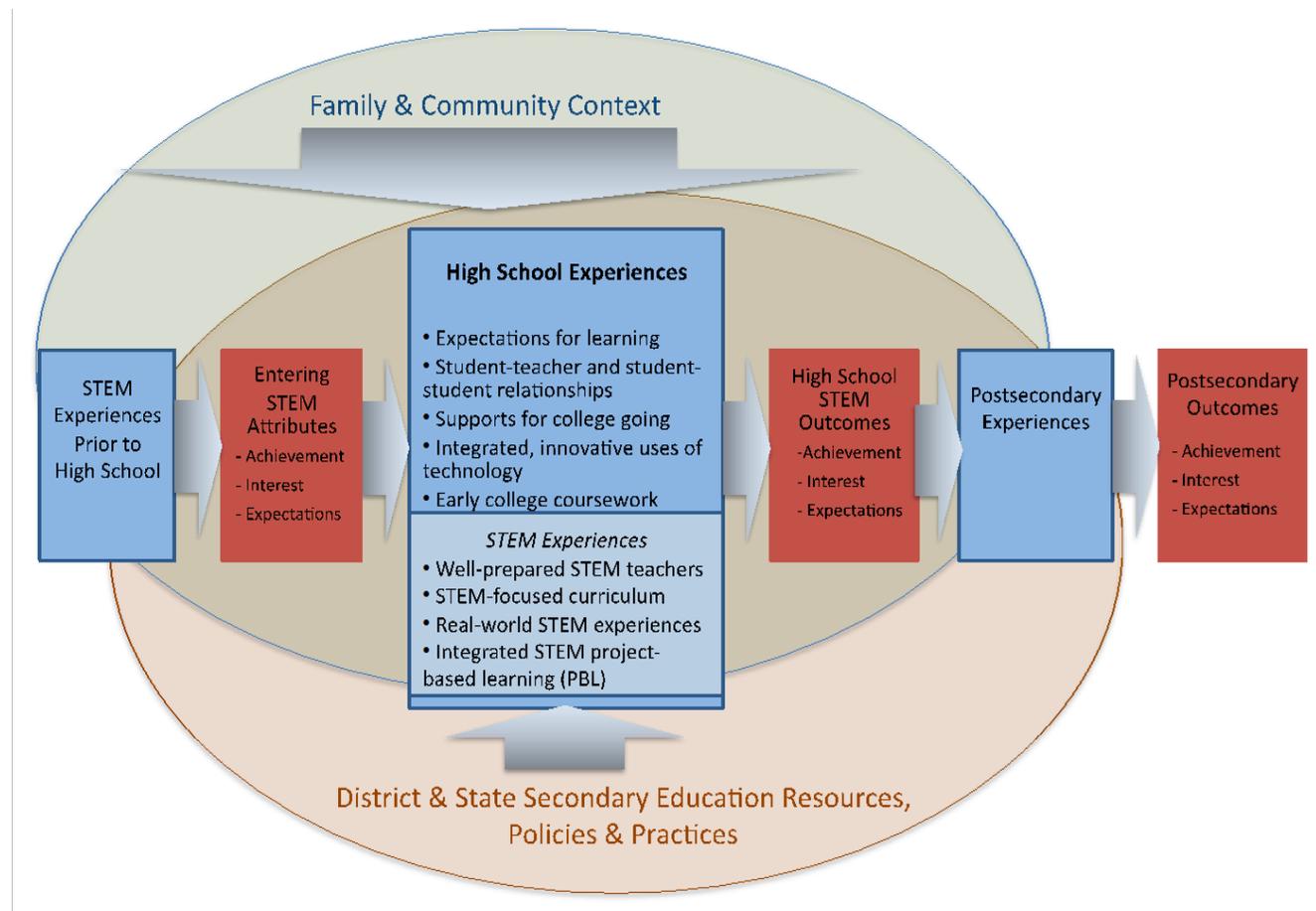

Exhibit C: ISTEM Conceptual Framework

References

Atkinson, R. D., Hugo, J., Lundgren, D., Shapiro, M. J. & Thomas, J. (2007). *Addressing the STEM challenge by expanding specialty math and science high schools* (The Information Technology and Innovation Foundation Report).. Retrieved from http://www.ncsssmst.org/CMFiles/Docs/STEM%20Final_03_20_07.pdf

Borgman, C. L., Abelson, H., Dirks, L., Johnson, R., Koedinger, K. R., Linn, M. C., & Szalay, A. (2008). *Fostering learning in the networked world: The cyberlearning opportunity and challenge*. Arlington, VA; National Science Foundation.

Brewer, D., & Goldhaber, D. (2000). Does teacher certification matter? High school teacher certification status and student achievement. *Educational Evaluation and Policy Analysis, 22,* 129-145.

Bryk, A. S., & Gomez, L.M. (2008). Ruminations on reinventing an R&D capacity for educational improvement. In Hess, F. M. (Ed), *The Future of Educational Entrepreneurship: Possibilities for School Reform*. Cambridge: Harvard Education Press.

Carnegie Corporation (2009). *The opportunity equation: Transforming mathematics and science education for citizenship and the global economy*. New York: Author.

Chatterji, M. (2002). Models and methods for examining standards-based reforms and accountability initiatives: Have the tools of inquiry answered pressing questions about improving schools. *Review of Educational Research, 72,* 345-386.

Coburn, C. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher, 32*(6)*,* 3-12.

Comer, J. (2009). *What I learned in school: Reflections on race, child development, and school reform*. San Francisco: Jossey Bass

Confrey, J., & Stohl, V. (2004). *On evaluating curricular effectiveness: Judging the quality of K-12 mathematics evaluations*. Washington, DC: The National Academies Press.

Dane, A., & Schneider, B. (1998). Program integrity in primary and early secondary prevention: Are implementation effects out of control? *Clinical Psychology Review, 18,* 23-45.

Dusenbury, L., Brannigan., R. Falco, M., & Hansen, W. (2003). A review of research on fidelity of implementation: Implications for drug abuse prevention in school settings. *Health Education Research Theory and Practice, 18*(2), 237-256.

Edutopia. (2013). *What works in education.* The George Lucas Education Foundation. Accessed April 2, 2013: www.edutopia.org

Elmore, R. (1996). Getting to scale with good educational practice. *Harvard Educational Review, Spring* (66), 1-26.

Lynch, S. (2000). *Equity and science education reform*. Mahwah, NJ : L. Erlbaum Associates.

Lynch, S. (2008). *How do curriculum materials improve student outcomes at the class level? Study construct validity, fidelity of implementation, and the comparison group.* In S.J. Lynch (Chair), C. Pyke, & J. Kuipers, Characteristics of effective middle science curriculum materials: Results and implications of a 6-year interdisciplinary study. Symposium conducted at the 2008 Annual Meeting of the American Educational Research Association, New York, NY.

Lynch, S. J., Behrend, T., Means, B. M., & Peters-Burton, E. (2011). *Multiple instrumental case studies of inclusive STEM-Focused high schools: Opportunity structures for preparation and inspiration (OSPrI).* Proposal to the National Science Foundation.

Lynch, S., Szesze, M., Pyke, C., & Kuipers, J.C. (2007). Scaling-up highly rated middle science curriculum units for diverse student populations: Features that affect collaborative research, and vice versa. In B. Schneider & S.K. McDonald (Eds.). *Scale-up in education, Volume II: Issues in practice.* Lanham, MD: Rowman & Littlefield.

Martinez, M., & Klopott, S. (2005). *The link between high school reform and college access and success for low-income and minority youth.* Washington, DC: American Youth Policy Forum and Pathways to College Network.

Means, B., Confrey, J., House, A., & Bhanot, R. (2008). *STEM high schools: Specialized science technology engineering and mathematics secondary schools in the U.S.* (Bill and Melinda Gates Foundation Report). Retrieved from National High School Alliance website: http://www.hsalliance.org/stem/index.asp

Means, B., Young, V., House, A. Lynch, S.J., (2011). The Effectiveness of inclusive STEM schools at scale: A Multi-state, longitudinal, quasi-experiment. Proposal to be submitted to NSF DR-K12, Jan. 6, 2011.

Monk, D. (1994). Subject area preparation of secondary mathematics and science teachers and student achievement. *Economics of Education Review, 13*, 125-145.

Monk, D., & King, J. (1994). Multilevel teacher resource effects on pupil performance in secondary mathematics and science. In Ronald G. Ehrenberg (Ed.), *Choices and Consequences.* Ithaca, NY: ILR Press.

Mowbray, C., Holter, M., Teague, G., & Bybee, D. (2003). Fidelity criteria: Development, measurement, and validation. *American Journal of Evaluation, 24*(3), 315-340.

National Research Council (NRC). (1999). *Being fluent with information technology.* Committee on Information Technology Literacy. Washington, DC: National Academies Press.

National Research Council (NRC). (2001). *Adding it up: Helping children learn mathematics.* Mathematics Learning Study Committee, J. Kilpatrick, J. Swafford, and B. Findell (Eds.), Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academies Press.

National Research Council (NRC). (2004). *Engaging schools: Fostering high school students' motivation to learn.* Committee on Increasing High School Students' Engagement and Motivation to Learn. Washington, DC: National Academies Press.

National Research Council (NRC). (2005). *How students learn: History, mathematics, and science in the classroom.* Committee on How People Learn, A Targeted Report for Teachers. M.S. Donovan and J.D. Bransford (Eds.). Washington, DC: National Academies Press.

National Research Council. (2007) *Rising above the gathering storm: Energizing and employing America for a brighter economic future.* Washington, DC: The National Academies Press.

National Research Council (NRC). (2007). *Taking science to school: Learning and teaching science in grades K-8.* Committee on Science Learning, Kindergarten Through Eighth Grade. R.A. Duschl, H.A. Schweingruber, and A.W. Shouse (Eds.). Washington, DC: The National Academies Press.

National Research Council (NRC). (2009). *Learning science in informal environments: People, places, and pursuits.* P. Bell, B. Lewenstein, A. W. Shouse, & M. A. Feder (Eds.). Washington, DC: National Academies Press.

National Research Council (NRC). (2010). *Preparing teachers: Building evidence for sound policy.* Committee on the Study of Teacher Preparation Programs in the United States. Washington, DC: National Academies Press.

National Research Council (NRC). (2010). *Successful K-12 STEM education: Identifying effective approaches in science. Technology, engineering and mathematics.* Committee on Highly Successful Schools or Programs in K-12 STEM Education. Washington, DC: National Academies Press Na

National Research Council. (2011). *Successful K-12 STEM education: Identifying effective epproaches in science, technology, engineering, and mathematics.* Washington, DC: The National Academies Press.

National Science Foundation (NSF). (1995). *Restructuring engineering education: A focus on change.* Report of an NSF Workshop on Engineering Education, June 6-9, 1994. August 16, 1995. NSF 95-65. Arlington, VA: Author.

National Science Foundation (NSF DR-K12). (2010). *Discovery Research K-12: Program solicitation NSF 10-610.* Arlington, VA: Author.

New Tech High Foundation. (2010). *New tech network.* Retrieved from http://www.newtechnetwork.org/

O'Donnell, C. (2008). Defining, conceptualizing, and measuring fidelity of implementation and its relationship to outcomes in K-12 curriculum intervention research. *Review of Educational Research, 78*(1), 33-84.

Obama, B. (2010, September 16). Remarks by the President at the announcement of the "Change the Equation" Initiative. Available at http://www.whitehouse.gov/the-press-office/2010/09/16.

Obama, B. (2013). The 2013 state of the union. *The White House President Barack Obama.* Retrieved March 28, 2013 from http://www.whitehouse.gov/state-of-the-union-2013

Partnership for 21st Century Skills. (2012). *Partnership for 21st Century Skills*. Retrieved March 18, 2012 from: http://www.p21.org/index.php

President's Council of Advisors on Science and Technology (PCAST). (2010). *Prepare and inspire: K-12 education in science, technology, engineering, and math (stem) for America's future.* Washington, DC: Author.

Pearson Foundation. (2009, July 17). 21st century skills culture at high tech high [Video file]. Retrieved from http://www.youtube.com/watch?v=Yie4q8LscBs.

Roberts, K. (1968). The entry into employment: An Approach towards a general theory. *Sociological Review, 16,* 165-184.

Roberts, K. (1984). *School leavers and their prospects*. Buckingham, UK: OU Press.

Rosenstock, L. (2008, December 3). Taking the lead: An interview with Larry Rosenstock [Video file]. Retrieved from http://www.edutopia.org/collaboration-age-technology-larry-rosenstock-video

Rowan, B., Correnti, R., Miller, R.J., & Camburn, E.M. (2009). *School improvement by design*. Madison, WI: CPRE.

Rowan, B., Chiang, F., & Miller, R. (1997). Using research on employee's performance to study the effects of teacher on students' achievement. *Sociology of Education, 70,* 256-284.

Scott, C.E. (2009). *A comparative case study of characteristics of science, technology, engineering, and mathematics (STEM) focused high schools.* Retrieved from Proquest (AAT 3365600).

Stake, R. E. (2006). *Multiple case study analysis*. New York, NY: Guilford Press.

Subotnik, R.F., Tai, R. H., Rickoff, R., & Almarode, J. (2010). Specialized public high schools for science, mathematics, technology and the STEM pipeline: What do we know now and what will we know in five years? *Roeper Review*, *32*, 7-16.

Success for All Foundation (2010, September). *Success for All*. Retrieved from http://www.successforall.net/

The National Commission on Mathematics and Science. (2000). *Before It's Too Late: A Report to the Nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. Retrieved April 2, 2013, from http://www.compadre.org/Repository/document/ServeFile.cfm?ID=4059&DocID=2813

U.S. Department of Education. (2007). *Report of the Academic Competiveness Council.* Washington DC: Education Publications Center. Retrieved April 2, 2013 from http://www.ed.gov/about/inits/ed/competitiveness/acc-mathscience/index.html

Wilson, W.J. (2009). *More than just race: Being black and poor in the inner city*. NY, NY: W.W. Norton & Co.

Yin, R.K. (2008). *Case study research design and methods*. Thousand Oaks, CA: Sage