Multiple Instrumental Case Studies of Inclusive STEM-focused High Schools (ISHSs): Opportunity Structures for Preparation and Inspiration (OSPrI)

Research Framework for ISHS Case Studies

Research Goal

The goal of the OSPrI study is to find and characterize *exemplar inclusive STEM-focused high schools* (ISHSs) and develop detailed case studies to illuminate how they function. By *inclusive* we mean that the school admits a range of academically-average students who choose to attend a STEM-focused school, i.e., the school's admissions criteria does not limit applicants to students who demonstrate that they are gifted and talented in STEM or are very high achievers. By *STEM-focused* we mean that the school requires more, or more rigorous, mathematics and science courses to graduate than district and state requirements, or its science, technology, engineering and mathematics classes are more integrated than comparison schools. By *exemplar* we mean that the school has a reputation for success; it should show some unusual successes with its student population in comparison to school district or state averages, given the demographically appropriate comparison groups. In addition, the school should be well established within the school district or state, having been planned thoughtfully with community support.

OSPrI hypothesizes that successful ISHSs do more than focus on STEM or use new technologies. Rather, they 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. Although "opportunity structure" was used to explain how youth chose deviant career paths, it can be adopted 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.

Specifically, for each case study of an ISHS, we ask:

- Is there evidence of each of the candidate critical components[1] (listed in Table 1, to be explained later) in the design of the school that is the focus of the case study?

- How are the critical components implemented at the school? Do other components emerge from the data collected on-site that are critical to the school's character and success?

- What are the contextual affordances and constraints that influence the school's design, implementation and student outcomes?

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[1] In the remainder of this document, these components are referred to as *critical components* but with the understanding that they are *candidate critical components* being examined to ascertain whether they are critical to the success of an ISHS.

- How do student outcomes, particularly STEM-related outcomes, compare with those of the school district and state (e.g., STEM achievement measures, graduation rates, college acceptance rates)?

The conceptual framework for this study draws upon and extends the evaluation framework proposed in the NRC Committee that reviewed K-12 Mathematics Curricular Evaluations (Confrey & Stohl, 2004). In order to understand an ISHS as an instructional and educational entity, there are three primary dimensions to consider: the program's design, the program as implemented, and student outcomes. These dimensions interact (Means et al., 2008), but are moderated by the school's context. The reader is referred to Lynch, Behrend, Peters-Burton, and Means (2012) for a detailed discussion of the conceptual framework and theoretical perspective.

Instrumental Case Study Methodology

This study employs an instrumental case study design (Yin, 2003; Stake, 1995; 2006). This method provides insights about a purposefully selected high school and describes the school through systematic and consistent means. Research using case study methods to study school-level redesign include SRI International studies of International Baccalaureate programs (Bland & Woodworth, 2009), KIPP schools in San Francisco (David, Woodworth, Grant, Guha, Lopez-Torkos, & Young, 2006), small high schools and their learning cultures (Shear, Song, House, Martinez, Means, & Smerdon, 2005), and Chicago's Renaissance Charter Schools (Young et al., 2010); as well as Consortium for Policy Research in Education studies of school districts' strategic management of human capital (Koppich & Showalter, 2008) and Stanford's School Redesign Network led by Linda Darling Hammond (e.g., Wentworth, 2010). This method is ideally suited to the OSPrI research study because it is a thorough approach to studying new school models such as ISHSs and promises rich results. It provides a means for rigorous school-level analysis, but also is open-ended, allowing new empirical evidence and interpretation to inform the research.

Selection of Exemplar ISHSs

We were primarily interested in STEM-focused high schools that required all their students to pursue a rigorous STEM curriculum, although the school may or may not require engineering or technology courses.

The selection process combined an expert nomination process with screening and categorization according to promising elements in their design and outcomes. Each school was chosen as a critical case (Yin, 2009), with a unique governing structure and academic organization likely to have broad effects on implementation and outcomes. The nomination process began by contacting individuals knowledgeable about STEM schools and state STEM networks, reviewing the OSPrI definition of inclusive STEM-focused high schools with these experts, and asking for their nominations of schools that reflected our protocol. We then researched publicly available information about the nominated schools to ascertain that they met the study criteria for inclusiveness, STEM focus, being well established, and having strong student outcome measures compared to the district and state.

Methods

School and Site Coordinator Recruitment. We contacted principals of selected ISHSs, providing them a project summary of the study objectives, data collection activities, and incentives for participation. We then called principals who indicated interest to discuss the project in more detail. Once the principal of the ISHS accepted the invitation to participate in the research, we requested that the school designate an on-site study facilitator/coordinator; the principal could self-nominate. The principal or designated site coordinator worked with us to answer our preliminary questions and to plan the site visit and schedule activities, including classroom observations; separate focus groups with teachers, students, and parents; and interviews with administrators and members of the community including business/industry and higher education experts closely involved with the school. The on-site coordinator received $3000 to facilitate the on- and off-site data collection. In addition, the school received $5000 as an incentive to participate. This incentive was awarded in a lump sum to the school after its case study was completed. The school was free to use this money as it chose, including costs associated with the visit such as pay for substitute teachers, teacher and student participation stipends, or food (e.g., pastries, pizzas) for focus-group and after-school meetings.

Data sources. We created data sources to focus on the design and implementation dimensions of the 10 hypothesized critical components, shown in Table 1.

Table 1
Candidate Critical Component Definitions

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* (National Research Council [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; President's Council of Advisors on Science and Technology [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).

We use multiple data sources and multiple researchers attending the same event for triangulation purposes (George & Bennett, 2005), for example conducting focus groups with teachers and with students as well as classroom observations. We carefully considered data sources for their ability to provide complete and accurate descriptions to address the research questions, mindful of efficiency and feasibility (King, Keohane & Verba, 1994). Data sources focused primarily on the design and implementation dimensions for the candidate critical components described in Table 1 above and included:

- STEM-focused Curriculum appraised by examining curriculum and pacing guides; scope and sequence documents provided by administration and teachers; semi-structured interviews with principals and curriculum specialists; classroom observations of STEM and non-STEM classes (to determine STEM integration); and information about STEM opportunities outside the typical school day and year, ascertained by teacher and student interviews.

- Reform Instructional Strategies and Project-Based Learning assayed by interviews with administrators; teacher focus groups; student focus groups; and classroom observations using valid and reliable instruments such as Reformed Teaching Observation Protocol (RTOP) (Piburn, Sawada, Falconer, Benford & Bloom, 2000) and the Lesson Flow Classroom Observation Protocol (Lynch & Hansen, 2005), a gauge of the time spent on student-centered activity in classrooms, adaptable for any subject matter including technology- or engineering-focused classrooms.

- Integrated, Innovative Technology gauged by existing valid and reliable technology surveys such as the Technology Integration Progress Gauge (Corn, 2007).

- Blended Formal/Informal Learning beyond the Typical School Day, Week, or Year appraised by examining course syllabi; formal assignment rubrics; student project samples; teachers' records of participation in extended learning experiences; yearbooks; records of competitions and awards for projects beyond typical school day; student and teacher focus groups.

- Real-world STEM Partnerships gauged by school website and MOU documents; interviews with principals, teachers and representatives from partner organizations.

- Early College-level Coursework appraised by scheduling documents; student records; interviews with administrators, curriculum specialists and with educators from colleges involved; and, student focus groups.

- Well-Prepared STEM Teaching Staff assessed by a specially developed survey instrument that teachers were able to fill out on-line, prior to the site visit, as well as classroom observations and teacher focus groups.

- Inclusive STEM Mission determined by examination of promotional materials and websites; interviews with administrators and teachers; student focus groups; and comparisons of student demographic data at school level with that of school district.

- Administrative Structure determined by organizational structure diagrams and other school documents, as well as interviews with school and school district administrators.

- Special Supports rated by examining documents offering supports and rates of participation; principal interviews; and, teacher and student focus groups.

Data Collection. Before the research team visited the school, we collected publicly available information on the ISHS including relevant outcome data for the school, its district, and its state. We analyzed documents on the school's website to begin to understand the school's design. We verified the accuracy of this data with the school during a series of three phone interviews with the principal, the onsite coordinator, or both, before the site visit. We administered two online questionnaires about a month before the site visit. The first was a School Description questionnaire based on the survey used by SRI in its study of STEM-focused schools (Means, Confrey, House, & Bhanot, 2008). For this questionnaire, the principal or the principal's designated site coordinator responded online to questions regarding the critical components (Table 1) and other important aspects of the school's design, model, and goals. The second questionnaire was for teachers and designed to collect data on their qualifications, experience, and perceptions of the school.

Three phone interviews before the site visit provided opportunities to follow up on responses to The School Description questionnaire, and to ask open-ended response questions using a semi-structured interview protocol about the 10 critical components. During these phone calls, we

planned the data collection activities for a four-day on-site visit. Table 2 shows a typical set of data collection activities.

Table 2.
Data Collection Activities during the School Site Visit.

School Tour	
Student Focus Groups	9th graders, 11th graders, mixed grade levels on use of technology and on informal learning
Teacher Focus Groups	Science teachers, Mathematics teachers, mixed content areas on use of technology and on informal learning
Parent Focus Group	
Interviews—Key School Staff	Principal, Counselor(s), Dean(s), Instructional Specialist, Technology Specialist, Special Education teacher(s)
Interviews—Partners	School district representative(s), Business representatives, College representatives
Classroom Observations	STEM: Biology, Chemistry, Physics, Algebra 1 or Geometry, One or two upper level mathematics class(es), Engineering class(es) Non-STEM class for STEM integration
Other Observations	STEM club, STEM internship, teacher professional development, school assembly, advisory, tutoring
Principal Debrief	

A six-person team traveled to the school for a four-day site visit. In most cases, each data collection activity was conducted by two researchers working in tandem and was designed to have content specialists present for relevant activities. For instance, during an 11th grade mathematics classroom visit, a mathematics educator and a science educator employed two classroom observation instruments while watching the same lesson. Assigning two researchers per activity block helped to optimize the reliability of the data collected, and assisted with triangulation and interpretation of the observations and interviews.

We conducted classroom observations using two valid and reliable instruments: the Reformed Teaching Observation Protocol ([RTOP], Piburn, Sawada, Falconer, Benford & Bloom, 2000) and the Lesson Flow Classroom Observation Protocol (Lynch & Hansen, 2005), a gauge of the time spent on student-centered activity in classrooms, adaptable for any subject matter including technology- or engineering-focused classrooms. We used data collected with these instruments, along with artifacts collected from teachers (e.g., syllabi, lesson plans, and student products), to describe the level of rigor and types of learning opportunities implemented at the school.

We used focus groups and interviews with administrators, teachers, curriculum specialists, students, outside partners, and parents to inform curriculum design and implementation, technology usage, learning opportunities outside of the classroom, the nature of external partnerships, early college coursework, professional development, interpretation of mission, administrative structure, and supports for students.

For the outcome dimension, we collected data on indicators such as number of students taking college-level courses or working with mentors, or extent of student participation in learning

experiences beyond the school day or year, using administrative records of such activities as available. We also used district, state, and national databases for data on the school and its district: attendance and graduation rates, achievement on STEM-related district and state tests, and college acceptance rates. We used these data to provide comparable descriptive statistics for the ISHS. Such comparisons are rough estimates of the impact of an ISHS and do not usually take into account differences in students' achievement and STEM interest before entering high school. An effectiveness study is beyond OSPrI's scope. However, educators/policymakers often rely on such rough descriptive estimates of a school's success to continue, expand or curtail programs.

After the school visit, we followed up with the site coordinator/principal to ask for any relevant materials that we had seen during the site visit but that we did not have in our possession. This was especially important for outcome data that were not currently on public websites but that were presented by the principal to various audiences. We also requested clarification of some details. The agreement between researchers and site coordinator was that when the final draft of the case was completed, the site coordinator and principal could check it for accuracy.

Data Analysis

This section is divided into two subsections, one detailing data analysis methods associated with the design and implementation dimensions of the ISHS and the other, the outcomes dimension.

Exploring the design and implementation dimensions. Following the site visit, team members examined data for each activity, expanded researcher notes for clarity, and saved data files (e.g., audio and notes from interviews and focus groups, RTOP and LFCOP files) on a secure server. The team members read the data for each of the activities in which they participated (e.g., focus group, observation), judging the relevance to a codebook (Smith, 1979) designed to more fully describe the 10 critical components (see Table 1). Coding was done in iterative cycles. The first cycle of coding consisted of segmenting the text data into discrete units (Straus, 1987) and labeling the segments into one or more of the critical components. This cycle of the coding was done for each activity by the two members of the research team who collected the data. One half of each pair of researchers/observers from the school visit independently coded the data and then passed their coded data to the other researcher for checking. Pairs of researchers discussed the choices made for coding until there was consensus and then inputted the coded text into NVivo (QSR, 2013) and generated reports of data by critical component. The use of NVivo software allowed coded data for each activity to be reorganized into separate documents for each critical component. Research team members wrote the narrative reports of critical components according to their expertise, emphasizing important quotes from interactions with school personnel (teachers, administrators, students, parents and business partners). The narratives answered the following research questions: (a) In what ways were the critical components present at the school? And, (b) To what extent were the critical components present at the school? We compiled the narratives of the critical components and then all of the researchers who went on the site visit met as a team to rate each critical component for its prominence or strength using a rubric developed for this purpose. We discussed each critical component until we reached consensus on a rating that best described how strongly the component was operating within the school.

We also used NVivo to print a report of open coded data. As noted earlier, our methodology allowed for open coding of text segments as emergent themes, as well as coding by critical component. The codes were organized on a spreadsheet with posited themes. The team members met to discuss whether any of these data segments actually matched the codebook for a particular critical component or whether they were actually a new idea and belonged in a new category of an emergent theme. We conducted a second cycle of coding of the open coded data segments in NVivo with attention towards these emergent themes (e.g., school culture or Twenty-first Century Skills). We then generated NVivo reports for emergent themes and integrated them into the case study narratives.

Exploring the outcome dimension. Before the site visit, we examined the student outcomes using the most current data available on state and school websites, including data provided by the school. 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, Confrey, House, & Bhanot, 2008; NRC, 2004). To capture this student outcome information, we compiled data on demographics and near-term outcomes such as attendance rates and assessment scores from state databases and/or the school's administrative team. The important role that student attendance plays in promoting academic success is widely acknowledged and accepted (see, for example, Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010). In our study, we use this attendance outcome data as an indicator of student engagement in their high school learning experiences. We compared attendance rates at the ISHS to those of the district and state, including data for various demographic subgroups, especially those underrepresented in STEM fields (African Americans, Hispanics, low SES). We also compared an ISHS's assessment data to that of their district and state. It should be noted, however, that these data for the district and state generally may not be disaggregated by grade level or grade band (e.g., grades 9-12). In other words, the data for the district and state may include outcomes for students who are in the elementary and middle school grades and are not directly applicable comparison points for the ISHS. We also gathered information on longer-term outcomes such as graduation rates, college admission rates and, if available, college attendance rates, and compared them against district and state rates, when available.

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.* Washington, DC: National High School Center. Retrieved from http://www.ncsssmst.org

Bland, J. & Woodworth, K. (2009). *Case studies of participation and performance in the IB diploma programme.* Menlo Park, CA: SRI International.

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.

Brody, L. (2006, September). Measuring the effectiveness of STEM talent initiatives for middle and high school students. Paper presented at the meeting of the National Academies Center for Education, in collaboration with the American Psychological Association, U.S. Department of Education, National Institutes of Health, National Science Foundation, and National Commission on Teaching and America's Future. Washington, DC. Retrieved from http://www7.nationalacademies.org

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.

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

David, J., Woodworth, K., Grant, E., Guha, R., Lopez-Torkos, A., & Young, V. (2006). *Bay area KIPP schools: A study of early implementation first year report 2004-05.* Menlo Park, CA: SRI International.

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

George, A. L. & Bennett, A. (2005). *Case studies and theory development in the social sciences.* Cambridge: MIT Press.

King, G., Keohane, R. O. & Verba, S. (1994). *Designing social inquiry: Scientific inference in qualitative research*. Princeton: Princeton University Press.

Koppich, J. & Showalter, C. (2008). *Strategic management of human capital: Cross-case analysis.* Madison, WI: Consortium for Policy Research in Education.

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. S., Peters-Burton, E., and Means, B. M. (2012). *Multiple instrumental case studies of inclusive STEM-focused high schools: Opportunity structures for preparation and inspiration (OSPrI).* Paper presented at the annual meeting of AERA, Vancouver, BC. Retrieved August 10, 2013, from the AERA Online Paper Repository.

Lynch, S., & Hanson, A. K. (2005). *Lesson Flow Classroom Observation Instrument (LFCOP)*. Washington, DC: SCALE-uP.

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/

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

National Research Council. (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. (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. (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). *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. (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. (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 Science Foundation. (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). (2013). *Discovery Research K-12: Program solicitation NSF 10-610.* Arlington, VA: Author.

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

Obama, B. (2010, September 16). Remarks by the President at the announcement of the "Change the Equation" Initiative. Retrieved from http://www.whitehouse.gov/

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

Piburn, M., Sawada, D., Falconer, K., Turley, J. ,Benford, R., & Bloom, I. (2000). Reformed teaching observation protocol (RTOP): The RTOP rubric form, training manual and

reference manual containing statistical analyses [Downloadable site profile instrument]. Retrieved from: http://PhysicsEd.BuffaloState.Edu/AZTEC/rtop/RTOP_full/PDF

QSR, International. (2013). Nvivo10. Retrieved from http://www.qsrinternational.com/

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

Rosenstock, L. (2008). Taking the lead: An interview with larry rosenstock. *Edutopia*. Retrieved from http://www.edutopia.org/collaboration-age-technology-larry-rosenstock-video

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).

Shear, L., Song, M., House, A., Martinez, B., Means, B., & Smerdon, B. (2005). *Creative cultures of learning: Supportive relationships in small high schools.* Washington, DC: The National Evaluation of High School Transformation.

Smith, M. L. (1987 or 79?). Publishing qualitative research. *American Educational Research Journal, 24*, 173-183.

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.

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

Straus. A. L. (1987). *Qualitative analysis for social scientists.* Cambridge: Cambridge University 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.

Wentworth, L. (2010). *Effective schools addressing the achievement gap: Case studies and cross case analysis of three schools in San Francisco* (Stanford Doctoral Dissertation).

Young, V., Humphrey, D., Wang, H., Bosetti, K., Cassidy, L., Wechsler, M., Murray, S. (2010). *Renaissance schools fund-supported schools: Early outcomes, challenges, and opportunities.* Menlo Park, CA: SRI International.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.