FACTORS RELATED TO ADVANCED COURSE-TAKING PATTERNS, PERSISTENCE IN SCIENCE TECHNOLOGY ENGINEERING AND MATHEMATICS, AND THE ROLE OF OUT-OF-SCHOOL TIME PROGRAMS: A LITERATURE REVIEW

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FACTORS RELATED TO ADVANCED COURSE-TAKING PATTERNS, PERSISTENCE IN STEM, AND THE ROLE OF OUT-OF-SCHOOL TIME PROGRAMS: A LITERATURE REVIEW

I. Introduction

In the past quarter century, two national commissions have called for America's students to be the "best in the world in science and mathematics"-- initially by the year 1995 by the National Science Board (National Science Board [NSB] Commission on Precollege Education in Mathematics, Science and Technology, 1983) and then by the year 2000 by the U.S. Department of Education (U.S. Department of Education's National Commission on Excellence in Education, 1983). In 2000, the Glenn Commission reported that, "The future well-being of our nation and people depends not just on how well we educate our children generally, but on how well we educate them in mathematics and science specifically" (National Commission on Mathematics and Science Teaching for the 21st Century, p. 4). The Education Commission of the States (Coble & Allen, 2005, p. 2), warned that, "America's competitive edge in the global economy, the strength and versatility of its labor force, its capacity to nourish research and innovation—all are increasingly dependent on an education system capable of producing a steady supply of young people well prepared in science and math." Other recent reports have reiterated and intensified concern that the scientific and technological foundation of America is eroding, while other nations are gaining strength (Building Engineering & Science Talent [BEST],2004a; Jackson, 2004; National Academy of Sciences [NAS], 2007; National Science Board [NSB], 2006a, 2006b). This alarm is not new, but it is growing in urgency. The latest indicators report, Science and Engineering Indicators 2006, Volume 1, (NSB, 2006a) warns that, "… the time to act is now!"

In *Rising Above the Gathering Storm: Energizing and Employing America for A Brighter Economic Future (*NAS, 2007), the Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, made four recommendations that focus on implementing action in K-12 education, higher education, research, and economic policy. Among the action plans for K-12 education are to recruit 10,000 science and mathematics teachers by awarding four-year scholarships; to strengthen 250,000 teachers' content and pedagogical skills through training-and-education programs including Advanced Placement (AP), International Baccalaureate (IB), pre-AP, and pre-IB; and to prepare more students, through AP and IB science and mathematics courses, to be able to enter college and graduate with a degree in Science, Technology, Engineering, or Math (STEM). A recent National Academy of Sciences (2007) report is encouraging, because it outlines practical actions for the U.S. system of public education to "lay the foundation for developing a workforce that is literate in mathematics and science" (p. 5-1).

Statistics from the National Science Foundation (2007), *Women, Minorities, and Persons with Disabilities in Science and Engineering*, reveal that the number of women earning bachelor's degrees in sciences and engineering (S & E) has steadily increased since 1966, and that since 2000 more women earned bachelor's degrees in science and engineering (S&E) fields than did men. Males continued to earn more associate's and bachelor's degrees in computer sciences than did females, and females earned more bachelor's and master's degrees in psychology. (See Table 1.)

Table 1.

Sciences and Engineering Bachelor's Degrees, by Sex and Race/Ethnicity, 1995-2004

	1995	1996	1997	1998	2000	2001	2002	2003	2004
Total	378,148	384,674	388,482	390,618	398,622	400,206	415,611	437,436	452,338
Sex									
Female	175,931	181,333	187,011	190,397	200,953	202,583	211,203	220,348	227,813
Male	202,217	203,341	201,471	200,221	197,669	197,623	204,408	217,088	224,525
Race/Ethnicity									
White	275,819	276,786	274,800	272,561	270,416	267,848	276,379	287,701	294,105
Asian/P.I.	28,604	30,419	32,568	34,004	35,553	36,398	37,452	39,505	41,022
Black	26,911	28,397	29,825	30,751	32,924	33,290	34,796	36,400	38,050
Hispanic	21,359	22,886	24,445	25,712	27,984	28,321	29,871	32,025	33,077
Am Indian/AK	1,995	2,149	2,298	2,392	2,611	2,796	2,642	2,864	3,201

Note. No data are available for 1999. S & E includes mathematics, statistics, computer science, social sciences, psychology, engineering, physical sciences, biological sciences, agricultural sciences, and Earth, atmospheric, and ocean sciences.

SOURCE: National Science Foundation, Division of Science Resources Statistics, special tabulations of U.S. Department of Education, National Center for Educational Statistics, Integrated Postsecondary Education Data System, Completions Survey, 1995-2004.

The number of S&E bachelor's degrees awarded by sex and race/ethnicity displayed in Table 1 reveals that S&E degrees earned by Blacks increased by 41 percent and those earned by Hispanics increased by 55 percent. Though this is promising progress, much progress remains to be done to increase the percentage of underrepresented populations in sciences and engineering, particularly the quantitative sciences and engineering. One disturbing statistic is that the percentage of Black undergraduate engineering students has steadily declined over the last ten years, from roughly 7 percent to approximately 6 percent. However, the percentage of Hispanic undergraduate engineering students has generally increased from 7 percent in 1995 to 9 percent in 2005. The percentage of Asian undergraduate engineering students has declined in the last two years.

Organizations such as MESA USA (Mathematics Engineering Science Achievement), SECME (formerly known as the South Eastern Consortium for Minorities in Engineering) and the National Action Council for Minorities in Engineering (NACME). MESA, SECME, and NACME have worked for over thirty years to increase the pool of students who are prepared and able to enter STEM studies and to provide scholarships and professional opportunities for these promising young people. Though overall the NSF statistics are somewhat heartening, much work remains to be done to encourage more women, minorities, and persons with disabilities to enter and persist in STEM careers.

Purpose of Paper

This paper seeks to review the research, evaluation, and experiences related to persistence in STEM by U.S. students and the selection of sequential and advanced STEM courses including Advanced Placement and International Baccalaureate. The literature on persistence and self-efficacy in STEM is reviewed and overlaid with the best practices in after-school and out-of-school-time programs that provide support for students to engage in, continue in, and develop capacity in STEM. The project was guided by the conceptual framework of Engagement, Capacity, and Continuity—the ECC Trilogy—developed by Jolly, Campbell, and Perlman (2004). “Each of these factors is necessary but individually is not sufficient to ensure student continuation in the sciences and quantitative disciplines” (p.3).

In this paper, Engagement and Self-efficacy Factors are addressed first in an exploration of what is essential for students to stay on tack in advanced courses and of evidence that after-school programs support engagement and persistence in STEM. In this section, literature on self-regulated learning, self-efficacy, social cognitive theory, and agency were reviewed to illuminate reasons that students persist in STEM education and to augment the ECC Trilogy. Next, in Capacity Factors, the science and mathematics content and skills needed for entry into and success in advanced STEM courses are reviewed along with capacity factors related to after-school staffing and professional development. Finally, sociocultural and institutional factors related to Continuity in STEM are reviewed, and the support roles of after-school programs and community organizations are discussed.

Impact of Afterschool on STEM

After-school programs have potential to increase student engagement, capacity, and continuity in STEM. These programs in the United States have long provided safe environments and recreational activities for underserved students from ethnically diverse, low-income populations. After-school programs are operated by various groups and have myriad sponsors. "The philosophy, goals, and components of the [afterschool and outside-of-school] programs may vary as much as the supporting groups" (Shumow, 2001, as cited in Olszewski-Kubilius & Lee, 2004).

However, after the No Child Left Behind (NCLB) Act of 2001 placed more emphasis on academic accountability, afterschool programs began emerging as providers of academic enrichment aimed at improving student performance in core content areas. The 21st Century Community Learning Centers (CCLC) programs, in which over 1 million students are enrolled (Naftzger, Kaufman, Margolin, & Ali, 2006), have played a pivotal role in this paradigm shift (Huang, 2007a), but these programs vary greatly in the quality and quantity of academic enrichment that they offer to students. In an effort to better understand and to expand the best practices of promising afterschool programs, the U.S. Department of Education, Office of Elementary and Secondary Education commissioned a review of programs by the National Partnership for Quality Afterschool Learning (NPQAL). In addition to the U.S. Department of Education, NPQAL is comprised of six organizations—Southwest Development Laboratory (SEDL); National Center for Research on Evaluation, Standards, and Student Testing (CRESST); Mid-continent Research for Education and Learning (McREL); Northwest Regional Educational Laboratory (NWREL), SERVE Center at the University of North Carolina at Greensboro, and WGBH Educational Foundation. By summer 2007, the Partnership will have visited up to sixty promising afterschool sites—both 21st CCLC and others. Findings from these site visits have been used to develop a web based instructional toolkit.

II. Engagement and Self-efficacy Factors that Influence Students to Persist in STEM and Sequential and Advanced Placement Courses

Introduction to Engagement and Self-efficacy

Young children come to school with an innate desire to learn (Driver, 1988; National Research Council, 1998). However, by the time children reach middle grades and high school, data show that students often take the minimum number of science and mathematics courses required for high school graduation. The distribution of students who take three or more years of science or mathematics in high school mirrors test results by ethnicity/race (NCES, 2007a, 2007b, 2004). Essential aspects of student engagement (interest, investment, and effort) in and persistence in STEM at the high school level includes students electing and attending STEM classes. However, the path starts far earlier in elementary school with nurturing the child's inquisitive mind and laying the foundation for middle grades learning and experiences. During this time, children need to experience positive relationships and learning opportunities that increase their science/math self-efficacy. This sense of self-efficacy will enable them to persist in STEM coursework and career paths.

Several organizations including The National Center for Education Statistics (NCES), The College Board, International Baccalaureate Organization, and the Council of Chief State School Officers (CCSSO) produce reports on STEM course-taking trends, graduation requirements, and the degree to which achievement scores in mathematics and science are affected by the courses that students elect.

The *2005 High School Transcript Study* (HSTS; NCES, 2007b) revealed that the mean course credits earned by high school graduates in mathematics and science continue to rise. Graduates earned an average of 2.8 credits in science and 3.2 credits in mathematics in 1990 and 3.4 in science and 3.8 in mathematics in 2005. This increase in the number of credits earned follows the trend of states to increase graduation requirements subsequent to NCLB requirements of states, districts, schools, and students to be accountable for student achievement in reading, mathematics, and science. Table 2, Number of States Requiring 2 or Less, 3, or 4 Mathematics and Science Credits for High School Graduation, 1995-2004 from the Key State Education Policies on PK-12 Education: 2004 (Cavell, Blank, Toye, & Williams, 2005) illustrates that the number of states requiring three or more years of mathematics and three or more years of science has more than doubled between1995 and 2004. About a third of the states now require Algebra I or higher and about half of the states require biology. However, no state requires higher level math beyond Algebra II or higher level science beyond chemistry, despite the fact that students who take advanced- level courses have higher achievement test scores (Horn & Kojaku, 2001; NCES, 2007a, 2007b, 2006) and are more successful in completing a college degree (Adelman, 2006; Horn & Kojaku, 2001; NAS, 2007; Trusty, 2002; Trusty & Niles, 2003).

Table 2.

Number of States Requiring 2 or Less, 3, or 4 Mathematics and Science Credits for High School Graduation, 1995 – 2004

Subject (years required)	1995	1998	2000	2002	2004
Mathematics					
2 or less	26	24	18	18	18
3	17	17	21	21	20
4	0	1	4	5	6
Science					
2 or less	30	26	19	20	18
3	11	13	19	18	20
4	0	1	4	2	3

Note. Some states allow local districts to set requirements.

SOURCE: Cavell, L., Blank, R.K., Toye, C., & Williams, A. (2005). *Key State Education Policies on PK-12 Education: 2004.* Council of Chief State School Officers. Washington, DC. Available at

http://www.ccsso.org/content/pdfs/FINAL%20KSP%202004.pdf.

This increase in the number of science and mathematics courses required for graduation has resulted in a slight increase in the average number of rigorous high school STEM courses that students are taking, but the distribution of students in these courses differs by ethnicity/race and gender. The *Nation's Report Card Science 2005* (NCES, 2006) reports that more males than females took biology, chemistry, and physics, and more Asian/ Pacific Islanders (P.I.) took all three courses than did Whites, Hispanics, or Blacks. In addition, males had slightly higher NAEP Science average scores than did females, and Asian/Pacific Islanders had higher scores than did other racial/ethnic groups. Differences in the course taking by race/ethnicity and gender are shown in Table 3. "Twelfth graders who took biology, chemistry, and physics scored higher [on NAEP] than students who took just biology or other science courses" (NCES, 2006, p. 34).

Table 3.

Percentage of Twelfth Grade Students in Science Course-taking Categories by Race/Ethnicity and Gender with Corresponding Average 2005 NAEP Science Score

Race/Ethnicity	**Biology Only or Other**	**Biology & Chemistry**	**Biology, Chemistry, & Physics**	**Average 12th Grade Score**
White	31	37	31	156
Black	39	39	22	120
Hispanic	39	36	25	128
Asian/P.I.	23	33	45	153
Gender				
Male	37	32	31	149
Female	29	42	29	145

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005 Science Assessment

As Figure 1 illustrates, data from the 2005 High School Transcript Study (NCES, 2007b) reveal that Asian/Pacific Islander graduates were also more likely than other racial/ethnic groups to have completed an advanced science such as AP or IB Biology, AP or IB Chemistry, or AP or IB Physics (35 percent compared to 20 for White graduates, 12 percent for Black graduates, and 13 percent for Hispanic graduates).

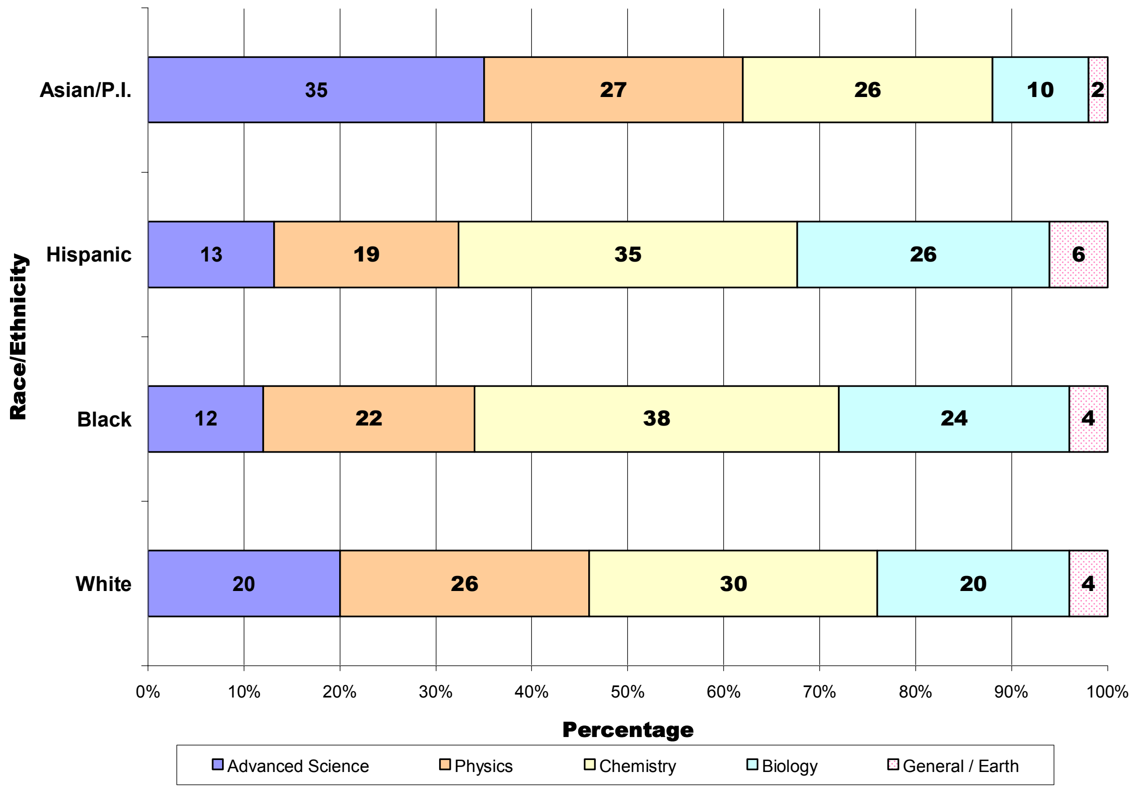

Figure 1. Highest Level Science Course Completed by Race/Ethnicity: 2005

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS), 2005.

The *Nation's Report Card 12th Grade Reading and Mathematics 2005* (NCES, 2007a) report similar results for mathematics—students who took more advanced math courses scored better on NAEP and that the enrollment of students in more rigorous courses differed by race/ethnicity. "Sixty-one percent of students nationwide performed at or above the *Basic* achievement level in 2005 and 23 percent performed at or above the *Proficient* level (NCES, 2007a, p. 15)." Students who took geometry, Algebra I or lower had average scores *Below Basic* level, those who took Algebra II or trigonometry had average scores in the *Basic* range, and those who took calculus had average scores in the *Proficient* range. As shown in Table 4, a higher percentage of Asian/Pacific Islander students scored *Proficient* or *Advanced* on NAEP 2005 Mathematics Assessment than did students from other racial groups. Data from the 2005 HSTS further revealed that 62 percent of Asian/Pacific Islander graduates completed calculus or another advanced math course compared to 28 percent of Hispanic graduates, 29 percent of Black graduates, and 46 percent of White graduates (see Figure 2).

Table 4.

Twelfth Grade NAEP Mathematics Achievement Levels Profiles by Race/Ethnicity: 2005

Race/Ethnicity	**Percentage At or Above Proficient**
White	29
Black	6
Hispanic	8
Asian / Pacific Islander	36
American Indian / Alaska Native	6

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2005 Mathematics Assessment.

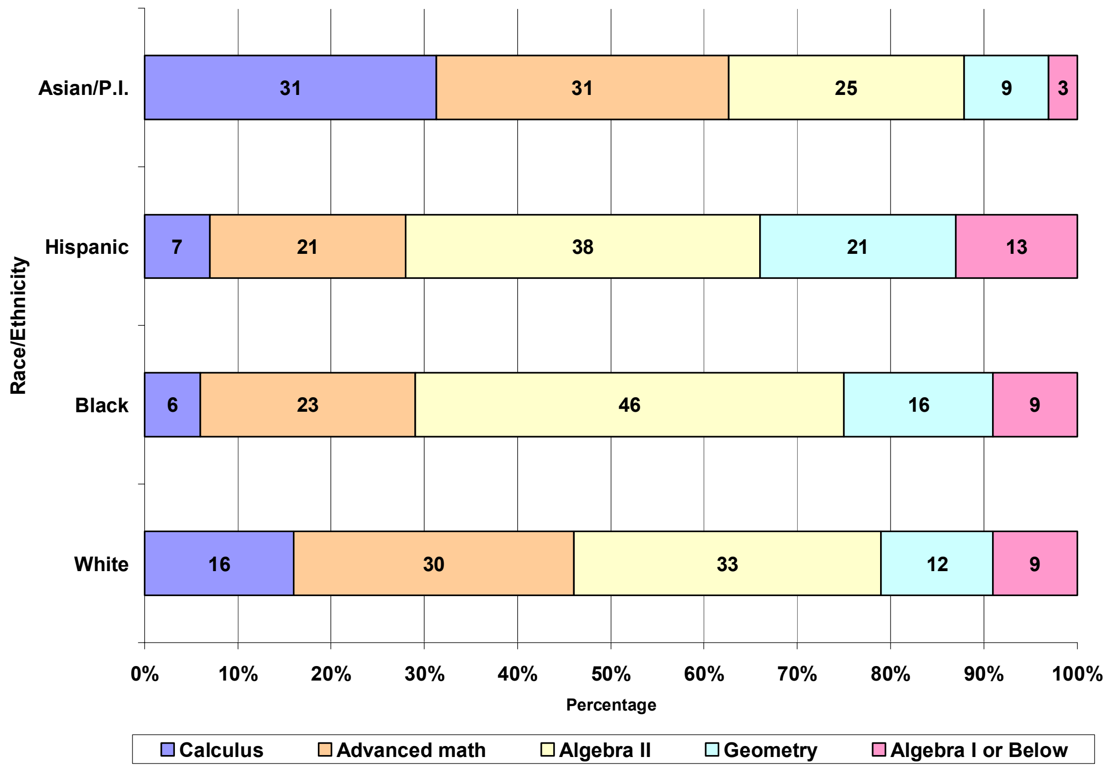

Figure 2. Highest Level Mathematics Course Completed by Race/Ethnicity: 2005

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS): 2005.

Using data from the most recently completed NCES longitudinal study, known as NELS:88/2000, in which a cohort of eighth-graders in 1988 were followed through December 2000, Adlelman (2006, p. xviii) found that “the academic intensity of the student’s high school curriculum still counts more than anything else in precollegiate history in providing momentum toward completing a bachelor’s degree.” Successful students in the study had transcripts with, among other things, at least 3.75 units of mathematics (highest mathematics—calculus, precalculus, or trigonometry), and 2.5 or more units of science (biology, chemistry, and physics), and at least one Advanced Placement course. These results confirmed earlier studies (Adelman, 1999, 2004). Adelman (2006, p. xix) concludes that, “The highest level of mathematics reached in high school continues to be a key marker with the tipping point of momentum toward a bachelor's degree well above Algebra II."

Recent studies comparing AP students with non-AP students were done in Texas. The Hargrove, Godin, and Dodd Study (cited in The College Board, 2007) found that, "AP students statewide in Texas earn higher college GPAs and have higher four-year graduation rates when compared to students with similar SAT scores and socioeconomic backgrounds who did not take AP courses and exams (p.12)." Another Texas study (cited in NAS, 2007, p. 5-17) found that "a student who passes an AP examination has a better chance overall—regardless of ethnicity—of completing a bachelor's degree within 6 years."

Dougherty, Mellor, and Jian (2006), of the National Center for Educational Accountability, explored the relationship between college graduation rates and student participation and success in Advance Placement (AP) courses and exams. They concluded that "the percent of students who take and pass AP exams is the best AP-related indicator of whether the school is preparing increasing percentages of its students to graduate from college" (p.2). They encouraged districts to pay close attention to the quality of teaching in AP classes and to the academic preparation of students prior to taking AP classes.

Unfortunately, too few students take challenging science and mathematics courses (Achieve, 2004; Adelman, 2006; NCES, 2006, 2007). Even though the AP classroom is becoming more diverse, African American and Native American students are significantly under-represented nationwide and Hispanic students are under-represented in some states (The College Board, 2007). Some students are not afforded these opportunities because not all high schools offer advanced courses, particularly those with enrollments of large percentages of students from the lowest socioeconomic status quintile (Adelman, 2006). Adelman (2006, p. xviii) concludes that, "If we are going to close gaps in preparation—and ultimate degree attainment—the provision of curriculum issue has to be addressed."

While it is true that some students do not have the opportunity to take advanced, courses, there is some good news in the *Advanced Placement Report to the Nation 2007* and in the National Academy of Sciences' (2007) recommendations outlined in *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* Some state and local initiatives to increase enrollment in AP and success on AP exams (grade of 3 or better) have yielded positive results (The College Board, 2007). Arkansas, New Hampshire, Delaware, Nebraska, Oklahoma, and Virginia were recognized as having the greatest expansion of AP scores of 3+ from 2005 to 2006. Other states--Florida, Delaware, Maryland, and North Carolina—have made significant expansion of AP in the last five years. Florida has "dramatically expanded AP participation and performance among Hispanic students, such that the percentage of AP students who are Hispanic [24.2%] exceeds the percentage of non-AP students who are Hispanic [20.7%] (The College Board, 2007, p.8)."

"Positive actions include[e] offering incentives to AP and Pre-AP teachers for student success, strengthening the skills of teachers through AP and IB training programs, developing free national curriculum materials, and increasing the number of students who pass AP and IB STEM courses" (NAS, 2007). If these recommendations are implemented, many additional underrepresented students will be able to engage in advanced STEM courses and will be provided a much better chance of success in STEM career paths.

Essential Factor to Staying on Track—Self-efficacy

Enrollment in advanced mathematics and science courses is not the only key for students to engage in STEM. One significant indicator of student engagement in, success with, and persistence in science is a students' science self efficacy (Britner and Pajares, 2006).

Self-efficacy researchers posit that students' belief in their ability to succeed in science tasks, course, or activities, or their *science self-efficacy*, influences their choices of

> science-related activities, the effort they expend on those activities, and the perseverance they show when encountering difficulties, and the ultimate success they experience in science (Bandura, 1994; Britner & Pajares, 2006); Zeldin & Pajares, 2000). This makes self efficacy a prime focus of science educators who want to increase student accomplishment and engagement in science. (p. 486)

In 1994, Bandura documented the importance of self-efficacy to people's lives. "Perceived self-efficacy refers to beliefs in one's capabilities to organize and execute the courses of action required to manage prospective situations. Efficacy beliefs influence how people think, feel, motivate themselves, and act" (p.2). He defined four ways for developing a strong sense of self-efficacy—mastery experiences, social modeling, social persuasion, and physical and emotional states. In 2004, in an invited essay, *Swimming Against the Mainstream: The Early Years from Chilly Tributary to Transformative Mainstream*, he revisited these factors:

> The most effective one is through *mastery experiences*. Successes build a robust belief in one's efficacy. Failures undermine it. If people have only easy successes they are readily discouraged by failure. Development of a resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort. Resilience is also cultivated by learning how to manage failure so that it is informative rather than demoralizing.
>
> The second way of creating and strengthening beliefs of personal efficacy is through *social modeling*. [*Social modeling* is also known as *vicarious experiences*.] If people see others like themselves succeed by sustained effort they come to believe that they, too, have the capacity to do so. Competent models also build efficacy by conveying knowledge and skills for managing environmental demands.

> *Social persuasion* is the third way of strengthening people's beliefs in their efficacy. [*Social persuasion* is also known as *verbal persuasions*.] If people are persuaded that they have what it takes to succeed, they exert more effort than if they harbor self-doubts and dwell on personal deficiencies when problems arise. But effective social persuaders do more than convey faith in people's capabilities. They arrange things for others in ways that bring success and avoid placing them prematurely in situations where they are likely to fail.
>
> People also rely on their *physical and emotional states* to judge their capabilities. They read their tension, anxiety, and depression as signs of personal deficiency. In activities that require strength and stamina, they interpret fatigue and pain as indicators of low physical efficacy. (pp. 622-623)

In a qualitative study of the personal lives of women who excelled in mathematics, science, and technology careers, Zeldin and Pajares (2000) found that "verbal persuasions and vicarious experiences were critical sources of the women's self-efficacy beliefs" (p.215). These women cited experiences with "significant others" as persuasive in their career choices, which led Zeldin and Pajares (p.227), to suggest that in male-dominated domains these sources of self-efficacy may be more important than in traditional settings. "These self-beliefs helped the women in our sample to be resilient to both academic and social obstacles." The vicarious experiences and verbal persuasions cited by these women came from family (particularly fathers and brothers), teachers, peers, and supervisors.

Dr. Shirley Jackson, the first African American woman to earn a doctorate in physics from MIT, to lead the National Research Council, and to hold the office of President of Rensselaer Polytechnic Institute, also credits her family for instilling in her a love of learning (Collison, 1999). Collison quotes Jackson, "My father had an expression: 'Aim for the stars so that you can reach the tree tops. … The message was that if you don't aim high, you don't go far. I've carried that with me my whole life.'"

Gushue (2006) examined the influence of ethnic identity and parental/teacher support on the cognitive variables of career decisions self-efficacy and outcome expectations in a sample of 104 African American ninth-grade students. He found that parental support, not ethnic identity, positively related to career decision self-efficacy and career outcome expectations of students in the study.

Although Collins (2003) did not use the words *self-efficacy*, her white paper for the National Action Council for Minorities in Engineering supports Bandura's social cognitive theory as well as identifying environmental factors that support persistence in STEM. "The training, entry, and persistence of women and minorities in science and engineering are determined by a complex set of inter-related social and economic factors. These include family acceptance and encouragement [social persuasion], early and continued training in mathematics and science and their prerequisites [mastery experiences], a supportive educational environment, science training that engages students and relates to their interests, availability of role models and mentors [social modeling], assistance in designing education and career paths, adequate financial resources, collegial employment settings, and commitment by the larger community" (p.1).

This strong influence of parents on children's aspirations was also found by Bandura, Barbaranelli, Caprara, and Pastorelli (2001). They examined the self-efficacy beliefs in 272 children and found,

> Familial socioeconomic status is linked to children's career trajectories only indirectly through its effects on parents' perceived efficacy and academic aspirations. The impact of parental self-efficacy and aspirations on their children's perceived career efficacy and choice is, in turn, entirely mediated through the children's perceived efficacy and

> academic aspirations. Children's perceived academic, social, and self-regulatory efficacy influence the types of occupational activities for which they judge themselves to be efficacious both directly and through their impact on academic aspirations. Perceived occupational self-efficacy give direction to the kinds of career paths children seriously consider for their life's work and those they disfavor. Children's perceived efficacy rather than their actual academic achievement is the key determinant of their perceived occupational self-efficacy and preferred choice of work-life. (p.187)

Efficacy beliefs shape career aspirations during early formative years. The stronger students believe in their efficacy, the more occupational options they consider possible, the greater the interest they show in these options, and the better they prepare themselves educationally (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996). Students who believe that they can succeed academically set high goals, try harder, and show more resilience in times of trial (Bandura et al., 1996; Pajares, 1996). Many struggling learners, on the other hand, think that they cannot succeed academically and have low self-efficacy. According to Margolis and McCabe, (2004):

> A key to reversing this perspective—getting struggling learners with low self-efficacy to invest sufficient effort, to persist on tasks, to work to overcome difficulties, to take on increasingly challenging tasks, and to develop interest in academics—is for teachers to systemically stress the development of high self-efficacy. (p. 241)

Research on sources of science self-efficacy in middle school students found that mastery experience had the most significant correlation of the four sources of self-efficacy identified by Bandura and was a strong predicator of achievement (Britner & Pajares, 2006; Usher & Pajares, 2005; Zimmerman, Bandura, & Martinez-Pons, 1992). Patrick, Ryan, and Kaplan (2007), in a study of fifth-grade students (*N*=602) who participated in the Young Adolescents' Motivation in Math project, found that the classroom social environment (teacher support, promotion of interaction, and student support) were related to engagement (self-regulation and task-related instruction), and “those relations were fully or partially mediated by motivational beliefs [mastery goals, academic efficacy, social efficacy]” (p. 83).

Lent, Brown, and Hackett (1994), based on Bandura’s work, developed the social cognitive career theory (SCCT) and have conducted numerous studies of students in STEM career choices. In a recent study (Lent, Brown, Schmidt, Brenner, Lyons, & Treistman; 2003) of 328 engineer majors at a large Eastern university, researchers reported that “Findings indicated good support for a model portraying contextual supports and barriers as linked to choice goals and actions (i.e., persistence in engineering) indirectly, through self-efficacy, rather than directly as posited by SCCT” (p. 458).

Others have explored the relationship between social cognitive variables and career-decision making self-efficacy. Two recent studies explored perceptions of barriers and outcome variables of vocational identity and career-exploration behaviors in urban, Latino high school students (Gushue, Clarke, Pantzer, & Scanlan, 2006) and in African American high school students (Gushue, Scanlan, Pantzer, & Clarke, 2006). In both cases, they found that higher levels of career decision-making self-efficacy—individuals’ degree of confidence that they can engage in tasks associated with career and the commitment to the career choice—are related to both a more differentiated vocational identify—conceptualization of one’s own vocational interests, talents and goals—and a greater engagement with career exploration tasks. These findings indicate that educators—teachers, career counselors, and afterschool providers—should explore students’ beliefs about their capacity to engage in STEM careers; provide opportunities for students to explore these careers and help them develop interests, abilities, and goals; and help students identify prerequisite courses that will enable them to engage in STEM careers.

Howard (1992, p. 4) posits that most children “are more than intelligent enough to learn, if we learn to teach them.” Through his Efficacy Institute, he has worked with dozens of schools whose children have grown in self-confidence and have shown significant achievement gains in mathematics and reading by applying a new paradigm. The paradigm shift is from the philosophy of "innate ability" and tracking students into self-filling prophesies of failure to a philosophy of constructed intelligence—all students have wonderful potential and can learn. Howard sums up the philosophy as, "Smart is not something you just are, smart is something you can get" (Howard, 1992, p.8). When this idea is applied and children understand that development is something that they can control though expenditure of effort, then "Children are empowered and energized by the notion that they can choose to get smart" (p.8). He encourages educators and parents to apply a new pedagogy that shows children how to learn.

Howard is quick to point out that self-confidence is not self-esteem (Raney, 1997). He defines self-confidence as, "a psychological state based on an understanding of previous accomplishments and future potential" (Rainey, 1997, p.5). "Kid's beliefs in their own capabilities will generate commitment. They get that belief from us, so we'll always be an essential component. Once they engage, they become independent of us as they mature. We have tremendous power" (p.10).

This idea of efficacy is not only for students, it is for educators as well. Howard (2003) talks of effective teachers..

> They establish aggressive learning-outcomes objectives for every subject they teach, and they communicate these as targets to their students; they believe all their students can achieve the targeted outcomes by the end of the school year, and they regularly and credibly communicate that belief. Confident in their own capacities to shape effective learning environments, they use the data from a regular schedule of assessments to drive ongoing adjustments in the curriculum they use and the instructions strategies they employ. (pp 91-92)

Related Factors—Authentic Work, Effective Teaching Strategies, Instructional Technology, Locus of Control, and Internal Motivation

Schools do not control all of the factors that influence student's academic engagement. Particularly in disadvantaged urban communities, academic engagement and achievement are adversely influenced by the economic and social marginalization of the students' families and communities. These disadvantages can be lessened, however, by participation in an engaging school community with high academic standards, skillful instruction, and the support students need to pursue their educational and career goals. (NRC, 2003, p. 1)

In seeking to understand factors that influence student engagement, literature was examined that addressed authentic work, supportive structures, and internal motivation. Building Engineering and Science Talent (BEST, 2004b), an initiative of the Council on Competitiveness, conducted a two-year assessment of best practices in K-12 education, higher education, and the workplace to increase participation of women, African Americans, Hispanics, Native Americans, and persons with disabilities in science, engineering, and technology professions. Using a rigorous protocol, in collaboration with the American Institutes for Research, BEST evaluated an initial list of 200 programs, 34 of which were selected for review. Twenty of these interventions "yielded research-based or descriptive evidence. Although none of the programs examined had high enough evidence to be consider verified, two earned the rating of probable" (BEST, 2004b, p.9). Direct Instruction (in Mathematics) and Project SEED (Special Elementary Education for the Disadvantaged) were the two programs that received a probable rating. Advancement Via Individual Determination (AVID), The Algebra Project, Foundational Approaches in Science Teaching (FAST), Gateway to Higher Education, Project GRAD (Graduation Really Achieves Dreams), Puente, and Yup'ik Mathematics were identified as notable. Eleven other programs were identified as providing robust descriptive evidence that warrants further research. Many of these programs are out-of-school-time programs such as Operation SMART—Girls, Inc., and Xavier University's Summer Science Academy. From these studies, "BEST identified a framework of design principles. … While these design principles do not account for the success of any particular intervention, they represent a checklist of essential characteristics of programs that have passed through a research filter." (p.10).

- **Defined outcomes** drive the intervention and are successfully accomplished for the entire population. Students and educational staff agree on goals and desired outcomes. Success is measured against the intended results. Outcome data provide both quantitative and qualitative information. Disaggregated outcomes provide a basis for research and continuous improvement.
- **Persistence** enables effective interventions to take hold, produce results, adapt to changing circumstances, and persevere in the face of setbacks. The conditions that ensure persistence include proactive leadership, sufficient resources, and support at the district and school levels.
- **Personalization** acknowledges the development of students as individuals as the goal of the intervention. Student-centered teaching and learning methods are core approaches. Mentoring, tutoring, and peer interaction are integral parts of the learning environment. Individual differences, uniqueness, and diversity are recognized and honored.
- **Challenging content** provides the foundation of knowledge and skills that students master. Curriculum is clearly defined and understood. Content goes beyond minimum competencies; relates to real-world applications and career opportunities; and reflects local, state, and national standards. Students understand the link between content rigor and career opportunities. Appropriate academic remediation is readily available.
- **Engaged adults** who believe in the potential of all students provide support, stimulate interest, and create expectations that are fundamental to the intervention. Educators play

> multiple roles as teachers, coaches, mentors, tutors, and counselors. Teachers develop and maintain quality interactions with students and each other. Active family support is sought and established. (p. 10)

These characteristics of well-designed programs not only apply to schools, but out-of-school-time programs as well. Challenging content and personalization are salient to authentic work and effective teaching discussed in the next paragraphs.

Authentic Work and Effective Teaching Strategies

In a study involving 3,669 students in 24 schools, Marks (2000) examined the effect of reform initiatives—offering students challenging and compelling instructional work, providing school and classroom environments supportive of learning, and involving parents with their children's schooling—on elementary, middle, and high school students' engagement in social studies and mathematics. She found that positive orientation toward school, "authentic instructional work," and positive school environments (respectful, fair, safe, positive communication) were important factors in engagement. "Authentic instructional work," according to Marks, involves higher order thinking, depth of knowledge, substantive conversation, and connectedness to the world beyond the classroom. Parental involvement influenced engagement of elementary school and high school students, but not middle school students, in this study. "Notably, race and ethnicity did not differentiate the levels of engagement in instructional activity" (p. 174). Social class was not a factor of engagement in elementary school and high school classrooms, but it was in middle school. This study provided support for the "importance of intellectual substance and quality in school restructuring initiatives" (p.176). Authentic instructional work and structures of support for learning were important in raising student engagement.

Other studies have found that authentic work is critical for women, girls, and minority engagement in STEM. The National Council for Research on Women's 2001 report (cited in Collins, 2003), *Balancing the Equations: Where Are Women and Girls in Science, Engineering and Technology,* "reviewed programs that successfully increase STEM participation of girls, women, and minorities and 'finds that women and girls excel in environments that encourage hands-on research, include mentoring and role models, and link science, technology and engineering to other disciplines and real world applications' " (p.2).

In the 2003 NSF publication, *New Formulas for America's Workforce: Girls in Science and Engineering,* multiple NSF-funded initiatives aimed at increasing under-represented populations in S&E were reviewed. Several teaching techniques were identified that have "proven to engage all students more, including girls and other groups who previously tended not to be drawn to the subjects":

- Hands-on activity, using touch, smell, and motion to experience and study the physical world.
- Working in cooperative teams, with students helping and showing each other.
- Looking at real-world contexts with a scientific eye—chemistry in the home, ecology in the community park, the physics of sports.
- An emphasis on personal mastery and confidence through problem-solving.
- Exposure to a diverse array of working scientists and engineers, to capture students' interest and to open their minds to many attractive careers. (p.1).

Burton, Whitman, Yepes-Baraya, Cline, and Kim (2002) studied teachers' characteristics and classroom behaviors that enabled their minority AP Calculus and AP Literature students to be successful. "Study results showed successful teachers of minority students were good teachers for all groups. They express a high opinion of students, both majority and minority, and hold them to high standards" (p.1). Furthermore, these teachers ensured that students understood and could apply discipline concepts and helped parents and students' to gain a better understanding about college-level work and what it is like to attend college. They possessed strong content knowledge and teaching skills and used a variety of teaching techniques. In this study, the teachers identified as successful came from schools with fewer free or reduced-priced lunch students and taught classes composed of fewer minorities than did teachers identified as not as successful. These teachers did not recruit potential AP students; their focus was on teaching students who enrolled.

Basu and Barton (2007) conducted a qualitative study of urban, high-poverty youth to examine the relationships between "funds of knowledge" (knowledge one brings to new learning through life experiences, beliefs, and conceptions) and sustained interest in science. They found that "youth developed a sustained interests in science when: (1) Their science experiences connected with how they envision their own futures; (2) learning environments supported the kinds of social relationships students valued; (3) science activities supported students' sense of agency for enacting their views on the purpose of science" (p. 466).

In her classic book, *Teaching Science as Continuous Inquiry: A Basic* (1978), Mary Budd Rowe's belief was that science provides a powerful means for teaching students basic orientations of survival through providing opportunities that help them to understand that they can influence what happens in their lives. Working with poor, urban students in New York City, Rowe's stance was that science can help students develop and maintain an adaptive fate-control orientation. She defined fate control as a belief about one's ability to control his or her own destiny. In essence, Rowe saw science as a venue for teaching students about cause-and-effect relationships. The factors that underlie the instructional development of a sense of fate control include language, conceptions of causality, reinforcements from the environments and their sources, and imaginations. Much of what Rowe argues is played out through a system of students interacting with instructional materials, the teacher, and the other students. Her metaphor of "craps versus bowling"--going from games of fate to games of fate control--offers a powerful notion of how one's world view can affect dispositions on life matters. To the external control believers (craps players), strategically planning makes no sense; however, for the internal control believers (bowlers), those who believe that their action can affect an outcome, will persist to make it happen.

The implications from this work are that teachers are critical to planning and implementing science lessons that are shaped into experiences for children that will allow them to interact with the classroom materials (the curriculum) individually and collectively with their peers and with the teachers. For example, Rowe's (2003) classic wait time is one means of facilitating classes in a manner that allows teachers to increase their wait-time after asking students questions from the mean of one second to three seconds to five seconds. When students are allowed more time to think and respond, changes occurred on ten student variables.

1. The length of response increases.
2. The number of unsolicited but appropriate responses increases.
3. Failures to respond decrease.
4. Confidence as reflected in decrease of inflected responses increases.
5. Incidence of speculative responses increases.
6. Incidence of child-child comparisons of data increases.
7. Incidence of evidence-inference statements increases.
8. The frequency of student questions increases.
9. Incidence of responses from students rated by teachers as relatively slow increases.
10. The variety in type of moves made by students increases. (Rowe, 1974/2003, p. S19)

Rowe found that results were similar for elementary school and high school students and were even more beneficial for less advantaged students than for advantaged students.

Instructional Technology in STEM Courses

Using computers and related technology have been found to be effective at increasing students' engagement in and achievement in advanced STEM courses (Friedler & McFarlane, 1997; Huffman, Goldberg, & Michlin, 2003; Kelly & Crawford, 1996; McClure, 1996) and middle school (Guerrero, Walker, & Dugdale, 2004; Lapp & Cyrus, 2000; Linn & Songer, 1991). Early studies of the use of microcomputer-based laboratories (MBL; dataloggers and sensors) found student understanding of kinematics increased more with technology than traditional methods of teaching (Thornton, 1989; Thornton & Sokoloff, 1993, 1990). When students use computer-related technology in science classes, discourse among students illustrated that their conceptual understandings were mediated by interaction between each other and with the visual images on the computer screen as experiments were conducted (Kelly & Crawford, 1996; McClure, 1996; Russell, Lucas, & McRobbie, 2004).

Although computer-related technology has been found to be effective at increasing student learning in science, the reality is that few teachers have access to critical masses of computers, sensors, and dataloggers; have adequate professional development in the use of these devices; and have appropriate curriculum tied to state standards. One state, West Virginia, has begun a statewide high school science initiative to provide these critical elements and evaluative studies are being conducted (Kees, personal correspondence, 2006).

Locus of Control and Internal Motivation

Reis and Park (2001), using NELS:88 data, examined gender differences between high-achieving students in math and science with respect to their achievement, self-concept, locus of control, number of math and science courses taken, and the important people who contributed to their decisions to enroll in advanced courses in high school. The results of their study "indicated that there were more males than females in both subsamples of high-achieving students in math and in science. The results also suggested that the best predictor for distinguishing between mathematically high-achieving males and females was locus of control. "High-achieving males had both higher self-concept and higher standardized math test scores than high-achieving females" (p. 52). Reis and Park encourage educators and parents to "consider grades and classroom performance in the identification of mathematically and scientifically talented students" (p.66). Encouragement of parents and teachers was also found to be important for high-ability girls to persist in science and mathematics. Other suggestions included encouraging parents and teachers to foster high educational and career expectations for high-achieving students, encouraging students to take advanced STEM courses, and for teachers to provide relevant and interesting mathematics and science curricula.

Borman and Overman (2004) conducted a study of the academic resilience in mathematics among poor and minority students using national data from the Prospects study. They found that, "Greater engagement in academic activities, an internal locus of control, efficaciousness in math, a more positive outlook toward school, and more positive self-esteem were characteristics of all low-SES students who achieved resilient mathematics outcomes" (p.177). They also found that a supportive community school model, which shielded children from adversity, promoted resiliency more than other models in the study—effective school, peer group composition, and school resources.

Sullo (2007), in his recent work, *Activating the Desire to Learn,* advocates internal control psychology for engaging students. He writes:

> Internal control psychology in general, and choice theory in particular, provide an accurate model for understanding human behavior. … When you apply the ideas of internal control

> psychology, you create classrooms and schools that are compatible with the fact that humans are motivated from the inside out. You believe the struggle is not in how to motivate students to learn. The struggle is in creating lessons and classroom environments that focus and attract students' intrinsic motivation; thus increasing the likelihood that students will actively engage in learning (Rogers, Ludington, & Graham, 1997, p.2). (p.14)

The studies of self-efficacy and other studies of cognitive and developmental scientists in the past four decades have uncovered new information on and understanding about how people learn and the characteristics of an academic environment that supports student learning. Their research "has increased our understanding of human cognition, providing greater insight into how knowledge is organized, how experience shapes understanding, how people monitor their own understanding, how learners differ from one another, and how people acquire expertise" (NRC, 2002b, p. 117). The research on how people learn encompasses seven principles for learning and four perspectives on the learning environment.

Factors Related to How People Learn

The research originally presented in *How People Learn: Mind, Brain, Experience, and School* (NRC, 2000a) and later in *Learning and Understanding: Improving Advanced Study of Mathematics and Science in U.S. High Schools* (NRC, 2002) indicates that there are seven principles of learning:

1. Learning with understanding is facilitated when new and existing knowledge is structured around the major concepts and principles of the discipline.
2. Learners use what they already know to construct new understandings.
3. Learning is facilitated through the use of metacognitive strategies that identify, monitor, and regulate cognitive processes.
4. Learners have different strategies, approaches, patterns of abilities, and learning styles that are a function of the interaction between their heredity and their prior experiences.
5. Learners' motivation to learn and sense of self affects what is learned, how much is learned, and how much effort will be put into the learning process.
6. The practices and activities in which people engage while learning shape what is learned.
7. Learning is enhanced through socially supported interactions.

Environments for Learning

The principles for learning can be organized into four environments that are a "framework for thinking about teaching, learning and the design of classroom and school environments" (NRC, 2005, p. 13-20). Those four are

- Learner centered—"this encourages attention to preconceptions and begins instruction with what students think and know. …This involves paying attention to students' backgrounds and cultural values as well as to their abilities."

- Knowledge centered—"this focuses on what is to be taught, why it is taught, and what mastery looks like. . .There is a need to emphasize connected knowledge that is organized around the foundational ideas of a discipline . . . to support the development of expertise."
- Assessment centered—"this emphasizes the need to provide frequent opportunities to make students' thinking and learning visible as a guide for both the teacher and the student in learning and instruction. Assessment is required to monitor student progress, to understand where students are in the developmental path from informal to formal thinking."
- Community—this suggests a culture of questioning, respect, and risk taking. Every community, including classrooms and schools, operates with a set of norms, a culture—explicit or implicit that influences interactions among individuals…and mediates learning."

Together, the seven principles of how people learn and the four perspectives on the learning environment can guide the work of educators as they strive to enhance their students' chances to engage in STEM and to learn successfully. This research is not gender or culturally specific. Effective learning environments support students of both genders and are appropriate across races, ethnicities, socioeconomic status, and abilities or special needs.

How Science Is Learned

Research indicates that the body of evidence on how people learn can be translated and refined to individual disciplines including the sciences. However, it may need to be contextualized to the specific content area, e.g., "some metacognitive strategies need to be taught in the context of individual subject areas" (NRC, 2005, p.17). In general, these seven principles and the research on learning environments can be viewed as the best information available on how students learn and the ways in which educators can support that learning.

To address the misalignment of the growing research base indicating how people learn science with traditional methods for teaching science, the American Association for the Advancement of Science (1993) and the National Research Council (1996) developed policy statements (Anderson, 2002; Bybee, 1997) for standards on what students should learn in science and how they should learn it. It was recommended that inquiry be an integral component of a student's science education (AAAS, 1993; NRC, 1996, 2000a, 2000b). Using scientific inquiry has been recognized as a way to support how students learn (NRC 1998, 2000a, 2000b, 2005).

One significant reason for the use of inquiry is to allow students to confront preconceptions and misconceptions that they may hold about a particular science topic. Many students develop their own ideas on natural phenomena before they are taught in school and often; those conceptions are inadequate or incorrect (Driver, Squires, Rushworth, & Wood-Robinson, 2005). For example, many students believe that the reason it is warmer in the summer is because the earth is closer to the sun rather than because of the tilt of the earth. Those ideas can be difficult to change through conventional teaching strategies (Wandersee, Mintzes, & Novak, 1994). Inquiry pedagogy, particularly the conceptual change model, has been shown to increase students' awareness of their inaccurate views (Stephans, 2003).

Additionally, within the inquiry process, as students have a chance to articulate their findings and challenge other students' explanations they have a chance to reconstruct their own knowledge (Roseberry, Warren, & Conant, 1994 as cited in NRC, 2000b). Finally, inquiry allows students to learn with understanding and thereby be more able to transfer their knowledge to new situations (NRC, 2000a, 2000b).

Research shows that the use of inquiry promotes student learning. Students can conduct increasingly open-ended experiments and formulate more complex questions about the content being taught (Hofstein, Shore, & Kipnis, 2004), draw conclusions (Cuevas, Lee, Hart, & Deaktor, 2005) and increase their positive attitudes toward science (Chang & Mao, 1999). The use of inquiry particularly influences the achievement in and attitude toward science for African American males (Kahle, Meece, & Scantlebury, 2000). Similar results have occurred with the use of inquiry in students with emotional disabilities (McCarthy, 2005) and students with diverse linguistic and cultural groups (Cuevas et al., 2005; Klentschy, 2001; Lee, Deaktor, Hart, Cuevas, & Enders, 2005).

Research also shows that the use of inquiry can particularly support the learning of disadvantaged students who derive greater benefits than other students (Bredderman, 1983) and minority and female students (Klentschy, 2001; Shymansky, Hedges, & Woodworth, 1990). Furthermore, one significant urban study of 8,000 middle school students showed "statistically significant increases on curriculum-based test scores for each year of participation [in an inquiry based science curriculum]. Moreover, the strength of the effects grew over the years" (Marx, Blumenfeld, Krajcik, Fishman, Soloway, Geier, & Tal, 2004). After-school programs are a particularly appropriate venue for inquiry; students may be able to explore science concepts more deeply and over a longer period of time without the typical time pressures of the classroom.

Evidence of OST Programs Engaging Underrepresented and Underserved Students, Promoting Self-Efficacy, and Persistence in STEM

Many museums, zoos, botanical gardens, science centers, and universities have programs that engage young people in STEM learning opportunities. Some of them train young people to work in the institution and encourage these young workers to continue in STEM career paths.

These informal education out-of-school-time programs and other afterschool can help to increase students' self-efficacy by providing environments in which students can cultivate their skills, where they can feel competent, and experience success. Effectiveness of out-of-school-time mathematics programs were examined in a meta-analysis by Lauer, Akiba, Wilkerson, Apthorp, Snow, and Martin-Glenn (2004). They found that OST strategies in mathematics improved the mathematics achievement of low-achieving or at-risk students. However long-term effects and persistence in STEM education and career trajectories as a result of OST programs are less documented.

In the NSF (2003) book, *New Formulas for America's Workforce: Girls in Science and Engineering,* two-hundred eleven NSF self-reported initiatives were reviewed, many of them were out-of-school time programs sponsored by professional organizations, museums, science centers, and universities. Though the overwhelming majority reported positive attitudinal changes and increased interest in and engagement in STEM, longitudinal studies of the students who participated in the most promising programs need to be conducted in order to determine if students' course-taking patterns and career path trajectories persist after the experiences. Some programs such as PATH (Pathways Through Calculus) and E-WORMS (Women's Ways of Learning Calculus) supported advanced coursetaking. Many of these initiatives were aimed at middle school girls such as HOP (Hands-on Engineering Projects for Middle School Girls) and minorities such as SECME RISE and SECME GIRLS RISE.

SECME, as discussed in the Introduction, is a national organization, which provides hands-on learning opportunities in engineering for minority and other underrepresented students in middle school and high school. SECME's Saturday sessions and summer academies are making a difference in students' lives, as the findings form the 2004 SECME Graduate Survey show. These findings include:

- Ninety-six percent of SECME graduates, on average, planned and did enroll in a four-year college.
- Sixty-two percent of SECME graduates in the past years, on average, majored in science, technology, engineering, or mathematics.
- The average SECME SAT score was 1050, 193 points higher than the U.S. African American average of 857 and 139 points higher than the U.S. Hispanic student average of 911.
- The average SAT score of SECME seniors planning to major in STEM disciplines was 1141.
- The average SECME senior during 2003 had a GPA of 3.97. (M. Williams, personal communication, March 12, 2007)

There is evidence that some after-school programs are seeking to inform students and parents of career paths, course sequences, and college planning. An example of such a program is The After-School Corporation's (TASC), The College Board, and the Partnership for Afterschool Education (PAS) collaborative initiative, After-School CollegeEd (Friedman, 2006). Friedman writes, "Through this pilot project, we aim to demonstrate that after school is an untapped but effective venue for supporting and encouraging youth on the path to college" (p. 9). First-year reports are positive, and TASC hopes to conduct longitudinal studies of young people involved in CollegeEd.

College and career planning are also part of MESA USA's program. MESA USA (n.d) is a K-16 collaborative academic enrichment effort in eight states—Arizona, California, Colorado, Maryland, New Mexico, Oregon, Utah, and Washington—"to support the national science and mathematics educational agenda by ensuring that MESA students develop a high level of literacy in mathematics and science so that they can play a leading role within an increasingly technology-based world" (p.2). The MESA program in California is the oldest and most successful of the precollege intervention programs (Jones, 2001). Results from 2004-2005 California MESA program (MESA, 2006) include:

- Seventy-seven percent of MESA students successfully completed Algebra I before the tenth grade.
- Of the MESA seniors who went on to postsecondary education, 47 percent went on to four-year colleges and universities compared to the state average of 23 percent.
- Of the MESA graduates, 57 percent went on to postsecondary education as math, science, or engineering majors.

Many out-of-school-time enrichment programs promote STEM knowledge and careers. An example of such a program is the Ben Carson Science Academy at the Morehouse School of Medicine (2006). For over ten years, the academy has developed an educational pipeline through which students participate in science and mathematics enrichment programs and are encouraged to enroll in upper-level STEM classes in high school. Longitudinal evaluative studies of this program have not been conducted.

Another example of an OST program is the Women in Natural Science (WINS) program. Fadigan and Hammrich (2004), in a longitudinal study of the educational trajectories of 152 young women who participated in the WINS program in high school, found that 93 percent of the participants enrolled in college and 45 percent of them pursued careers in either health, science, engineering, technology, or mathematics fields. "The majority of participants perceived having staff to talk to, the job skills learned, and having the museum as a safe place to go as having influenced their educational and career decisions. These findings reflect the need for continued support of informal science education programs for urban girls and at-risk youth" (p. 835).

Most after-school programs in the NPQAL mathematics and literacy site validation study served "ethnically diverse populations primarily lower-income students" (Huang, 2007a, p. 5).

Huang (p. 7) reported these finding, “Regarding student engagement, observers found students captivated in learning and activities at the sites they visited. Interview data revealed a common feature that most staff seemed to care about the students, had high expectations, and worked to establish good relationships with them. Instructors attempted to develop curriculum and activities that were captivating and related to students’ daily lives.” Key strategies used by promising programs to engage students included:

- “Empowering the students—The programs embraced student-centered learning.” Students were provided opportunities for providing input and were given choices.
- “Meaningful experiences—Several programs set aside time for open dialogue and for connecting learning to personal experiences and problems.”
- “Active learning—Inquiry-based approaches and cooperative learning were common strategies … instructors at most grantees employed problem solving and scaffolding.”

In the Summary for Qualitative Science Findings-9 Programs, Huang (2007b) found that After-school Providers (ASP) staff used various techniques and strategies for engaging students and developing self-efficacy.

- They “consistently described the use of multiple grouping structures and cooperative learning to promote science discovery … to encourage student participation through hands-on experimentation and science exploration … and to provide ‘real world’ connection’ between science content and students’ lives” (p.2).
- “Less frequently mentioned teaching strategies (but still fairly consistently implemented across programs) were dialogical learning, differentiated instruction, incorporation of multicultural content, and use of science-based computer software” (p.3).

In addition to these techniques and strategies, students at these sites “participated in science-related outings (p.3)” and interacted with “invited science experts from the community (p.3).” ASP staff “described a broad range of community connections that served to enhance science instruction at their sites. Most frequently cited were partnerships with local science-related agencies or organizations such as exploratoriums, nature centers, zoos, parks, farms, arboretums, a 'cosmosphere', observatories, and science museums." They had the opportunity to develop vicarious experiences.

21st CCLC Grantees report that a high percentage of these students who regularly attend demonstrated improved grades in mathematics (41% in 2003-04 and 39% in 2004-05) as well as improved performance on state assessments in mathematics (30% in 2004-05). Similar improvements were reported for reading/language arts (Naftgzer et al., 2006). Most of the 21st CCLC grantees serve at-risk and minority students, particularly elementary students (Naftzger et al.). Eighty-five percent of the feeder schools, schools which these students attend, are eligible for Title I funds, and 63 percent of the students in these schools are eligible for the free or reduced-price lunch program (indicating a high poverty rate). Hispanic and Black students make up 65 percent of program participants (see Table 5).

Table 5.

Population of 21st CCLC Grantees Feeder Schools by Race/Ethnicity, 2004-05

Race/Ethnicity	**Percentage of Feeder School Population**
Native American	1
Asian	4
Black	25
Hispanic	40
White	29
Unknown	2

SOURCE: Naftzger, Kaufman, Margolin, & Ali. (2006, p. 16).

While much evidence has been presented to illustrate that OST programs increase student engagement in and persistence in STEM, rigorous longitudinal studies are needed to substantiate these claims.

III. Capacity Factors that Influence Students to Persist in STEM and the Selection of Sequential and Advanced Courses

Introduction to Capacity Factors

Jolly et al. (2004, p.3) define capacity as "Possessing the acquired knowledge and skills needed to advance to increasingly rigorous content in the sciences and quantitative disciplines." One way to measure knowledge is through standardized assessments, but as Jolly et al. express, tests should measure content and skills rather than define them. The knowledge, skills, and habits of mind that students should acquire in school are the heart of the standards movements.

Approximately eighteen years ago, the National standards efforts in mathematics and science (American Association for the Advancement of Science, 1989, 1993; National Council of the Teachers of Mathematics, 1989, 2000; National Research Council, 1996) began. These standards defined what students need to know and be able to do in order to be scientifically and mathematically literate. The implementation of these National standards vary widely across the U.S. NCLB brought greater accountability for student learning to states, districts, and individual schools by requiring not only state standards for core academic areas but periodic assessment of these standards. As of 2007, science joins reading and mathematics as content areas which must be assessed under NCLB. While these efforts have improved the quality of STEM education in many ways, they do not prescribe a national curriculum or resources needed to teach them. Too few classrooms have adequately prepared teachers with sufficient resources, and too many students are not adequately prepared to take or do not choose to take advanced courses. As a result, most American students are not achieving at proficient levels.

Several efforts including *The American Diploma Project Ready or Not: Creating a High School Diploma That Counts* (Achieve, 2004) are underway to improve the quality of education by better defining what students need to know to advance to higher level, more rigorous courses. The NAEP science framework is also being rewritten. *Science Framework for the 2009 National Assessment of Educational Progress* [*Framework*] (National Assessment Governing Board, in press) incorporates not only key facts, concepts, principles, laws, and theories of science, it incorporates the application of science to solve real-world problems. This new *Framework* will guide the development of the new national science assessment and more closely aligns with the frameworks for international assessments, TIMSS and PISA. This new NAEP assessment will have performance and computer interactive tasks that apply science knowledge.

The new *Framework* seems somewhat in line with the new Commission on the Skills of the American Workforce's (National Center on Education and the Economy, 2007) fourth step in a proposed ten-step plan of action (called "the new SCANS report). "Step 4: Develop new standards, assessments, and curriculum that reflect today's needs and tomorrow's requirements" (p.14). The Commission calls for high standards and quality assessments that are more closely tied to the needs of the workplace in this 21st century global economy. These new standards and assessments are to capture "creativity and innovation, facility with the use of ideas and abstractions, the self-discipline and organization needed to manage one's work and drive it through to a successful conclusion, the ability to function as a member of a team" (p.14). All of these efforts—the High School Diploma that Counts, the NAEP Science Framework, and the new "SCANS report"—define capacity as more than the ability to restate facts, it involves higher level of thinking such as application, analysis, synthesis, and evaluative identified in Bloom's Taxonomy.

Content and Skills Needed for Entry into Advanced STEM High School Courses

Advanced mathematics courses include trigonometry, pre-calculus, calculus, statistics, computer science, and any IB or AP mathematics course. Math courses are relatively sequential with the foundation courses being Algebra I, geometry, and Algebra II. In order for most students to take advanced math courses in high school, they need to take Algebra I in middle school.

Advanced science courses include physics, second-year science courses, and any IB or AP science course. Science courses are less sequential, but usually the foundational courses are biology and chemistry. Physics in most schools is a junior- or senior-year course, but in some high schools physics is taught in the freshman year. Both chemistry and physics are quantitative sciences and apply mathematical concepts. Algebraic thinking is needed for both and physics applies concepts from trigonometry and calculus as well. In order to help students take advanced science courses, some school systems offer biology (for high school credit) in middle school. Biology, chemistry, physics, and Earth science are considered “laboratory science” courses in most states and count for graduation credits. A few schools offer one or two years of “Integrated Science,” which combines physical, life, and Earth sciences.

Preparation for advanced STEM courses begins well before high school and includes capacity building in mathematics literacy and science literacy as well as language arts literacy—reading, writing, and oral communication. Students need a solid foundation in hands-on, inquiry learning at the elementary school level and at the middle school level. These mastery experiences, as suggested by Bandura, are most critical sources of self-efficacy. The College Board encourages school districts to provide a solid foundation for students and has developed a series of pre-AP professional-development courses to better equip middle school and high school teachers to prepare students for AP coursework. The College Board warns against restricting access to AP courses by labeling some courses as “Pre-AP.” The Board operates on the premise that all students can perform at rigorous academic levels and encourages schools to provide opportunities for all students. However, from upper elementary or sixth grade, students do need to be aware of the fact that most AP mathematics and science courses have recommended pre-requisites which require students to begin the study of algebra in middle school.

In order to prepare all students to take rigorous college level courses, The College Board created a preparatory program called the SpringBoard. This innovative program is designed for students in sixth-grade through twelfth-grade and provides teacher professional development, online student assessments, and materials for participating schools. SpringBoard may be adaptable for OST settings.

The International Baccalaureate Organization (IBO) has developed three programs—primary years (IBO, 2002c) and middle years (IBO, 2002b) and diploma (IBO, 2002a). Although students are not required to have had the foundational programs in order to participate in the high school diploma program, they do need a solid academic foundation. IB high schools identify IB diploma candidates from rising ninth graders and prepare these students though honors courses and sometimes AP courses in ninth and tenth grades.

AP Course Descriptions and Prerequisites

Although the College Board advocates not labeling courses as "Pre-AP," the Board produces course descriptions that outline in detail the philosophy and goals of, prerequisites for, and topics covered in each of their AP mathematics and science courses. Junior and senior high school students with solid academic foundations are the most likely candidates for AP STEM courses. All AP courses are designed to be equivalent to introductory college-level courses.

AP Biology- is designed to be taken by students after the successful completion of a first course in high school biology and one in high school chemistry as well" (The College Board, 2006a, p.3).

AP Calculus-there are two AP Calculus courses, AP Calculus AB and AP Calculus BC; both courses have the same prerequisites. "Before studying calculus, all students should complete four years of secondary mathematics designed for college-bound students: course in which they study algebra, geometry, trigonometry, analytic geometry, and elementary functions" (The College Board, 2005, p.6).

AP Chemistry-"The AP Chemistry course is designed to be taken only after the successful completion of a first course in high school chemistry" (The College Board, 2005c, p.3). It is also recommended that students successfully complete Algebra II prior to taking AP Chemistry.

AP Computer Sciences-There are two AP Computer Sciences courses, AP Computer Science A and Computer Science AB. Computer Science A is a subset of Computer Science AB, therefore the prerequisites are the same and includes "knowledge of basic algebra and experience in problem solving" (The College Board, 2006c, p.6). Students are expected to understand functions and have a solid foundation in mathematical reasoning.

AP Environmental Science.-"The AP Environmental Science course is an excellent option for any interested student who has completed two years of high school laboratory science—one year of life science and one year of physical science (for example, a year of biology and a year of chemistry)" (The College Board, 2005a, p.4). It is also recommended that students complete one year of algebra prior to taking AP Environmental Science.

AP Physics-There are two AP Physics Courses, Physics B and Physics C. Physics B is more appropriate for students planning to study life sciences, health sciences, Earth sciences, or non-science fields; while Physics C provides students with a solid foundation for studying physical sciences and engineering. It is recommended that both courses be taught as second-year physics courses. In addition, Physics B students need a solid algebra and trigonometry foundation with some basic calculus, and Physics C students should have a foundation in calculus (The College Board, 2005b).

AP Statistics-AP Statistics students should have successfully completed a second-year course in algebra and possess sufficient "mathematical maturity and qualitative reasoning ability" (The College Board, 2006d, p.4).

IB Diploma Programme and IB Learner Profile

International Baccalaureate (IB) Diploma Programme is a two-year rigorous course of study in which students "are required to select one subject of each of the six subject groups which correspond to the principal domains of knowledge. At least three and not more than four [subjects] are taken at higher level (HL), the others at standard level (SL)" (International Baccalaureate Office (IBO), 2002a, p.9). The six subject groups of knowledge are language (group 1), second language (group 2), individual and societies (group 3), experimental sciences (group 4), mathematics and computer science (group 5), and the arts (group 6). Higher level requires 240 hours of class time and standard level requires 150 hours. In addition to these courses, all students are required to participate in Theory of Knowledge (TOK) which includes taking a 100-hour, TOK class over a two-year period, submitting a 1,200-to-1,600 word essay, making a 10 minute presentation, and writing a self-evaluation as prescribed by IBO; to complete an extended essay (4,000 words) on one of 22 subjects; and to complete a Creativity, Action, Service (CAS) component. IB Diploma candidates must also successfully complete end-of-course assessments at higher level (3 to 4) and standard level (2 or 3). Students must choose one subject, at either higher or standard level, from each of the subject groups. There are multiple ways that student work is assessed, including performance assessments and end-of-course examinations. Not all IB students are diploma candidates. Although all students are encouraged to complete a full diploma program, some students take only one or two IB courses.

The closest descriptor of "capacity" for advanced course work that the researchers could find is the *IB learner profile booklet* (IBO, 2006). Rather than providing a detailed list of prerequisite courses or what students need to know and be able to do at various developmental junctures, the *IB learner profile* defines the characteristics of a life-long learner. The profile is meant for students at every level from elementary school to high school. The profile is reproduced here.

> The aim of all IB programmes is to develop internationally minded people who, recognizing their common humanity and shared guardianship of the planet, help to create a better and more peaceful world.
>
> IB learners strive to be:
>
> **Inquirers** They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning, and this love of learning will be sustained throughout their lives.
>
> **Knowledgeable** They explore concepts, ideas, and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.

Thinkers They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems and make reasoned, ethical decisions.

Communicators They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.

Principled They act with integrity and honesty with a strong sense of fairness, justice, and respect for the dignity of the individual, groups, and communities. They take responsibility for their own actions and the consequences that accompany them.

Open-minded They understand and appreciate their own cultures and personal histories and are open to the perspectives, values, and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view and are willing to grow from the experience.

Caring They show empathy, compassion, and respect toward the needs and feelings of others. They have a personal commitment to service and act to make a positive difference to the lives of others and to the environment.

Risk-takers They approach unfamiliar situations and uncertainty with courage and forethought and have the independence of sprit to explore new roles, ideas, and strategies. They are brave and articulate in defending their beliefs.

Balanced	They understand the importance of intellectual, physical, and emotional balance to achieve personal well-being for themselves and others.
Reflective	They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development. (p.9)

There is evidence that after-school programs increase students' mathematics and reading achievement (Cooper, Charlton, Valentine, & Muhlenbruck, 2000; Durlak & Weissberg, 2007; Huang, Gribbons, Kim, Lee, & Baker, 2000; Lauer et al., 2004; Naftzer et al., 2006; Smith, 1999). Based on 2004-2005 survey data of 21st CCLC centers, Naftzger et al. (2006, p.48) report that 33% of regular attendees increased their math proficiency and 33% increased their literacy proficiency. Fifty-four percent of the regular attendees scored *proficient* or *advanced* on math assessments.

Most of these studies have been conducted on after-school programs that target elementary school and middle school children. Hard evidence of informal Out-of-School Time (OST) programs having a lasting effect on secondary students' course-taking patterns and persistence in STEM has been more difficult to document. Most evidence is antidotal and based on attitudinal surveys. SECME's survey evaluations show that on average, 94 percent of their graduates planned or did enroll in a four-year college, and 62 percent of SECME graduates (2002-2004) majored in science, engineering, or mathematics. Longitudinal studies of informal education's impact on advanced course taking and persistence in STEM need to be conducted.

Afterschool Staff Profile for Developing STEM Students

The 21st CCLC 2004-2005 program evaluation (Naftzer et al., 2006) found that the overwhelming majority of after-school instructors are day school teachers. High school students, paid employees, and volunteers make up the next largest percent of staff. Therefore, most 21st CCLC after-school staff have a four-year or higher degree. Although the percentage of after-school staff who have degrees in or advanced coursework in STEM have not been collected, there are some data on academic content degrees held by school teachers. According to the NCES FAST Survey of 2000, 22 percent of elementary school teachers have degrees in academic content areas including STEM (NCES, 2001). Forty-four percent of middle school teachers and 66 percent of high school teachers reported having graduate or undergraduate major in an academic field. Most after-school programs serve elementary students and are primarily staffed by elementary school teachers.

Instructors at some of the promising NPQAL sites—Houston, Boston, New Orleans—have degrees in science, engineering, mathematics, or science or mathematics education. Instructors at other sites such as Atlanta have the qualities of being risk-takers and life-long learners and have utilized scientists as mentors to guide their efforts in teaching children science in after school. The quality of the program is directly affected by the quality of the teaching staff, but there are ample examples of sites across the country where students are benefiting from instructors who are willing to learn along with the children.

There are many ways that after-school programs can assist their staff by identifying and/or providing professional learning opportunities. "In many national organizations (e.g., Girls Inc. and 4-H), staff development is coordinated by a central office and integrated into the national infrastructure" (Harvard Family Research Project, 2004, p.2). Other groups such as The After-school Corporation (TASC; 2006) work with local organizations to provide professional-development opportunities from which site coordinators choose those best suited for their staff. Achieve Boston was founded in 2001 "to begin the process of creating a professional-development infrastructure for after-school and youth programs across the city" (Achieve Boston, n.d.). Many opportunities in the Achieve Boston database target science-, engineering-, technology-, and mathematics-related training events and programs.

In the last five years, professional-development opportunities for OST staff have emerged from local and national organizations. A number of organizations provide high-quality STEM professional development for after-school staff including the NPQAL team, Educational Development Center, Lawrence Hall of Science, the Exploratorium, NASA, The New York Hall of Science, Boston Children's Museum, Boston Museum of Science, and a myriad of local organizations, museums, and zoos. Producers of STEM after-school curricula also market professional development that accompanies their products.

In an effort to improve the quality of professional development for after-school staff, a group of after-school program coordinators in New Hampshire formed a learning community for professional development (Barnacle, 2007), and initial reports of their first year's efforts suggest that the overall quality of their professional-development programs have improved. These coordinators surveyed their staff, reviewed student-achievement data, coordinated with local schools, and planned their center's professional development based on personnel and programming needs. The group, lead by Barnacle, met three times in the past year and plan to meet again in a continuous staff development model.

Current Staffing Gaps

Currently most of the instructors in afterschool are day-school teachers, but few of these teachers have adequate preparation in STEM education. In order to support STEM capacity building, additional efforts must be made to identify mentors (for students and teachers) in the scientific, engineering, and mathematics communities and to develop prototype professional development models. Organized efforts to identify, solicit, train, and utilize STEM mentors have been limited, although there seems to be some programs in larger urban cities such as New York, San Francisco, and Boston.

One group of untapped STEM mentors may be the high school students in IB programs. In order to complete the required community service hours for an IB Diploma, a group of

Pensacola, Florida, high school students work as mentors for inner-city school children. In addition, they plan and implement Saturday Science activities for these children (McMichael, private communication, 2007). Not only do the Saturday Science days engage the younger students and develop their content and process skills, the IB students serve as role models for these children and help them plan for their futures. Other students at this IB high school serve as peer tutors for IB student who are struggling academically. In order for this type of effort to affect large numbers of students, a more organized national initiative might be considered.

Afterschool Professional Development Standards

There are no after-school professional-development standards that have been clearly articulated. After-school training is not only for professional educators but for youth workers, non-professional staff, and volunteers as well. However, the standards established by the National Staff Development Council (2001) for educators could easily be adapted to professional development of OST personnel. These standards are reproduced here:

Context Standards

Learning Communities: Staff development that improves the learning of all students organizes adults into learning communities whose goals are aligned with those of the school and district.

Leadership: Staff development that improves the learning of all students requires skillful school-and-district leaders who guide continuous instructional improvement.

Resources: Staff development that improves the learning of all students requires resources to support adult learning and collaboration.

Process Standards

Data-driven: Staff development that improves the learning of all students uses disaggregated student data to determine adult-learning priorities, monitor progress, and help sustain continuous improvement.

Evaluation: Staff development that improves the learning of all students uses multiple sources of information to guide improvement and demonstrate its impact.

Research-based: Staff development that improves the learning of all students prepares educators to apply research to decision-making.

Design: Staff development that improves the learning of all students uses learning strategies appropriate to the intended goal.

Learning: Staff development that improves the learning of all students applies knowledge about human learning and change.

Collaboration: Staff development that improves the learning of all students provides educators with the knowledge and skills to collaborate.

Content:

Equity: Staff development that improves the learning of all students prepares educators to understand and appreciate all students; create safe, orderly, and supportive learning environments; and hold high expectations for their academic achievement.

Quality Teaching: Staff development that improves the learning of all students deepens educators' content knowledge, provides them with research-based instructional strategies to assist students in meeting rigorous academic standards, and prepares them to use various types of classroom assessments appropriately.

Family Involvement: Staff development that improves the learning of all students provides educators with knowledge and skills to involve families and other stakeholders appropriately.

Not only should standards be established for after-school, criteria for evaluating the effectiveness of the professional development should also be developed. Harvard Family Research Project expresses the need, "Given the importance of staff development for both higher quality programs and better youth outcomes, it is critical that we design evaluations that will help programs understand the benefits of their professional development efforts" (2004, p.1).

In a TASC Resource Brief, *Training and Supervising After-School Staff* (2000), four techniques are outlined that show promise to help staff learn new skills. "First, some site coordinators meet regularly with project staff to solve problems and give advice. Second, some coordinators schedule time for staff to develop plans together. Third, some projects provide staff with high-quality materials to enrich instruction. Fourth, some site coordinators base staff development on research and best practices to emphasize proven methods" (p.1). Though these practices are for general staff development, they could apply to specific STEM initiatives.

In conclusion, building capacity in after-school staff that will enable them to enhance students' opportunities to build their own STEM capacity and self-efficacy will be challenging, but not impossible. Perhaps partnerships with key STEM, IB, and AP organizations as well as pilot programs modeled after other successful programs such as SECME, MESA, and AVID should be considered. In addition, longitudinal evaluations of these new initiatives will contribute to the evidence that OST programs make a difference in children's opportunities for and persistence in STEM career paths.

IV. Enhancing Students' Continuity in Science-, Mathematics-, Engineering-, and Technology-Related Careers Paths

Introduction: Factors Affecting Continuity in Science-, Mathematic-s, Engineering-, and Technology-Related Careers Paths

Jolly et al. (2004, p.7) define continuity as "institutional and programmatic opportunities, material resources and guidance that support advancement to increasingly rigorous content in the sciences and quantitative disciplines." In essence, it is a pathway that defines the skills, knowledge, and supports that students need to move to advanced levels of a given program. When thinking of continuity as related to student participation in advanced STEM courses access is a key factor that involves quality teachers, course availability, opportunities and support for test-taking for college acceptance, responsible others who can help navigate career pathways, and safety net programs that may include out-of-school formal and informal learning opportunities.

The previous sections on engagement and capacity building clearly point to the interconnectedness of the trilogy espoused by Jolly et al. (2004). A multitude of factors impact students' continuity in STEM-related courses. One way to facilitate the examination of these factors is by grouping them into sociocultural and institutional groupings. They are closely related and influenced by one another, but they are presented in different groups to facilitate discussion. Only some of the most relevant factors are discussed here (due to time limitation). The last section provides a discussion of current research in OST programs. It seems that the factors obstructing students' continuity in STEM-related careers are countered or at least ameliorated by involving students in effective out-of-school time programs. The characteristics of these will be elaborated below.

Sociocultural Factors

Ethnicity, Gender, and Lower Expectations.

Though there has been some improvement in recent years, current reviews of the literature clearly show that girls, as well as students from diverse ethnic backgrounds, and students from low-income homes, continue to perform significantly lower in national standardized tests, such as the National Assessment of Educational Progress (NAEP) and the National Education Longitudinal Study (Clewell & Campbell, 2002; Lee & Luykx, 2006; Rodriguez, 2004). In *Turning Despondency into Hope: Charting New Paths to Improve Students' Achievement and Participation in Science Education*, Rodriguez (2004) describes in detail how these trends in student achievement are persistent and consistent across various kinds of standardized tests and grade levels. So what would be more useful here is to briefly examine how a student's gender, socioeconomic status (SES), and/or ethnicity works against that student's opportunities to learn because of the way their teachers, their peers, their parents, and/or other adults act toward them.

For example, it has been well documented that parents often have lower expectations of their daughters' abilities in mathematics and science than they do of their sons (Clewell & Campbell, 2002). Adding to this is the fact that some teachers (many who are, of course, parents themselves) have lower expectations for female students, students from diverse backgrounds, poor students, and migrant/transient students. These lower expectations have been shown to have multiplicative and detrimental effects in a child's opportunities to learn (Oakes, Ormseth, & Campbell, 1990; Peng & Hill, 1995). Furthermore, all students are constantly bombarded with negative images of science and scientists in movies, TV and other media. Scientists are often portrayed as geeks with messy hair and odd personalities. The impact of these negative stereotypes has been clearly demonstrated in national and international studies using the Draw-a-

Scientist Test (Chambers, 1983). These drawings often showed that both girls and boys tend to draw mainly male and disturbed scientists conducting experiments in negative contexts with animals, explosives, and so on.

Now, these negative trends can be countered and some studies are beginning to provide much needed hope. Rodriguez and Zozakiewicz (2005) conducted a two-year longitudinal study with a group of 40 girls (most of whom were Latinas) from grade four through grade five. One of the main goals of this professional-development research project was to provide elementary teachers with support to make their science and mathematics classrooms more culturally and gender inclusive. The teachers participated in summer workshops and ongoing professional-development activities during the academic year. The impact of the study was measured by using a revised version of the Draw-a-Scientist Test mentioned above and by conducting focus-group interviews and in-class observations. Rodriguez and Zozakiewicz found that by the end of grade five, the girls' participation and attitudes toward mathematics and science remained high, and their drawings of scientists showed more gender representative and positive images. That is, many of the girls drew themselves (including representations of their cultural backgrounds) or other females as scientists conducting experiments or doing science in more positive contexts (e.g., helping others, working outside, etc.). These findings are also significant because we know that girls' interest and achievement in science and mathematics begins to decline as they progress through upper elementary and middle school (Clewell & Campbell, 2002; Rodriguez, 2004). Thus, professional-development interventions like the one described here with teachers and their students in upper elementary grades could be one of several approaches school districts could use to counter the current trends in student achievement and participation.

Another strong indicator that these negative trends in student achievement and participation can be countered is shown in a study of the characteristics, attitudes, and pedagogical strategies used by successful teachers of Advanced Placement Calculus AB and

English Literature and Composition courses in diverse classrooms (Burton et al., 2002). These researchers explain that successful teachers of culturally diverse students have high expectations and high opinions of all of their students. They also spend more time ensuring that students understand and know how to apply fundamental concepts.

High teacher expectations of all students—as opposed to the stereotypical notions that students from diverse cultural backgrounds cannot perform well in science and mathematics—was also found to be a key factor impacting student achievement according to the report, "Similar Students, Different Results: Why Do Some Schools Do Better" (Williams, Kirst, Haertel, et al., 2005). This was a large-scale survey study of 257 elementary schools with a high population of culturally diverse students in California. The researchers found that even though these schools had most students identified as at risk and limited resources, the students scored "as much as 250 points higher in the state's academic performance index"[1] (p. 2). Furthermore, they found that one of the key aspects influencing students' achievement in the high-performing schools was high teacher expectation of all students. These teachers and their principals also had well-defined curricula and instructional plans closely tied to grade-appropriate student assessments and follow-up. In short, the culture of the school was that of high expectation for everyone regardless of the cultural background of the students.

The schools participating in the study also served mostly low-income students. This factor and how it influences students' access to equal opportunities to learn is discussed next.

Socioeconomic Status.

While a school culture of high expectations plays a significant role in helping ethnically diverse and economically disadvantaged students perform better on standardized tests, there is a

[1] The academic performance index is based on students' scores on the California Standards Tests. These tests are standards based and measure students' subject knowledge at various grade levels.

substantial body of evidence indicating that a student's low socioeconomic status (SES) is like an anchor that prevents that student's advancement (Clewell & Campbell, 2002; Lee & Luykx, 2006; Rodriguez, 2004). Horn (1998) used data from the National Education Longitudinal Study mentioned above to demonstrate that students in the lowest SES quartile were at the highest risk of dropping out or failing school. He also found that students most likely at risk were those from Latino/a and African American cultural backgrounds.

More recently, the 2007 Quality Counts report, "From Cradle to Career: Connecting American Education From Birth Through Adulthood," provides a comprehensive state-by-state picture of how a child's SES (in combination with other key factors like the institutional and social factors being discussed here) affect that child's opportunities to experience success at school. In other words, states receive a score based on 13 success indicators (e.g., SES, parents' education, graduation from high school, etc). The state with the highest score was Virginia; whereas, the one with the lowest score was New Mexico. This means that a child born in New Mexico is most likely to experience many more obstacles from cradle to career than a child born in Virginia.

These findings illustrate how dominant SES is a factor for predicting academic success among culturally diverse students across grade levels, and how complicated it is going to be for schools to help tackle this issue when there are 37 million people living in poverty in the U.S. (12.6% of the total population). According to the U.S. Census Bureau (2005), poverty is defined as a family of four with an average income of $19,971; or a family of three with an income of $15,577; or a family of two with $12,755; and for unrelated individuals with an income of $9,973.

Just like academic success is divided across ethnic lines as shown above, so it is with the rate of poverty. The U.S. Census (2005) also reported that 24.9 of all African Americans and 21.8% of all Latinos/as in the U.S. live in poverty; while the poverty rate decreased by 8.7 for

Anglos and increased by 11.1% for Asians. The most astonishing figure continues to be the poverty rate for children under 18 years old—17.6%

It is no wonder then that so many children regardless of their great potential become victims of a pervasive cycle poverty that works against their opportunities to learn, to experience success in life, and to become active and productive members of society.

Parents and Siblings' Education.

Another factor closely tied to socioeconomic status is a student's parents' and/or siblings' education. The powerful influence of this sociocultural factor can be appreciated, for example, by looking at how first generation students in postsecondary school perform. Chen (2005) used data from the Postsecondary Education Transcript Study of the National Education Longitudinal Study (NELS) in order to investigate first generation students' course-taking patterns and academic performance. Chen then contrasted the results with those of students who had at least one parent with a college degree. Almost a third (28%) of all the NELS 1992 twelfth grade students were first generation students; however, these students were less likely to attend a 4-year institution within 8 years of graduating from high school. In addition, between 1992 and 2000, about 4 out of each 10 (43%) first-generation students who entered college dropped out before completing a degree. Chen states that "the opposite pattern was observed for students whose parents were college graduates: a large majority (68 percent) had completed a bachelor's degree" (p. iv). The first-generation students who stayed in college also encountered other disadvantages such as taking longer to graduate, having to take more remedial classes, having a harder time deciding what career to follow, and having lower grade point averages (Chen, 2005).

Horn (1998) also analyzed other aspects of the National Education Longitudinal Study mentioned earlier and found that 58% of the students identified as at risk of dropping out had parents with lower than a high school education. One positive finding, however, is that Horn discovered that parents who frequently discussed school-related issues with their children increased twofold their children's odds of going into college.

To better understand these findings, we need to move the discussion now from sociocultural factors to institutional ones.

Institutional Factors

Family and School Support.

Just like there is a considerable body of research that provides consistent evidence for the impact of the sociocultural factors on students' opportunities to learn, there is also significant evidence that family support strongly influences students' achievement in and attitude toward to school (Lee & Bowen, 2006; Lee & Luykx, 2006; Williams et al., 2005). When family support is considered in connection with school support, this combination becomes a powerful institutional factor that needs to be discussed in more detail.

We argue that Family/School support is an institutional factor because these two aspects of a child's education are closely associated, and they influence one another in ways that can either have a positive or negative impact. This interplay is best represented in the findings from Peng and Hill's (1994) study. These researchers used data from the National Education Longitudinal Study (NELS, 88) and found that high-achieving students were more likely to come from families who had higher educational expectations of them. This was the case regardless of the families' ethnic backgrounds. Smith and Hausafus (1998; cited in Lee & Luykx, 2006) support these findings. They conducted a study with 80 grade eighth grade students and their mothers in order to investigate the aspects of family support that most influence the students' achievement in science and mathematics. Smith and Hausafus concluded that regardless of the families' cultural backgrounds, students tended to have higher scores when their parents imposed limits on TV watching, visited science/mathematics related fairs or exhibits, and discussed with their children the importance of taking advanced mathematics and science courses. Furthermore, these researchers state that contrary to popular belief, parents do not need to be knowledgeable in science or mathematics, they just need to "be supportive by communicating and enforcing high expectations for achievement with their children" (Lee & Luykx, 2006, 139).

In a more recent study with 415 students from grades three through five, Lee and Bowen (2006) corroborated those conclusions. In addition, they stress that teachers' stereotypes or low students' expectations play a larger role on students' achievement and participation than the students' ethnic background and/or family involvement. Lee and Bowen also found that parents tended to be more involved in school activities that mirrored their own culture and lifestyle.

Therefore, it makes good sense for teachers and school administrators to seek ways to promote parent involvement in their children's education and to actively explore diverse ways to make school-related activities more culturally inclusive for parents.

Finally, Lee and Bowen (2006) urge us to move away from stereotypes and simplistic notions of parent involvement and to pay closer attention instead to the important role schools must play as educational institutions, "[The] deficit perspective not only devalues the educational involvement exhibited by parents from nondominant groups but also takes attention away from the professional responsibility of schools to establish effective parent involvement for those families" (215).

The results of these studies clearly point to the need to help parents better communicate with their children and their children's teachers about maintaining high expectations and high aspirations. This is the juncture at which school counselors and building principals could play a significant role in leveling the playing field for those students whose low SES, parents and siblings' low educational achievement, and/or teachers' low expectations conspire against the students' chances to experience academic success.

Course Taking Options and Impact on Pursuing STEM-Related Fields

Excellence in education cannot be achieved without all students having equal opportunities for access and success in advanced courses. A review of the literature on students' course-taking options and the impact these options have on their chances to pursue STEM-related fields revealed the following common findings:

- Students who enroll in rigorous advanced courses (including math, science, and foreign languages) score higher on standardized tests, have higher GPA's, and increase their chances to attend college (Chen, 2005; Goldrick-Rab & Mazzeo, 2005; Russell & Atwater, 2005). This can, of course, only happen if students have access to advanced courses in the first place. For example, Russell and Atwater (2005) conducted a study with 11 African American college seniors enrolled in a biology program. The students explained that their academic persistence at their predominantly Anglo-European college was partially attributed to their participation in advanced courses in high school.
- Early and effective counseling on college-admission policies and tuition costs enhances the odds that students will attend college (Goldrick-Rab & Mazzeo, 2005; Rodriguez, 2004) In an earlier and more extensive study than Russell and Atwater's mentioned above, Horn and Chen (1998) used data from the National Education Longitudinal Study (NELS: 88/94) to investigate the impact of college-preparation activities on students' chances to attend college. These researchers used a sample of up to 2,900 students from NELS who had two or more "at risk" factors. In other words, students were considered at risk if they were in the lowest SES quartile; were in a single-parent family; had an older sibling who dropped out of school; changed schools two or more times from first to eighth grade; had an average grade of C or lower from sixth grade to eighth grade; and

had repeated an earlier grade from first to eighth. Horn and Chen found that students who participated in college outreach activities, who received help with college application, who received help with exam preparation, and/or talked with advisors almost doubled their chances to attend a four-year postsecondary institution in spite of the risk factors stacked against them.

- Students who are continuously enrolled in advanced courses without dropping out have a greater chance to enter college (Goldrick-Rab & Mazzeo, 2005; Russell & Atwater, 2005; Trusty, 2002). In the same NELS project described earlier, Horn & Chen (1998) also discovered that at-risk students who demonstrated moderate-to-high class attendance in high school were more likely to enroll and persist in post-secondary institutions than those students who had poor high school attendance. Similar conclusions were drawn more recently by Bridgeland, Dilulio, and Morison (2007) in their report, "The Silent Epidemic: Perspectives of High School Dropouts." These researchers provide a refreshing contribution to the literature, because they actually conducted face-to-face interviews with 467 ethnically diverse young adults (16 through 25 years old) who dropped out of school. This group of students—although it is not a statistically representative sample of students from across the U.S.—is, nevertheless, drawn from a variety of large and small urban cities as well as smaller rural areas. Bridgeland et al. (2007) found that class attendance is a strong predictor of dropping out. In other words, when a student started to show a tendency to miss classes in any one year from grade nine through twelfth, it was then likely that the same student could drop out of school the following year. About 47% of the students interviewed stated that main reason why they dropped out was because "classes were boring." It is obvious from these findings that they are many identifiable "warning signs" that could be managed to help prevent a child from dropping out of school.

Homework.

Assigning students meaningful and reasonable homework[2] could also play an important role on their academic achievement. Cooper, Robinson, and Patall (2006) conducted an extensive review of studies published from 1987 through 2003 that focused on the effects of homework on student achievement. Even though there were a great variety of methodologies used in these studies, the researchers found that homework had an overall positive impact on students' academic achievement. They also found this to be most strongly represented in studies conducted with students from grades seventh through twelfth, and this may have to do with the fact that most of the studies reviewed focused on middle and high school grades.

In contrast, 26% of the students who dropped out of school, and who participated in the interviews conducted by Bridgeland et al. (2007) stated that they did not do homework at all. In addition, Bridgeland at al. found that 80% of the students interviewed did one hour or less of homework each day. The researchers explained that the students' low intrinsic motivation could have determined this finding, and just as equally possible, it could have also been the school's or teachers' low expectations of the students. Interestingly, the same group of students participating in this project seemed to have higher expectations for themselves but felt that they need to be "pushed." In other words, Bridgeland at al. explained, "Seventy percent of our respondents surveyed were confident that they would have been able to graduate if they had put forth more effort" (p. 5). According to these researchers, the majority (66%) of the students made it clear that "they would have worked harder if more had been demanded of them" (p. 5).

Based on these findings, one cannot help wonder about how much more beneficial it would be for all students to not only be assigned homework on a regular basis but to be assigned intellectually meaningful homework. What if homework instead of being more drill and practice

[2] Homework is defined here as academic work to be completed out of school.

of decontextualized knowledge became more connected to their everyday lives and involved more application of knowledge? Unfortunately, we cannot answer this question at this time because we are not aware that such a study has been conducted. Nevertheless, we do know that more intellectually challenging work has a positive impact on students' achievement and participation across grade levels. For example, a major study conducted by Newmann, Bryk, and Nagaoka (2001) with 5,000 students from 19 Chicago elementary schools showed significant students' academic growth on the *Iowa Test for Basic Skills* in reading and mathematics. More specifically, students exposed to high-quality classroom assignments[3] scored 20% greater than the national average; whereas, the students exposed to traditional classroom assignments obtained scores that were 25% less than the national average in reading and 22% less than the national average in mathematics.

Considering what we already know about best teaching practices, as well as about how students learn best, and considering what we know about how sociocultural and institutional factors impact students' academic achievement and participation in the last twenty years, we should have made a lot more progress when it comes to providing our children with better opportunities to learn. This issue requires that policymakers, community leaders, teachers, and researchers come together not to continue to discuss "the problem" or to continue to pass blame but to seriously use extensive available evidence to effect positive change in our schools. This event is going to take a great deal of political will and resources. However, considering the present alternative (i.e., high drop-out rates and low participation in STEM-related field by all students), the cost of maintaining the present course is nothing short of disastrous economically and socially for the future of the country.

[3] Newman et al. defined "intellectually challenging" classroom assignments as activities that required students to problem-solve, use prior knowledge, use complex oral and written communication skills, apply content knowledge, and those that were tied to the students' lives.

On a positive note, Out-of-School Time (OST) Programs across the U.S. are beginning to show signs that these programs may have a much greater impact on students' academic achievement and pursuit of STEM courses than expected. In other words, OST may just turn out to be "the equalizing factor" that helps counter the sociocultural and institutional factors discussed above by providing students with enriched opportunities to learn that complement and expand what students are receiving (or not) during normal school hours.

Out-of-School-Time Programs: Engineering Ways to Equalize and Provide Enriched Opportunities to Learn for All Students

Out-of-School-Time programs may be the great equalizer for at least providing students some enriched opportunities to learn. These programs provide what poorly funded and staffed schools don't or what parents are not able to provide due to financial hardship or low educational background. There are varied types of out-of-school programs that affect student's achievement, participation, and socioemotional development. In the paragraphs below, we examine literature on effective OST programs and conclude with common characteristics of these programs.

Types of OST Programs

Essentially, there are two kinds of OST programs, after school and summer. Summer school programs have been in use across the U.S. for decades, but it was not until the enactment of Title 1 from the Elementary and Secondary Education Act of 1965 that summer programs were formally set up to provide additional education for low-income students (Lauer, Akiba, Wilkerson, Apthorp, Snow, & Martin-Glenn, 2006). While the main purpose of most summer school programs continues to be remediation, many programs now offer a variety of enrichment activities for all students. However, the most widely attended and influential of the two types of OST programs are those offered after school.

According to Halpern (2002), after-school programs originated in the early 1990s in order to provide safe and structured activities for children who lived in dangerous neighborhoods and/or whose parents' work hours went beyond those of the school. However, more recently, the goals of after-school programs have widened considerably to provide much more than a safe heaven for children's play and entertainment. In the following section, the impact of after-school programs on students' achievement and participation is discussed.

Impact of OST Programs on Students' Achievement, Participation, and Socioemotional Development

The increasing variety of out-of-school time programs has also instigated the need to evaluate their effectiveness. In essence, there has been a great deal of interest in finding out what effect, if any, OST programs (either summer and/or after school) have had on students' participation and achievement. However, several researchers have argued that OST program-evaluation studies have not been "methodologically rigorous," thus making it difficult to ascertain their actual impact (Lauer et al., 2006; Scott-Little, Hamann, and Jurs, 2002). For example, Scott-Little and her colleagues (2002) conducted an in-depth meta-analysis of 23 evaluation studies of after-school programs. Out of these, only six studies were found to show statistically significant impact on student achievement (four studies) and on psychological variables (two studies). Scott-Little et al. concluded that, in spite of the lack of rigor and lack of adherence to the Program Evaluation Standards,[4] "Results from the synthesis on after-school

[4] These standards were developed by the Joint Committee on Standards for Educational Evaluation and represent a commonly used benchmark for quantitative evaluation studies.

evaluations yielded encouraging, but certainly not conclusive, evidence for the effectiveness of after-school programs" (p. 410).

In a more recent report, Lauer and her colleagues (2006) provide a more positive picture of OST programs. They conducted a meta-analysis of 35 OST studies that included a quasi-experimental design (i.e., the participation of control and comparison groups in order to perform quantitative analyses). The selected OST programs for the meta-analyses focused on improving reading and mathematics achievement for students identified as at-risk. In addition, Lauer and her colleagues included studies that represented all K-12 grades, with the vast majority of the studies being conducted at the elementary level. Fourteen of the studies selected were classified as summer programs and 15 were classified as after-school programs. Only one study had an OST program that involved both summer and Saturday school.

Since the Lauer et al's (2006) study was the most comprehensive and rigorous study identified in this review, these authors' key findings are contrasted below with those of other researchers who have made similar claims. This should be read with caution, however, because there is a need to conduct more well-designed qualitative and quantitative studies to better understand the specific impact of OST on culturally diverse students' achievement and participation in science, technology, engineering, and mathematics (STEM)-related careers. Most of the studies reviewed did not focus on STEM paths.

In general, these are common claims made about the impact of OST programs on student achievement, participation, and socioemotional development:

- <u>Student Achievement and Participation</u>: Overall, OST programs do have an effect on at-risk students' achievement in any of the curriculum areas tested (e.g., science, reading, mathematics, writing, and citizenship). For instance, Lauer et al. (2006) found statistically significant gains in student achievement in reading and mathematics after conducting a meta-analysis of 35 OST programs. These findings support similar results reported earlier by Cooper et al. (2000), who conducted a similar meta-analysis of summer programs. Another key study—and the only one we found that followed a longitudinal approach—was that conducted by LA's BEST. This program was a comprehensive and community-based initiative in the Los Angeles area that involved the participation of 69 sites and over 4,000 students—most of whom were Latino/a and from economically disadvantaged neighborhoods. The program started in 1993-1994 with students from grades 2 through 5. The same group of students was then followed through 1997-1998. Although several of the after-school programs included in LA's BEST offered science curriculum, again, quantitative evaluation component of projects like these focused on available standardized tests such as the Comprehensive Test of Basic Skills [CTBS] and/or the Stanford-9 Achievement Test [SAT-9] in reading, mathematics, and language arts. LA's BEST found that students demonstrated a consistent gain in achievement over time.

The Urban School Initiative (1999) in Ohio is another significant study that showed substantial growth in student achievement in science, mathematics, writing, and citizenship. In addition, the fourth and sixth graders participating in this program outperformed other non-participating students on the Ohio Proficiency Tests. It is important to note that this is one of the few examples where OST programs have specifically shown increased student achievement in science,

- Socioemotional Development: A common strand weaving the results of various evaluation studies is the positive impact of OST programs on students' socioemotional development. That is, quantitative and qualitative studies showed that students who participated consistently in OST programs demonstrated a more positive attitude toward school, worked well with peers and adults, and were able to transfer these positive dispositions to their regular school context. For example, Lauer et al's (2006) comprehensive review of OST programs concluded, "OST programs in which activities are both social and academic can have positive influences on student achievement" (p. 307). Other scholars like Scott-Little and her colleagues (2002) agree as they indicate in their meta-analysis of the literature that, "Evidence that after-school programs can have positive impacts on students' social and emotional functioning is a bit more conclusive" (p. 410). However, as it was mentioned above, these researchers warn that there is also a need to conduct more rigorous evaluation studies on the socioemotional impact of OST programs on students. Nevertheless, there does not seem to be a lack of reports that enumerate the positive influence of OST program on the psychological development of the whole child. For instance, the National Institute of Out-of-School Time (2006) recently published a very useful and practical "Making the Case: A Fact Sheet on Children and Youth in Out-of-School-Time." This document contains succinct statistics and findings from various studies based on OST Programs. Similarly, Miller's (2003) "Critical hours: After school programs and educational successes," cites a variety of reports and studies that indicate "quality after school programs promote school success by meeting the social, emotional, cognitive, and physical, needs of early adolescents" (p. 11).

Common Characteristics of Effective OST Programs

The existing plethora of OST programs and the lack of rigorous and standards-based research to evaluate them have made it difficult to identify conclusively the major components that make these kinds of programs effective. Nevertheless, it is possible to draw out some common characteristics that seem to have the greatest impact on students' academic achievement and socioemotional development. More focused quantitative and qualitative research on these characteristics—especially in STEM curriculum areas--will yield much needed information to guide the future development of effective OST programs. The following characteristics of effective OST programs were drawn mainly from reports written by Huang et al. (2000); Lauer et al. (2006); Fashola (1998); Miller (2003); and Scott-Little et al. (2002):

- Curriculum alignment: The alignment of OST programs with local school curriculum expands and enriches students' opportunities to learn in both contexts—in the regular classroom and in the OST program.
- Addressing students' needs: Provide homework help and tutoring for students. This was found to be particularly significant for students identified at risk. For example, one of the key findings from Lauer et al's (2006) meta-analysis was that at-risk students' reading performance substantially improved after receiving one-on-one tutoring.
- Social/Recreational Component: In addition to providing a safe and stimulating environment, OST programs that provide both social and academic activities have a positive impact on students.
- Trained Staff: Well-qualified and caring staff play a critical role in the implementation of the OST curriculum and activities. This has been an area of concern in recent years as the number of OST programs has increased significantly. Therefore, various organizations are working to develop professional standards for the training and evaluation of OST staff. See for example, the National Institute on Out-of-School Time website (http://www.niost.org/publications/briefs.html) for more information.
- Offer Well-Structured Programs: OST programs with well-defined goals that offer a variety of activities and curriculum subjects seem to increase students' engagement and participation.
- On-going Built-in Evaluations: This seems to be the weakest area identified across programs; therefore, well-designed and standards-based quantitative and qualitative evaluations are needed.

- Include Family and Children in the Planning: In order to increase participation and a sense of belonging, parents and their children should be involved in the planning of curriculum and activities. This is also an effective way to make programs more culturally responsive and family-oriented.
- Active Advisory Board: Tied to the above component, OST programs should have an advisory board composed of stakeholders elected from the community. The advisory board can ensure that policies are implemented fairly and that new course adjustments are made in response to the community's needs.

V. Next Steps and Areas for Further Study:

This review of the current literature on OST programs revealed many positive and promising aspects. One of these is the fact that OST programs seem to be playing the role of both leveling and enhancing the playing field for all students. Nevertheless, we also identified several areas in need of further study. For example, our review indicates that there is little information regarding access to OST programs. We found only one report that describes issues regarding students' access (National Institute on Out-of-School Time, 2006). This is a particularly important issue because as increased funding is allocated to OST programs, we must seek ways to ensure that students from economically disadvantaged neighborhoods also have access to computers, arts instruction, meals, and snacks as these are often found in programs located in more affluent neighborhoods. There also appear to be an assumption that all OST programs operate in the same schools in which students attend. While this may be most often the case, some OST programs may be located away from the school site, so transportation and/or transportation costs become an issue for parents with less financial resources. It would be helpful to look at successful and comprehensive programs as models, such as LA's BEST, which was offered to all students free of charge.

Another important area to further explore is the systematic study of OST programs that offer a comprehensive science, math, engineering, and/or technology (STEM) curriculum. Only a few OST programs evaluated in the meta-analyses reported here included science curriculum. Given the pervasive gap in student achievement in science and mathematics (Rodriguez, 2004), and given the positive impact OST programs are having on student achievement and socioemotional development, it is imperative that more STEM curriculum be included in OST programs and subsequently evaluated.

Most of the OST programs seemed to be geared for elementary and middle-school children. Only about 8% of those students in after-school programs are enrolled in grades 9-12 (National Institute on Out-of-School Time, 2006). It is reasonable to assume that high school students could also benefit from well-structured, after-school programs through which they could receive homework help and tutoring, academic counseling, enrichment activities in various subject areas (such as science and technology), and opportunities to participate in sports and other recreational activities. OST programs for high school students could play a significant role in addressing the gap in student achievement and participation in STEM-related fields.

In conclusion, many of the unanswered questions posed here could be answered by carrying out well-designed quantitative and qualitative longitudinal studies of OST programs that follow representative cohorts of students from the early grades into college. This type of study would require substantial time, financial resources, and a commitment from stakeholders. However, given the potential for OST programs to effect long-lasting and positive change in children's opportunities to learn, academic and socioemotional development, and future career choices, the investment is well worth it.

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Appendix

Status of U.S. Students' Performance on National and International STEM Assessments

One national assessment of student learning, the National Assessment of Educational Progress (NAEP), and two international assessments, Trends in International Mathematics and Science Study (TIMSS), and the Program for International Student Assessment (PISA), are conducted in the United States. NAEP is a congressionally mandated project of the National Center for Education Statistics (NCES) and has been conducted periodically over the last 30 years to assess student performance in reading, mathematics, science, writing, history, and geography. In this paper, only NAEP fourth, eighth, and twelfth grade mathematics and science results are reviewed. TIMSS has been administered four times since 1995 by the International Association for Evaluation of Educational Achievement (IEA) to fourth and eighth grade students in participating countries. PISA, administered by the Organization for Economic Cooperation and Development (OECD), was first conducted in 2000; it measures 15-year-old students' capabilities in reading, literacy, mathematics, and science. Each of these content areas is measured in three-year testing cycles; each year one subject is measured in depth, and the others are assessed more generally. In 2003, mathematics was measured in depth and in 2006, science was measured in depth. Results from the 2000 and 2003 testing cycles are reviewed in this report.

Although the fourth grade and eighth grade students' mathematics performance on NAEP has increased since 1990 (NCES, NAEP Mathematics 2005), U.S. results on international tests, (PISA and TIMSSS) are mixed. Fourth grade TIMSS average scores showed no measurable change, but eighth grade average scores improved slightly from 1995 to 2003 (see Figure 1A).

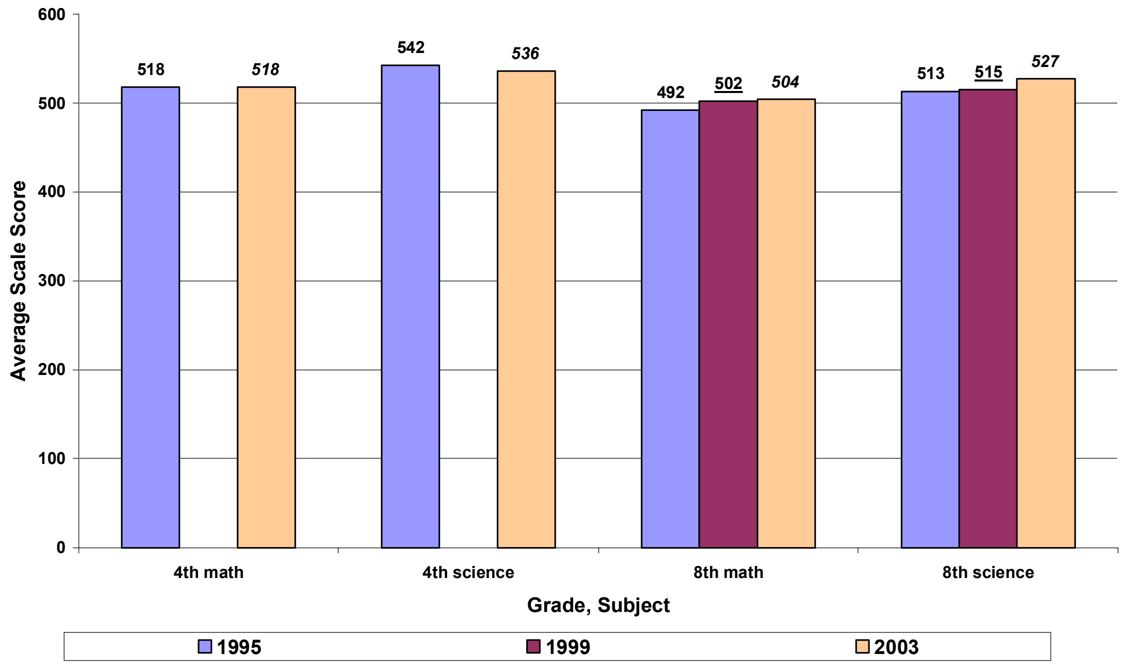

Figure 1A. TIMSS Average Scale Scores, Mathematics and Science, Grade 4, 1995 and 2003; and Grade 8, 1995, 1999, and 2003

Note. Fourth grade students were not tested in 1999.

SOURCE: International Association for the Evaluation of Educational Achievement (IEA), *Trends in International Mathematics and Science Study (TIMSS), 1995, 1999, 2003.*

As Figure 2A illustrates, another encouraging statistic is that while the overall TIMSS Science scale scores of eighth grade students increased from 1995 to 2003, the gap between the average scale scores of White and Black students decreased (97 to 77) as did the gap between the average scale scores of White and Hispanic students (73 to 60; Gonzales, Guzman, Parkelow, Pahlke, Jacelyn, Kastaberg, & Williams, 2004).

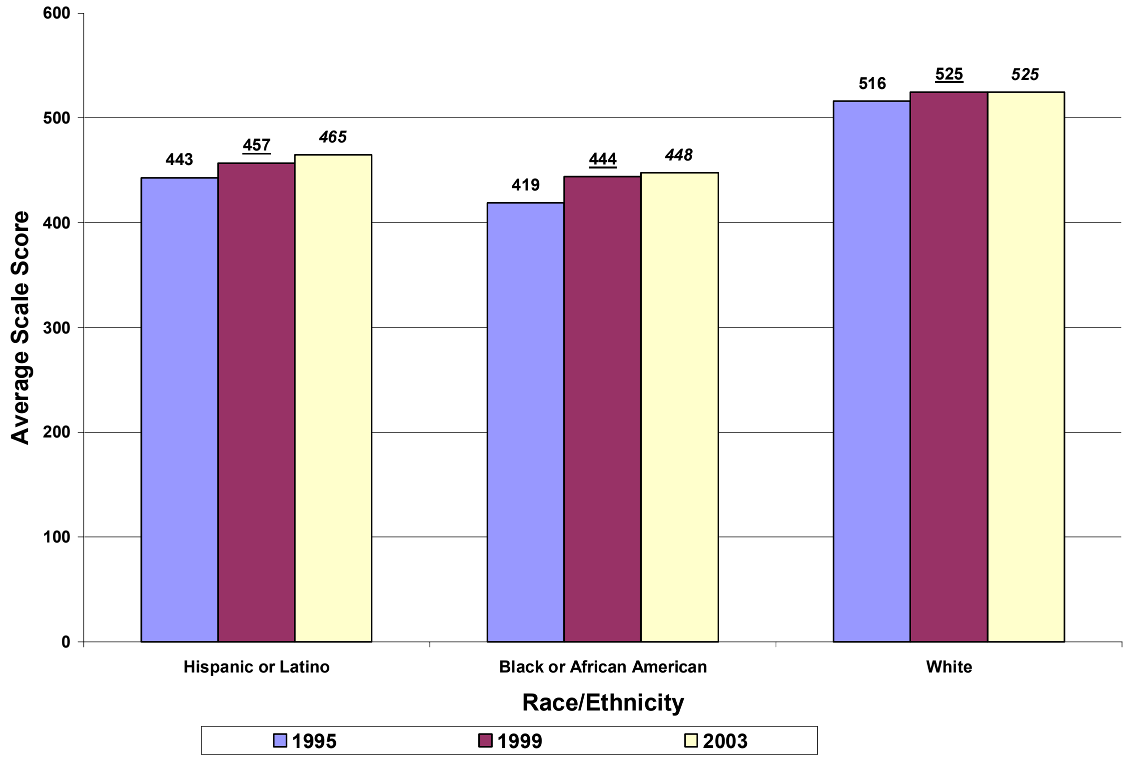

Figure 2A. TIMSS Science Average Scale Scores, U.S. Eighth Grade Students by Race/Ethnicity: 1995, 1999, and 2003

SOURCE: International Association for the Evaluation of Educational Achievement (IEA), Trends in International Mathematics and Science Study (TIMSS), 1995, 1999, 2003

However, as Figure 3A displays, when U.S. PISA 2003 data are analyzed by race/ethnicity, Blacks and Hispanics scored lower on average than Whites, Asians, and students of more than one race in mathematics literacy, problem solving, reading literacy, and science literacy (NCES, 2004).

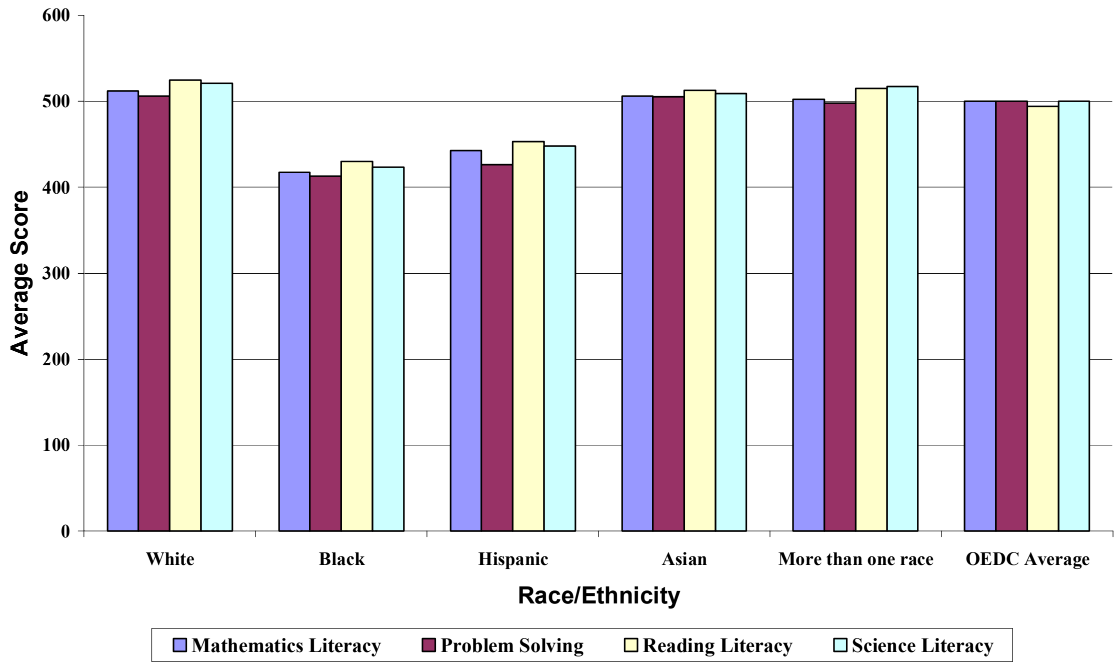

Figure 3A. Average Mathematics Literacy, Problem-Solving, Reading Literacy, and Science Literacy Scores of U.S. 15-Year-Old Students by Race/Ethnicity: PISA 2003

SOURCE: Organization for Economic Cooperation and Development (OECD), Program for International Student Assessment (PISA) 2003, cited in NCES (2004) document, *International outcomes of learning in mathematics literacy and problem solving: PISA 2003 results from the U.S. perspective.*

Student performance in mathematics literacy is associated with family socioeconomic data (as measured by parental occupational status) (PISA, 2003). Scores from Belgium, Czech Republic, Germany, Hungary, and Poland showed a stronger relationship and had more divergence than did U.S scores. The U.S. mathematics literacy average scores differed by 82 points between the bottom SES quarter to the top quarter compared to the average OEDC difference of 92 points (NCES, 2004). Clearly poverty affects student performance in all countries tested.