Realizing STEM Equity and Diversity through Higher Education-Community Engagement

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"If ability, and not the circumstances of family fortune, determines who shall receive higher education in science, then we shall be assured of constantly improving quality at every level of scientific activity."
—Vannevar Bush, 1945[1]

"Nothing is more conducive to innovation in social theory than collaboration on a complex practical problem."
—Paul F. Lazarsfeld and Jeffrey G. Reitz, 1975[2]

"[To] cultivate a world-class, broadly inclusive science and engineering work force and expand the scientific literacy of all citizens is crucial to the future of science and democracy itself."
—David B. Spencer and Sharon Dawes, 2009[3]

[1] National Science Foundation, *Science, the Endless Frontier, A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development* (Washington, DC: United States Government Printing Office, July 1945), 25.
[2] Paul F. Lazarsfeld and Jeffrey G. Reitz, *An Introduction to Applied Sociology* (New York: Elsevier Publishing, Co., 1975), 10.
[3] David B. Spencer and Sharon Dawes, *Report of the Advisory Committee for GPRA Performance Assessment FY 2009*, NSF 09-068 (Arlington, VA: National Science Foundation, 2009), 27.

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Introduction

The purpose of this white paper is to present a promising approach to advancing equity in science, technology, engineering, and mathematics (STEM) through higher education-community engagement. It is our intention that this paper will advance both the understanding and practice in the field by presenting key findings and recommendations for effective higher education-community engagement in STEM.

We propose a recursive, iterative approach that is based on the following propositions:

1. Significant societal problems cannot be solved without full inclusion.
2. Inclusion, in turn, will result in better science and a better society.
3. Higher education-community engagement focused on locally manifested universal problems is an effective strategy for realizing full inclusion and for producing better science and a better society.
4. Issues of knowledge generation, STEM equity, and social cohesion are faced by societies all over the world; they are universal problems that are manifested locally, which no single society can solve. An ongoing, global learning community focused on higher education-community engagement and STEM equity is needed to produce better science, broaden participation, reduce inequalities, and improve societies.

This paper is the product of a grant from the National Science Foundation (NSF), which supported an international workshop on the role of institutions of higher education in fostering P-20+ community engagement through knowledge production, human capacity building (including broadening participation and the integration of research and education), innovation, and social cohesion.[4] It builds upon a previous white paper on the state of STEM education in the United States.[5] This white paper summarizes the learning and knowledge generated through the international workshop held in the U.S., as well as a second international meeting held in South Africa.

Our discussion begins with a description of the first international workshop sponsored by NSF in 2012. It then describes key challenges and opportunities for STEM education and equity in the U.S., particularly for historically underrepresented groups in the STEM fields. It addresses the need for higher education to function as a core partner for generating knowledge, building intellectual capital, spurring innovation, and improving societal well-being—drawing upon promising examples from NSF's many collaborations with colleges and universities. We argue, however, that more must be done. Systemic and transformative change is needed to realize STEM equity. Specifically, this paper discusses the need to build upon current efforts to develop and implement an ambitious STEM education and workforce development strategy grounded in

[4] P-20+ refers to an integrated education system that extends from pre-kindergarten through higher education and the workforce.

[5] Ira Harkavy and Rita A. Hodges, "The State of Community Engagement in Science, Technology, Engineering, and Mathematics: A View from the USA," (Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration, University of Pennsylvania, Philadelphia, PA, February 2012).

a higher education-community engagement approach focused on broadening participation and equity.

Our paper concludes with a series of recommendations, derived from the two international workshops, which, we believe, have powerful implications for significantly enhancing STEM equity, driving broader participation, and producing better science. Moreover, the findings in this white paper, the authors further believe, demonstrate the value of learning and collaboration on a global basis for reducing inequalities in STEM in communities throughout the world.[6]

[6] The higher education-community engagement strategy described in this paper is also based on more than two decades of our own research and work on the ground.

International Workshops

In 2012, the Netter Center for Community Partnerships at the University of Pennsylvania (Penn) was awarded a grant by the National Science Foundation (NSF) to host "The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion, a U.S. – China – South Africa Collaboration." The workshop was held February 20-24, 2012 on Penn's campus.

This workshop was a result of collaboration between university and research foundation representatives from the U.S., China, and South Africa around STEM research and education. It was designed to be the first in a series of collaborative workshops, to be continued with meetings in each country. White papers from the U.S., China, and South Africa, as well as several presentations from the U.S. and the South African delegations, were produced in preparation for the U.S. workshop held at Penn. Workshop participants found that many of the challenges for effectively engaging universities with their communities, as well as for reducing STEM inequalities, were similar across the three countries. The U.S. workshop helped to further specify these challenges, as well as to identify joint strategies to effectively address them.

A second international workshop, supported by the National Research Foundation of South Africa, was held December 11-13, 2012 at the Durban University of Technology in South Africa.

The U.S. and South African workshops both revealed shared experiences and significant global interest in improving STEM equity, diversity, and inclusion, while promoting the role of higher education-community engagement in realizing these goals.

STEM Education and Equity in the United States: Issues, Challenges, and Opportunities

National Context

Promoting and enabling a vibrant STEM research and education enterprise has never been more vital to America's system of innovation, economic prosperity, and quality of life. Global leadership in science and technology is a national issue for the United States. Moreover, America needs not only a scientifically literate workforce, but also a scientifically literate population within each and every subgroup in society. And of particular significance, as U.S. demographics are changing, the STEM workforce must reflect the diversity of the American population.[7]

For over a century, institutions of higher education have played a major and distinct role in furthering knowledge development, building intellectual capital, spurring innovation, and improving societal well-being. As centers of discovery, learning, and innovation, it is imperative that institutions of higher education in the 21st century foster P-20+ community engagement through diverse human capacity building, knowledge generation, innovation, and social cohesion.

Human Capital Needs in STEM

Several major reports have emphasized that the U.S. must address its human capital needs in science and engineering (S&E) with a new sense of urgency. The National Academies' *Rising Above the Gathering Storm* was a call to action that recommended that the U.S. must invest in research, encourage innovation, and grow a strong, talented, and innovative S&E workforce.[8] *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5* called for direct action that covers K-12 education, funding for research, higher education support mechanisms, and incentives for innovation.[9] Several additional reports, such as the National Science Board's *Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Human Capital*, make clear that no one organization can address all of the recommendations for developing the STEM workforce.[10] The President's Council of Advisors on Science and

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[7] These views have been expressed in the President's 2013 State of the Union Address; America COMPETES Reauthorization Act, passed by Congress on January 5, 2010; The National Academies' *Gathering Storm* reports (2007 and 2010); and the Institute for a Competitive Workforce, a nonprofit affiliate of the U.S. Chamber of Commerce in *The Case for Being Bold: A New Agenda for Business in Improving STEM Education*, posted April 13, 2011.

[8] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (Washington, DC: National Academies Press, 2007).

[9] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5* (Washington, DC: The National Academies Press, 2010).

[10] National Science Board, *Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Human Capital* (Arlington, VA: National Science Foundation, 2010).

Technology's (PCAST) Report to the President highlighted the centrality of these challenges, pointing to "the need to add to the American workforce over the next decade approximately one million more STEM professionals than the U.S. will produce at current rates."[11]

Envisioning a 21st Century Science and Engineering Workforce for the United States challenged the political and professional communities by pointing out that "if the S&E workforce is inadequate to the need, the nation's innovation engine will slow, curtailing U.S. competitiveness in a global economy."[12] The significant need for S&E talent and expertise has led to "a more serious effort to inspire, educate, and recruit" increasing numbers and higher quality students to STEM disciplines, especially those who are currently underrepresented in STEM.[13] Indeed, engaging underrepresented populations[14] would help replenish STEM workforce needs due to retirement, as well as contribute to emergent areas of research and innovation such as cyberinfrastructure and sustainability.[15] Moreover, shared global interest in STEM inequalities and in learning across cultures presents a unique opportunity for global collaboration rather than competition.

In *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*, the National Academies emphasizes the need for a national commitment to increase the participation of underrepresented minorities in science and engineering: "Our sources for the future of S&E workforce are uncertain; the demographics of our domestic population are shifting dramatically; and diversity in S&E is a strength that benefits both diverse groups and the nation as a whole."[16] This book persuasively argues for three societal benefits by improving STEM education:

> (1) A citizenry better educated in science and engineering strengthens democracy and informed participation in a world in which STEM is more important than ever to policy; (2) Minority communities will be stronger with greater access to experts who understand science and engineering problems (e.g., water quality and toxic waste dumps) and policy choices for them; and (3) STEM-educated workers will be better able to perform in environments characterized by risk and complexity.[17]

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[11] President's Council of Advisors on Science and Technology, *Report to the President: Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics* (Accessed February 8, 2012), p. 1, http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf.

[12] Shirley A. Jackson, *Envisioning a 21st Century Science and Engineering Workforce for the United States*: *Tasks for University, Industry, and Government* (Washington, DC: The National Academies Press, 2003), 11.

[13] Jackson, *Envisioning*, 10.

[14] Underrepresented populations refer to underrepresented minorities, women, and persons with disabilities. Underrepresented minorities refer to African Americans, Hispanic or Latino Americans, Native Americans, Alaska Natives, Native Hawaiians, and Pacific Islanders.

[15] Potentially transformative research programs currently sponsored by NSF—such as Cyberinfrastructure Framework for 21st Century Science, Engineering, and Education (CIF-21); The Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE); and the NSF Innovation Corps (I-Corps)—might well provide opportunities for increased inclusivity through their cross-sector and interdisciplinary approaches.

[16] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: The National Academies Press, 2011), 22.

[17] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented*, 28.

Significantly, *Expanding Underrepresented Minority Participation* also highlights the need for both community engagement and building partnerships:

> While greater coordination and strategic partnerships can make both national and local efforts more effective and powerful, these efforts must be well conceived, leveraging programmatic strengths while retaining the intrinsic power found in the focus of individual programs designed to meet specific needs.[18]
>
> Industry and federal laboratories should expand their partnerships with institutions that enroll large numbers of underrepresented minorities in STEM in order to increase the articulations between universities and industry/federal laboratories and expand the number of role models to interact with an increasing diverse student population that will become the future workforce.[19]

Progress and Challenges in the STEM Education System and Workforce

In recent decades, the numbers of women, underrepresented minorities, and persons with disabilities earning STEM degrees and entering STEM careers have increased; however, significant gaps remain. Summarizing this finding, the Committee on Equal Opportunities in Science and Engineering (CEOSE) states in their 2011-2012 biennial report to Congress, "This is progress, but not sufficient progress to redress the historic patterns of underrepresentation for these groups."[20] Furthermore, the results of national assessments in mathematics and science illustrate that academic performance gaps, as well as participation disparities, continue to persist in America, while the United States' global leadership in STEM has eroded over the last decade.[21]

An examination of the U.S. education system reveals challenges at both the precollege and postsecondary levels, as well as early career development. Despite modest progress on national STEM assessments, relatively few students reached grade-level proficiency in math and science on the 2011 National Assessment of Education Progress, with only 32% of eighth graders performing at or above the proficient level. The percentage scoring below proficient was particularly high among black and Hispanic students (90% and 84%, respectively), with slightly worse performance among female students in these two groups (91% and 87%, respectively).[22]

The U.S. performance on international assessments in mathematics and science is also troubling. For example, on the Trends in International Mathematics and Science Study (TIMSS) science

[18] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented*, 148.
[19] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented*, 185.
[20] Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report to Congress: Broadening Participation in America's STEM Workforce*, CEOSE 13-01 (Arlington, VA: National Science Foundation, 2013), iv.
[21] National Science Board, *Science and Engineering Indicators 2014*, NSB 14-01 (Arlington, VA: National Science Foundation, 2014).
[22] National Science Board, *Indicators 2014*, chap.1, p.15.

assessments, between 1995 and 2011, U.S. eighth graders' performance improved modestly, while their relative international ranking was unchanged. At the same time, U.S. fourth graders' performance remained flat, and their international position slipped. The performance of 15-year-old Americans on the Program for International Student Assessment (PISA) has improved modestly, with the average score not statistically significantly different from the average among Organization for Economic Co-operation and Development (OECD) countries. In 2009, the U.S. average score ranked 13th in science out of 34 participating OECD countries. In 2010, 21 of 26 OECD countries outperformed the U.S. in terms of high school graduation rates. These trends raise concerns for early engagement in STEM, which is significant for establishing and sustaining commitment of students in the STEM pipeline.[23]

It is important to note that in American society, while we are challenged to train sufficient numbers and quality of STEM academics and professionals, the challenge is most acute for historically underrepresented groups in STEM fields: women, persons with disabilities, and ethnic minorities, particularly those identifying as African American, Hispanic, and American Indian or Alaska Native. Moreover, these populations often reside in under-served communities that most need the STEM expertise and resources that universities and other public and private partners can bring to bear.

Compounding these issues, low performing schools are most often in communities with high levels of poverty and high percentages of underrepresented minority student enrollment. The National Science Board points out that access to up-to-date resources and best practice opportunities for STEM learning are uneven across the nation. In 2012, science classes at schools with the highest percentage of non-Asian minority students were more likely to be taught by a novice science teacher (2 or less years of experience) than were classes at schools with the lowest percentages of non-Asian minority students (21% to 14%, respectively). Moreover, science classes at schools with the highest concentrations of students eligible for free/reduced-priced lunch were more likely to be taught by novice teachers than science classes with the lowest concentrations of students eligible for free/reduced price lunch (23% to 10%, respectively). In grades K, 4, and 8 on math and science assessments: students from lower-income families performed lower than those from higher-income families; students from homes where English is not the primary language scored lower than their peers; and Black, Hispanic, American Indian and Alaska Native students performed lower than their white, Asian or Pacific Islander peers. Some achievement gaps have narrowed modestly: from 2009 to 2011, the white-black gap decreased from 36 to 34 points, and the white-Hispanic gap decreased from 30 to 26 points.[24]

Such gross imbalance in access and quality of STEM education in primary school must be addressed systemically if the nation is to fulfill its mission of developing a diverse workforce of innovative and world-class scientists, technologists, engineers, and mathematicians. STEM talent needs to be developed from all populations in the U.S.

[23] National Science Board, *Indicators 2014*, full report and chap.1, pp.18-29; 17; 7.
[24] National Science Board, *Indicators 2014*, full report and chap. 1, pp. 27; 4; 15-16.

According to the National Science Board, the S&E workforce in the U.S. totaled between 5 and 19 million people in 2010, depending on the definition used.[25] Women, minorities, and persons with disabilities remain underrepresented in STEM higher education professions, while they are increasing percentages of the overall workforce and population at large. Women have earned about half of all S&E bachelor's degrees since the late 1990s, and the proportion of women earning doctoral degrees grew from 42% to 47% over the last decade, but major gender disparities persist among certain fields. For example, the share of women has remained disproportionately low for graduate programs in engineering (23%), computer sciences (25%), physical sciences (33%), and economics (38%).[26] Gender disparities persist in the workforce, where women made up only 29% of tenure-track faculty in STEM fields in 2008 and accounted for less than one-third of all S&E employment in 2010. Persistent gender bias and the challenges of balancing family and career have impeded progress.[27] The Career Life Balance Initiative, a ten-year initiative launched by First Lady Michelle Obama and former NSF Director Subra Suresh in September 2011, is a promising approach to reducing the number of women who depart from the STEM workforce due to family responsibilities by expanding best practices in family-friendly policies and procedures.[28]

Persons with disabilities[29] are also underrepresented in science and engineering, compared with the population as a whole, where they make up approximately 19% of the civilian, non-institutionalized U.S. population. Approximately 11% of enrolled STEM undergraduate students have disabilities; this drops to 7% of enrolled STEM graduate students and to 1 to 3% of

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[25] National Science Board, *Indicators 2014*, chap. 3, p. 5.

[26] National Science Board, *Indicators 2014,* chap. 2, pp. 5 and 32. The disparity in participation in STEM fields is also evident in undergraduate education. According to the National Science Board's *Science and Engineering Indicators 2014*, "Men earn the majority of bachelor's degrees in engineering, computer sciences, and physics. More women than men earn degrees in the biological, agricultural, and social sciences and in psychology…. Between 2000 and 2011, the proportion of S&E bachelor's degrees awarded to women remained flat. During this period, it declined in computer sciences, mathematics, physics, engineering, and economics" (chap. 2, p. 4). These figures, as well as those cited above for graduate education, indicate the need to develop discipline specific approaches and strategies for achieving STEM equity.

[27] Emilie Marcus, "Science, Gender and the Balanced Life," *Issues in Science and Technology* (Spring 2013), accessed November 20, 2013, http://issues.org/29-3/perspectives-2/; Mary A. Mason, Marc Goulden, and Karie Frasch, *Keeping Women in the Science Pipeline*, (Berkeley, CA: Center on Health, Economic, and Family Security, 2010); Corinne A. Moss-Racusin et al., "Science Faculty's Subtle Gender Biases Favor Male Students," *Proceedings of the National Academy of Sciences* 109, no. 41 (October 9, 2012): 16474-16479, pre-published September 17, 2012, doi: 10.1073/pnas.1211286109; Wanda E. Ward, "Career-Life Balance Fair Continues to Promote Flexible Workplaces for America's Scientists and Engineers," *Council on Women and Girls* (Blog), *White House Blogs*, February 15, 2012, http://www.whitehouse.gov/blog/2012/02/15/career-life-balance-fair-continues-promote-flexible-workplaces-america-s-scientists-; National Science Board, *Indicators 2014*.

[28] Ward, "Career-Life Balance."

[29] As defined by the World Health Organization, "Disabilities is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations." Available at http://www.who.int/topics/disabilities/en/. The National Science Board reports that of the 3% of doctorate recipients reporting a disability in 2011, nearly one-third reported a learning disability, 17% reported being blind or visually impaired, 13% reported a physical or orthopedic disability, 12% indicated being deaf or hard of hearing, 4% reported a vocal or speech disability, and 21% cited other or unspecified disabilities (National Science Board, *Indicators 2014*, chap. 2, p. 32).

doctorate recipients. Scientists and engineers with disabilities are also more likely than those without disabilities to be unemployed.[30] More data is needed for understanding why students with disabilities do not advance as far as their peers in STEM education, and what teaching methods would be best suited for helping to support such students.[31]

Racial and ethnic minority groups, the fastest growing population in America, will be needed at every level of postsecondary education to help fill the STEM jobs that are projected to grow twice as fast as jobs in other fields (21.4% vs. 10.4%, respectively). However, current participation rates for underrepresented minority groups are not what they should be across the academic levels. For example, in 2007, underrepresented minorities comprised approximately 26% of undergraduate enrollment, compared to this group constituting approximately 47% of the K-12 population in the U.S. While there has been some improvement, the number of underrepresented minority students remains disproportionally low in S&E at the highest education levels, where they comprised only 12% of students enrolled in graduate S&E programs in 2011 and earned 8% of S&E doctoral degrees.[32] Deficiencies along STEM educational pathways include lower proportions of Blacks, Hispanics, American Indians, and Alaska Natives completing bachelor's degrees, which leads to underrepresentation at the highest levels of STEM employment. These populations make up just 10% of workers in S&E occupations.[33] Minority-serving institutions, which award a substantial proportion of bachelor's and S&E doctoral degrees to blacks and Hispanics have a particularly significant role to play in providing STEM pathways for underrepresented minorities.[34]

Reducing barriers related to educational preparation and persistence for women, underrepresented minorities, and persons with disabilities is obviously a critical element of a U.S. strategy for broadening participation in the STEM workforce.

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[30] Richard E. Ladner, *CEOSE Mini-Symposium on Institutions Serving Persons with Disabilities in STEM—October 15, 2007 Report* (Arlington, VA: National Science Foundation, February 2008); National Science Board, *Indicators 2014*, chapter 3.

[31] Kristin Bowman-James, David Benson, and Tom Mallouk, *Workshop on Excellence Empowered by a Diverse Academic Workforce: Chemists, Chemical Engineers, and Materials Scientists with Disabilities* (Arlington, VA: National Science Foundation and the National Institutes of Health, 2009); Nathan Moon et al., *Accommodating Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM): Findings from Research and Practice for Middle Grades through University Education* (Atlanta: Georgia Institute of Technology, 2012).

[32] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads* (Washington, DC: The National Academies Press, 2011); "Infographic: Solving the STEM Dilemma," by Hyperakt, GOOD (Published August 3, 2011), http://magazine.good.is/infographics/infographic-solving-the-stem-dilemma; National Science Board, *Indicators 2014*, chap. 3.

[33] David Beede et al., *Education Supports Racial and Ethnic Equality in STEM*, ESA Issue Brief 05-11 (Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration, September 2011); National Science Board, *Indicators 2014*.

[34] National Science Foundation, National Center for Science and Engineering Statistics, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013*, Special Report NSF 13-304 (Arlington, VA: printed by author, 2013), http://www.nsf.gov/statistics/wmpd/2013/pdf/nsf13304_digest.pdf; Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report*.

STEM Equity and Social Cohesion

Social cohesion can be usefully defined as "the extent of connectedness and solidarity among groups in society."[35] Solidarity and connectedness are not advanced when historically underrepresented groups fail to be full participants in key societal activities.

The OECD report *Perspectives on Global Development 2012: Social Cohesion in a Shifting World* emphasizes the importance of schooling for increasing inclusion of disadvantaged groups and minorities (including women):

> The schooling experience itself also impacts social cohesion, as it shapes and transmits common values that underpin social capital and inclusion. How children are schooled is important for building their sense of belonging to a society. Schooling should be organised [*sic*] to increase the participation of children from disadvantaged groups, thus making education more inclusive. Greater inclusiveness can also result from the development of teaching techniques and curricula that foster diversity and enhance positive perceptions of others within the system and society.[36]

As with other forms of inequality, the lack of equity in STEM serves as a barrier to social cohesion in the U.S. and societies around the world.[37] The creation of STEM pathways in and through schooling is crucial for STEM equity.[38] In our judgment, the higher education-community engagement approach involving P-20+ partnerships, described below, is a promising strategy for developing these pathways.

Towards Improving STEM Equity

The National Academies has emphasized that STEM talent and leadership is at "a transformational moment."[39] Therefore, the response to broadening participation must be transformative—involving a cutting-edge approach both to achieve parity in meeting national labor needs and to demonstrate that a globally diverse STEM workforce is an asset for realizing national workforce goals and United States R&D leadership globally. NSF's Advisory Committee for GPRA Performance Assessment[40] has further emphasized that the goal of

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[35] Ichiro Kawachi and Lisa Berkman, "Social Cohesion, Social Capital, and Health" in *Social Epidemiology,* eds. Lisa F. Berkman and Ichiro Kawachi (Oxford: Oxford University Press, 2000), 175.
[36] Organization for Economic Co-operation and Development, *Perspectives on Global Development 2012: Social Cohesion in a Shifting World* (Paris: OECD Publishing, 2011), 23, doi: 10.1787/persp_glob_dev-2012-en.
[37] For a discussion of the negative impacts of inequality on social cohesion, see Organization for Economic Co-operation and Development, *Perspectives*.
[38] David B. Spencer and Sharon Dawes, *Report of the Advisory Committee for GPRA Performance Assessment FY 2009*, NSF 09-068 (Arlington, VA: National Science Foundation, 2009),
[39] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented*, 1.
[40] The Advisory Committee for GPRA Performance Assessment was established in 2002 to provide advice and recommendations to the NSF Director regarding the Foundation's performance under the Government Performance and Results Act (GPRA) of 1993.

broadening participation is not only an issue of fairness and equal opportunity, but is also the means of bringing diversity and intellectual breadth to the transformation of science itself.[41]

The findings of the GPRA Advisory Committee are highly germane to this white paper. The Committee emphasizes the following approaches for effective STEM learning across all education levels: integration of research with education; broadening participation of underrepresented groups; and contextualized STEM teaching and learning that focuses on real-world, hands-on, interdisciplinary-based problems. The GPRA report specifically highlights projects which demonstrate that "students, particularly those from underrepresented populations in STEM, are more attracted to, and retained in STEM if their studies and research have social meaning and real, immediate impact." The Advisory Committee also supports a P-20+ systemic approach to STEM education wherein an integrated research team includes pre-kindergarten through 12th grade students and teachers working with university faculty and college students (and other partners as needed) in research-based inquiry. Such inclusive teams are improving both teaching and learning across all levels of education, "exposing students to career paths they may not have thought possible." The Committee importantly claims that "connecting a major research project with a highly successful community program and outreach efforts to school children is extraordinarily innovative, creative, and significant." Finally, the report encourages the development of additional models that "integrate frontier research with frontier educational and community outreach involving STEM" that involve all students, especially those from historically underrepresented groups.[42]

[41] Spencer and Dawes, *Report*.
[42] Spencer and Dawes, *Report*, full report and quotes on pp. 31; 35; 39.

Rationale for a Partnership Approach: Theory and Best Practices

In the introduction of this white paper, we describe the partnership approach as being based on the following propositions:

1. Significant societal problems cannot be solved without full inclusion.
2. Inclusion, in turn, will result in better science and a better society.
3. Higher education-community engagement focused on locally manifested universal problems is an effective strategy for realizing full inclusion and for producing better science and a better society.
4. Issues of knowledge generation, STEM equity, and social cohesion are faced by societies all over the world; they are universal problems that are manifested locally, which no single society can solve. An ongoing, global learning community focused on higher education-community engagement and STEM equity is needed to produce better science, broaden participation, reduce inequalities, and improve societies.

The proposed approach is to create innovative multi-organizational partnerships focused on the development and advancement of human capital in science and engineering, bringing together a diversity of perspectives, institutions, individuals, and communities. To extend an argument made by Paul Lazarsfeld and Jeffrey Reitz, collaboration on complex intellectual problems, such as STEM diversity and equity, are conducive to ongoing innovation, social cohesion, and knowledge generation.[43]

Intellectual work involving diverse individuals in a research partnership can result in the continuous generation of knowledge, as the resolution of existing problems leads to the identification of new problems that need to be examined, understood, and solved.[44] Partnerships also bring together individuals with diverse orientations, perspectives, intellectual backgrounds, and access to resources. This enhances innovation and creates greater social cohesion as people work together on complex intellectual problems.[45]

Why Higher Education as Core Partner

Colleges and universities are recognized as the central sources for the production of new knowledge at the frontier, as well as the dissemination of knowledge throughout the world.[46] The integration of research and education is core to higher education institutions, particularly

[43] Lazarsfeld and Reitz, *Applied Sociology*.

[44] John Dewey, *The Public and Its Problems* (New York: Holt, 1927); Kurt Lewin, "Problems of Research in Social Psychology," in *Field Theory in Social Science*, ed. Dorwin Cartwright (New York: Harper & Row, 1951), 155-169; Donald A. Schön, "Knowing-in-Action: The New Scholarship Requires a New Epistemology," *Change* 27, no. 6 (November-December 1995): 26-34.

[45] Scott E. Page, *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies* (Princeton, NJ: Princeton University Press, 2007); and "Diversity Powers Innovation," Center for American Progress (Published January 26, 2007), http://www.americanprogress.org/issues/economy/news/2007/01/26/2523/diversity-powers-innovation/.

[46] Derek Bok, *Universities and the Future of America* (Durham, NC: Duke University Press, 1990); Schön, "Knowing-in-Action;" John Saltmarsh and Matt Hartley, eds., "*To Serve a Larger Purpose": Engagement for Democracy and the Transformation of Higher Education* (Philadelphia: Temple University Press, 2011).

research universities.[47] Since the founding of Johns Hopkins, the first modern research university, in 1876, the success of higher education has been built upon this principle.[48] Universities are also widely recognized as *the* centers of innovation in American society and around the world. Moreover, higher education institutions, particularly research universities, are knowledge-advancing and problem-solving institutions that are charged with successfully educating leaders who will be at the cutting edge of innovation.[49]

Higher education has historically engaged in service, as well as increasing opportunity for excluded populations. This commitment, which emerged during the colonial period, expanded significantly with the founding of land-grant colleges, the development of the research university, and the creation of regional colleges and universities and community colleges.[50]

According to the series of reports discussed above,[51] now is a crucial time to create innovative higher education-public-private partnerships to design and implement solutions to national (and international) STEM challenges, focusing on workforce development across all educational and professional levels. For broadening participation, it is particularly necessary to create effective pathways across higher education institutions, starting with community colleges, and including minority-serving institutions, which serve many first-generation and underrepresented college students.[52] Educational pathways, of course, must begin before college. Higher education's

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[47] Jonathan R. Cole, *The Great American University: Its Rise to Preeminence, Its Indispensable National Role, Why It Must Be Protected* (New York: Public Affairs, 2009).

[48] Ernest L. Boyer, *Scholarship Reconsidered: Profiles of the Professoriate* (Princeton, NJ: Carnegie Foundation for the Advancement of Teaching, 1990); Charles W. Anderson, *Prescribing the Life of the Mind* (Madison: University of Wisconsin Press, 1993).

[49] Bok, *Universities and the Future;* Ben Wildavsky, *The Great Brain Race: How Global Universities are Reshaping the World* (Princeton, NJ: Princeton University Press, 2010).

[50] In particular, service to society and fulfilling America's democratic mission were the founding purposes of the land-grant universities. Established by the Morrill Act of 1862, land grant colleges and universities were designed to spread education, advance democracy, and improve the mechanical, agricultural, and military sciences. Labeled "Democracy's Colleges" in 1942 by historian Earle D. Ross, public universities throughout this country committed to innovation through collaboration and to social opportunity through education. The spirit of the Morrill Act was perhaps best expressed at the University of Wisconsin, which designed programs around the educational needs of adult citizens across the state. In 1912, Charles McCarthy, a graduate of the University of Wisconsin and the first legislative reference librarian in the United States, coined the phrase "The Wisconsin Idea" to describe a concept that had been in practice for a number of years. The Wisconsin Idea's goal was to make "the boundaries of the university…the boundaries of the state." When asked what accounted for the great progressive reforms that spread across the Midwest in the first two decades of the 20th century, Charles McCarthy replied, "a combination of soil and seminar." McCarthy's answer captures the essence of the Wisconsin Idea—focusing academic resources on improving the life of the farmer and the lives of citizens across the entire state. Earle D. Ross, *Democracy's College, The Land-Grant Movement in the Formative Stage* (Ames: Iowa Stage College Press, 1942); Scott Peters, *Democracy and Higher Education: Traditions and Stories of Civic Engagement* (East Lansing: Michigan State University Press, 2010); Charles McCarthy, *The Wisconsin Idea,* (New York: MacMillan, 1912); Jack Stark, *The Wisconsin Idea: The University's Service to the State*, reprinted from the 1995-1996 Wisconsin Blue Book (accessed June 20, 2014), http://www.legis.state.wi.us/lrb/pubs/feature/wisidea.pdf.

[51] Jackson, *Envisioning*; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Rising Above; Rising Above Revisited*; *Expanding Underrepresented*; National Science Board, *Indicators 2014*; President's Council of Advisors on Science and Technology, *Report to the President.*

[52] National Science Foundation, National Center for Science and Engineering Statistics, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013*, Special Report NSF 13-304 (Arlington, VA: printed by author, 2013), http://www.nsf.gov/statistics/wmpd/2013/; Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report*; Century Foundation Task Force on Preventing Community Colleges from

central role in shaping the schooling system has long been recognized.[53] Moreover, its increasing commitment to preK-12 schooling is particularly crucial to broadening participation now and in the future.[54]

Building partnerships across institutional, geographic, and political structures, as proposed in this multi-institutional and multi-national project, extends the collaborative work inherent in scientific inquiry. Institutions of higher education are capable of leading change and innovation by transcending traditional boundaries to engage in interdisciplinary, interactive, democratic scholarship for improving education in America. A community of inquiry is needed wherein any problem of interest to teaching and learning in higher education is studied in the actual contexts of practice,[55] allowing academicians and practitioners to work collaboratively in mutually beneficial university-school-community partnerships.[56] Universities are also becoming more deeply involved in community engagement that focuses on the benefit to the community as the driver for a collective vision of change. A key role of the university in community development partnerships is to mobilize resources, particularly information and problem-solving expertise.[57]

Examples of NSF's collaboration with Colleges and Universities[58]

The National Science Foundation (NSF) has had a unique historic partnership with universities in all fields of science for promoting discovery, learning, transformation, and innovation, and has partnered more recently with universities to broaden participation in STEM. In other words, NSF is, among other things, a catalyst for university action and change across the nation. As such, the approach proposed resonates with and carries forward NSF's core role and function. Approximately 80% of NSF's research and development budget goes to academic institutions,

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Becoming Separate and Unequal, *Bridging the Higher Education Divide: Strengthening Community Colleges and Restoring the American Dream* (New York: The Century Foundation Press, 2013).

[53] William Rainey Harper, *The University and Democracy* (Chicago: University of Chicago Press, 1899).

[54] Lee Benson, Ira Harkavy, and John Puckett, *Dewey's Dream: Universities and Democracies in an Age of Education Reform* (Philadelphia: Temple University Press, 2007).

[55] Schön, "Knowing-in-Action."

[56] Lee Benson, Ira Harkavy, and John Puckett, "An Implementation Revolution as a Strategy for Fulfilling the Democratic Promise of University-Community Partnerships: Penn-West Philadelphia as an Experiment in Progress," *Nonprofit and Volunteer Sector Quarterly* 29, no. 1 (March 2000): 24-45.

[57] Over the past decade, the concept of "anchor institutions" has emerged as a new paradigm for understanding the role that place-based institutions, particularly institutions of higher education and medical centers ("eds and meds"), could play in building successful communities and local economies. This concept recognizes that higher education institutions are not only educators and knowledge producers, but also major employers, real estate developers, purchasers, incubators for business and technology, and centers for arts and culture. For examples of leading universities who are engaged in this work, including Syracuse University, Widener University, Miami Dade College, Tulsa Community College, Lehigh University, University of Michigan, and University of Tennessee, see the special issue of the *Journal of Higher Education Outreach & Engagement* on anchor institutions, Volume 17, Number 3, 2013. For further discussion on anchor institutions, see Ira Harkavy and Harmon Zuckerman, *Eds and Meds: Cities' Hidden Assets* (Washington, DC: The Brookings Institution Center on Urban & Metropolitan Policy, September 1999); Henry Taylor and Gavin Luter, *Anchor Institutions: An Interpretative Review Essay* (Anchor Institutions Task Force: 2013), accessed June 3, 2013, http://www.margainc.com/files_images/general/Literature_Review_2013.pdf.

[58] Most of the NSF programs mentioned in this section are undergoing rigorous program evaluations to determine program effectiveness and to identify the programmatic model of implementation for replication and advancement of the knowledge base.

providing 21% of all federally supported basic research at colleges and universities. The agency's share increases to 58% when NIH biomedical research support is omitted.[59]

There are several longstanding intellectual strategies that are core to the partnership approach and which have been exemplified by past and present NSF programs:

1. *Provide merit-based awards to local teams composed of higher education institutions, school systems, and other partners to improve math and science education P-20+.*

For example, NSF's former Math and Science Partnership Program awarded teams comprised of colleges and universities, local K-12 school systems, and their supporting partners (e.g., community organizations, state education agencies, informal science education organizations, business and industry, and others with a stake in educational excellence). This program also focused on increasing the number, quality, and diversity of mathematics and science teachers, especially in underserved areas. By engaging scientists, mathematicians and engineers at local colleges, universities, and industries to work with K-12 educators and students, these partnership efforts have aimed to enhance K-12 schools' capacities to provide challenging curricula and encourage more students to succeed in advanced mathematics and science courses.[60] NSF's STEM-C (Science, Technology, Engineering and Mathematics, including Computing) Partnerships program combines and advances the efforts of the former Math and Science Partnership Program with the former Computing Education for the 21st Century program to support innovative partnerships aimed at improving teaching and learning in STEM disciplines particularly computer science education. The STEM-C Partnerships program also focuses on K-16 education, emphasizing practices that are effective for groups underrepresented in STEM.[61]

2. *Enhance the institutional and societal impacts of graduate education.*

One example of effective graduate student engagement is NSF's former National Graduate STEM Fellows in K-12 Education (GK-12) Program. The GK-12 program solicitation encouraged Principal Investigators to "involve fellows and teachers in international research collaborations," offering supplementary funding to currently active awards for international research activities. One of the expected outcomes was transformation of graduate programs that entailed "strengthened and sustained partnerships with local school districts, industry, and non-profit sector, etc.," for enhanced institutional impact of graduate education to society.[62] Another example is the Graduate Research Fellowship Program (GRFP), which supports outstanding

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[59] American Association for the Advancement of Science, *AAAS Report XXXVIII: Research & Development FY 2014* (Washington, DC: printed by author, 2013), 74-75.
[60] National Science Foundation, *Math and Science Partnership Program: Strengthening America by Advancing Academic Achievement in Mathematics and Science* (Arlington, VA: printed by author, 2005).
[61] National Science Foundation, *STEM-C Partnerships: Computing Education for the 21st Century (STEM-CP: CE21)*, NSF 14-523 Program Solicitation (Arlington, VA: printed by author, 2013), http://www.nsf.gov/pubs/2014/nsf14523/nsf14523.pdf.
[62] National Science Foundation, *NSF Graduate STEM Fellows in K-12 Education*, NSF 09-549 Program Solicitation (Arlington, VA: printed by author, 2009), http://www.nsf.gov/pubs/2009/nsf09549/nsf09549.htm.

graduate students in STEM disciplines who are pursuing research-based master's and doctoral degrees at accredited U.S. institutions, with a focus on underrepresented populations, including women, racial and ethnic minorities, and persons with disabilities.[63] A third example is the NSF Research Traineeship (NRT) program, which encourages the development and implementation of transformative and scalable models for STEM graduate training, advances interdisciplinary research in high national priority areas, and prepares STEM graduate students for multiple career pathways, including those outside the university.[64]

3. *Provide support for higher education institutions that are willing to document and create new strategies to address the institutional culture that women and minorities face in STEM.*

NSF's ADVANCE Program (Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers) offers a model for inclusion when structural problems cause gender and racial underparticipation. Workplace equality in STEM is achieved by connecting inclusiveness to institutional values and practices as well as identifying the barriers to full participation and the pivot points for removing those barriers to increase participation. ADVANCE projects employ integrative and inclusive collaborative approaches directed at institutional transformation by eliminating bias, reducing barriers, and building capacity. As described by Susan Sturm, the ADVANCE program has become an exemplar for articulating "gender equality goals within the frame of citizenship and scientific improvement," emphasizing that "all institutional citizens should be able to realize their potential and participate fully in the life of the institution." The ADVANCE program also calls on universities to expand capabilities for creating broad access to academic STEM careers and for developing scientific knowledge to benefit diverse communities.[65] NSF's Historically Black Colleges and Universities Undergraduate Program (HBCU-UP) has also focused on developing evidence-based approaches for improving the preparation and success of HBCU undergraduate students so that they might pursue STEM graduate programs and/or careers. Such approaches include curricular modification to incorporate community-based research, service-learning projects, and problem- and place-based learning on STEM topics.[66]

4. *Support multi-institutional partnerships.*

NSF's Louis Stokes Alliances for Minority Participation (LSAMP) Program is an example of a program that supports multi-institutional alliances. The program promotes sustained and comprehensive approaches to broadening participation at the baccalaureate level and to

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[63] National Science Foundation, *Graduate Research Fellowship Program (GRFP)*, NSF 14-590 Program Solicitation (Arlington, VA: printed by author, 2014), http://www.nsf.gov/pubs/2014/nsf14590/nsf14590.htm.
[64] National Science Foundation, *National Science Foundation Research Traineeship (NRT) Program,* NSF 14-548 Program Solicitation (Arlington, VA: printed by author, 2014), http://www.nsf.gov/pubs/2014/nsf14548/nsf14548.htm.
[65] Susan Sturm, "The Architecture of Inclusion: Advancing Workplace Equality in Higher Education," *Harvard Journal of Law and Gender* 29, no. 2 (Summer 2006), quotation on p. 303.
[66] Quality Education for Minorities Network, *Effective Institutional STEM Instructional Strategies at HBCU-UP Grantee Institutions*, published December 2012, http://qemnetwork.qem.org/Major_QEM_Reports.htm.

preparing and motivating historically underrepresented students who are STEM majors to pursue graduate education. LSAMP takes a comprehensive and longitudinal approach to student development and retention, creating partnerships among colleges, universities, school systems, national research labs, business and industry, private foundations, federal/state/local government agencies, and professional STEM organizations, to increase the quality and quantity of minority students who earn STEM baccalaureate degrees and succeed in STEM fields.[67] A benefit for the partnering institutions is the cultural change that promotes innovative practices and policies for embracing diversity.[68]

5. Create collaborations among higher education institutions, particularly minority-serving institutions and research universities, to improve preparation and retention of underrepresented students.

An exemplar of this collaborative effort is the Fisk-Vanderbilt Master's to PhD Bridge Program, which had been supported by NSF's Innovation through Institutional Integration (I^3) Activity. Here, multi-institutional partnerships connect minority-serving institutions (MSI) to major research universities to leverage both the academic resources (from research universities) and the expertise in retaining and preparing underrepresented students (from MSIs) needed to support broadening participation in doctoral STEM programs.[69] NSF's Alliances for Graduate Education and the Professoriate (AGEP) Program also creates collaborations among higher education institutions that leverage shared resources and increase the number of underrepresented minorities earning graduate degrees in STEM fields and securing faculty positions in academia.[70] Another example is the Opportunities for UnderRepresented Scholars (OURS) program at the Chicago School of Professional Psychology. With support from NSF, OURS helps prepare women of color at Historically Black Colleges and Universities for postgraduate certificates in academic leadership in the STEM disciplines.[71]

6. Promote a multicultural, multi-institutional, collaborative approach for advancement in technical fields.

A multicultural collaborative approach to solving complex community problems can help shape a problem-focused strategy that brings together different disciplinary perspectives to provide

[67] Daryl E. Chubin and Wanda E. Ward. "Building on the BEST Principles and Evidence: A Framework for Broadening Participation," in *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*, eds. Mary K. Boyd and Jodi L. Wesemann, 21-30 (Washington, DC: Council on Undergraduate Research, 2009).
[68] Beatriz Chu Clewell et al., *Revitalizing the Nation's Talent Pool in STEM: Science, Technology, Engineering, and Mathematics* (Washington, DC: The Urban Institute, 2006).
[69] Vanderbilt University, *Fisk-Vanderbilt Master's to PhD Bridge Program*, accessed June 20, 2014, http://www.vanderbilt.edu/gradschool/bridge/.
[70] National Science Foundation, *Alliances for Graduate Education and the Professoriate (AGEP)*, accessed June 20, 2014, http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5474.
[71] The Chicago School of Professional Psychology, *NSF/OURS Program*, accessed June 20, 2014, http://www.thechicagoschool.edu/NSFOURS_Program.

new solutions to human capital issues in science and engineering.[72] NSF's Advanced Technological Education (ATE) Program offers some insights for engaging diverse communities for integrative thinking in emerging technical fields that resulted in mutually beneficial societal impacts. This program is an example of linking academic and industrial partners to regional communities with impressive outcomes related to an appreciation for STEM technical careers and employment diversity, workforce benefits related to economic development, and cutting-edge technician education. The ATE program has supported educators from two-year colleges in leading initiatives that improve the skills of technicians and develop strong connections with regional and national employers of technicians in fields like energy and environmental technologies, micro- and nanotechnologies, and geospatial and security technologies. These collaborations among community colleges, secondary schools, universities, and industries have become the national model for addressing the technical workforce and technician education challenges for the 21st century.[73] NSF's Innovation Corps (described in detail below) is another example of this approach.

7. Promote innovative academic-industry partnerships.

A particularly relevant NSF program that encourages public-private partnership, fosters entrepreneurship, and develops and nurtures an innovation ecosystem at the local and national levels is the NSF Innovation Corps (I-Corps). I-Corps teams are comprised of academic researchers, student entrepreneurs, and business mentors that participate in a targeted I-Corps curriculum that builds upon experience from established entrepreneurs. Academic institutions serving as I-Corps sites support multiple local teams as they transition their technology concepts into the marketplace. I-Corps is building human capital by developing entrepreneurial knowledge and skills among scientists and engineers. I-Corps contributes to the innovation ecosystem—comprised of the people, institutions, policies, and resources that promote the translation of new ideas into products, processes, and services—by fostering innovation among higher education faculty and students, as well as promoting regional and national coordination.[74]
NSF supports other academic-industry partnerships, particularly through its Industrial Innovation and Partnerships (IIP) division. This division works across NSF to support technological breakthroughs that benefit society and enable academic researchers to undertake the translation of fundamental research and discovery. Programs managed or supported through IIP include:

- Industry/University Cooperative Research Centers (I/UCRC) program develops long-term partnerships among industry, academe, and government, as well as conduct research that is of interest to both industry members and center faculty.
- Partnerships for Innovation (PFI) program is an umbrella for two complementary subprograms that focus on different stages of the movement of academic research into the marketplace. One subprogram emphasizes the transformation of knowledge to market-accepted innovations created by the research and education enterprise, and the other

[72] Marilyn J. Amey, Dennis F. Brown, and Lorilee R. Sandmann, "A Multidisciplinary Collaborative Approach to a University-Community Partnership: Lessons Learned," *Journal of Higher Education Outreach and Engagement* 7, no. 3 *(Spring/Summer 2002)*: 19-26.
[73]Madeline Patton, ed., *ATE Centers Impact 2014: Partners with Industry for a New American Workforce* (Tempe, AZ: Maricopa Community Colleges, 2014).
[74] National Science Foundation, *Innovation Corps Teams Program (I-Corps Teams)*, NSF 12-602 Program Solicitation (Arlington, VA: printed by author, 2012), http://www.nsf.gov/pubs/2012/nsf12602/nsf12602.pdf.

emphasizes the translation of research to commercialization by NSF-funded research alliances.

- Grant Opportunities for Academic Liaison with Industry (GOALI) is an initiative that aims to synergize university-industry linkages by making funds available to an eclectic mix of activities. GOALI particularly funds high-risk/high-gain research with a focus on fundamental topics that would not have been undertaken by industry; new approaches to solving generic problems; development of innovative collaborative industry-university educational programs; and direct transfer of new knowledge between academe and industry. [75]

As previously described, NSF is, among other things, a catalyst for university action and change. The seven strategies listed above, exemplified by current and past NSF programs, have been central to engaging higher education institutions in improving STEM diversity.

[75] National Science Foundation, *Industrial Innovation and Partnerships Division (IIP),* accessed June 20, 2014, http://www.nsf.gov/eng/iip/about.jsp.

Building Upon NSF's Current Efforts

NSF should be commended for its leadership and collaboration with universities to increase STEM diversity, particularly through broadening participation programs. More, however, must be done. Systemic and transformative changes are needed to truly realize STEM equity.

The U.S. has the capacity (and a timely opportunity) to initiate an ambitious STEM education and workforce development strategy grounded in multiple partners to ensure constant and meaningful engagement in developing diverse STEM talent and motivating historically underrepresented students to maintain their interest in science and maximize their quantitative and analytical skills for STEM and non-STEM careers.

Higher education-community engagement can be the catalyst and driver for this approach. It is essential to work with schools and school districts in a coordinated manner to promote consistent contact with teachers and continuous engagement with students from pre-kindergarten through higher education. In other words, STEM talent for discovery and innovation must be developed at all ages. Therefore, a comprehensive, truly systemic response is one that is not only P-20+ inclusive, but one that also engages a range of partners to solve the multidimensional bases of STEM challenges. The expanded partnership or alliances of institutions, involving business/industry and community partners, is viewed as transformative since the work of the collaboration will go beyond a pedagogical/instrumentation focus to a broader strategy—one that addresses the multiple disadvantages facing those left behind in STEM to reduce and eventually eliminate disparities and enrich the quality of life of all.

A P-20+ partnership approach, with the inclusion of industry partners and local community agencies, can identify and focus on the skills needed for the 21^{st} century STEM workforce. This approach, while emphasizing the education of the next generation of scientists and engineers, will also help effectively educate a STEM workforce in the emerging sub-disciplinary fields and interdisciplinary careers in science and engineering, as well as journalists, lawyers, and economists. This also includes adding Art to the subjects of Science, Technology, Engineering, and Math, toward developing a national agenda focused on "STEAM" education and research, which would open up new fields and careers, draw increased interest from a diverse future generation, and spur further innovation. Indeed, innovative, collaborative, integrative, and focused partnerships that involve government, industry, community, and academic institutions are needed to create a sustainable world-class STEM workforce at all levels and ranges of STEM employment.

America is well-positioned to link high quality STEM opportunities and experiences from pre-kindergarten through advanced careers by nurturing the long-term commitment of business and industry to a diverse partnership model. High quality, sustainable efforts involving partners from diverse organizations have demonstrated that business-community partnerships offer invaluable opportunities for new work relationships and multi-tiered mentoring experiences, which are essential in attracting and retaining world-class STEM professionals comprised of both the STEM instructional and scientific workforce.

University partnerships with their local communities have empowered the general public to not only become more scientifically literate, but also become part of the solution for promoting innovation through diversity. The engagement of demographically diverse partners within communities is essential in advocating for quality education in general, talent development for careers in science nationally, and local societal benefits resulting from local investments in STEM. Additionally, public support is needed to effectively highlight that students at all levels must be proficient in mathematics and science for future careers that require scientific and technological literacy for employability in both STEM and non-STEM degree-specific jobs.

In addition to a cross-sector, multi-institutional approach for broadening participation, it is important to enrich the perspectives about current and future STEM challenges through international collaborations. Expanding geographical boundaries to include and leverage international collaborators working on STEM education and career development is a unique feature of the proposed higher education-community engagement model.

Findings and Recommendations from the International Workshops

It is in this spirit of global engagement that two international workshops were held on higher education-community engagement and STEM. The first was hosted by the University of Pennsylvania in February 2012. The second was hosted by the Durban University of Technology in Durban, South Africa in December 2012.

The deliberations at both international workshops produced a deeper understanding of STEM challenges and opportunities and how to advance the work through a higher education-community engagement strategy. Moreover, the results seem to confirm the value of international collaboration and that such collaborations are worth exploring and developing over time as an important component for increasing STEM equity.[76]

Presented below are the key findings and recommendations from the U.S. workshop, along with clarifications and new findings and recommendations made during the workshop in South Africa. The findings are organized into three general areas: new conceptualizations and core concepts, new approaches to research and knowledge generation, and new global community.

New Conceptualizations and Core Concepts

1. *Redefine the challenge of increasing STEM diversity as "Realizing the STEM Imperative through Higher Education-Community Engagement (HE-CE)."*

In its 2011-2012 biennial report, the Committee on Equal Opportunities in Science and Engineering (CEOSE) commends NSF for outstanding leadership in broadening participation in STEM throughout the government and America's scientific community.[77] The report also emphasizes the changing nature of STEM. It describes how the increase in challenges to

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[76] For example, South African colleagues shared innovative approaches to higher education-community engagement, including dedicated funding programs. The South Africa Council on Higher Education (1997) and its quality assessment unit, the Higher Education Quality Committee (HEQC), established "knowledge based community service" as a requirement for program accreditation and quality assurance and made reporting on community engagement mandatory for institutional audits. "One of the consequences of the HEQC audits has been the institutionalization of community engagement in South African universities," including the establishment of offices of community engagement in all 21 universities. The National Research Foundation (NRF) of South Africa released its *Vision 2015* strategic plan in 2008, which identified a number of strategic investment areas including community engagement. "The decision to initiate investment in community engagement signaled the NRF's commitment to better support research into and about community engagement for knowledge production, innovation and human capital development to align more closely with the higher education mandate of research, teaching and community service/engagement." The NRF's inaugural Community Engagement Program was launched in 2010 and awarded approximately $116 million to 17 projects over a three-year period. See Andrew M. Kaniki and Candice Steele, "Community Engagement Landscape in South African Higher Education and Critical Issues of Science, Technology, Engineering and Mathematics (STEM)" (Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration, University of Pennsylvania, Philadelphia, PA, February 2012), quotes on pp. 3 and 4.

[77] Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report.*

U.S. competitiveness; complex domestic security issues; the creative advantages of achieving workforce diversity; and the drive to realize America's democratic principles and promise of equal opportunity for all require more multidisciplinary, innovative, transformative intellectual work designed to achieve the genuine inclusion of all citizens in STEM education and in the STEM workforce. Most importantly, the CEOSE report recommends:

> NSF should implement a bold new initiative, focused on broadening participation of underrepresented groups in STEM, similar in concept and scale to NSF's centers, that emphasizes institutional transformation and system change; collects and makes accessible longitudinal data; defines clear benchmarks for success; supports the translation, replication and expansion of successful broadening participation efforts; and provides significant financial support to individuals who represent the very broadened participation that we seek.[78]

The CEOSE report further suggests that higher education-community partnerships are a means to develop "a bold new initiative:"

> This initiative might include several multisite, geographically-based, national experiments of foundational and implementation research involving universities, schools, and communities. The ongoing research experiments would be inclusive of all underrepresented populations and would be designed to significantly advance broadening participation across all levels of schooling, resulting in sustainable pathways preK-20+.[79]

2. *Establish core principles and strategies of Higher Education-Community Engagement, notably interdependence, mutual learning, and mutual benefits, which lead to mutuality of change within both the university and the community.*

Principles of mutuality, for example, are at the core of the growing Anchor Institutions Task Force (AITF). In 2009, a national task force coordinated by the University of Pennsylvania advised the U.S. Department of Housing and Urban Development (HUD) on how the agency could leverage anchor institutions, particularly institutions of higher education and medical centers ("eds and meds"), to improve communities and help solve significant urban problems. Soon after the Anchor Institutions Task Force submitted its report, *Anchor Institutions as Partners in Building Successful Communities and Local Economies*, it became an ongoing organization with the mission of forging democratic civic partnerships involving anchor institutions. The Task Force is guided by the core values of collaboration and partnership, equity and social justice, democracy and democratic practice, and commitment to place and community. With approximately 600 individual members, the Anchor Institutions Task Force is an important

[78] Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report*, 1.
[79] Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report*, 21.

voice for increasing the engagement of anchor institutions in their localities and regions in the United States and around the world.[80]

3. *Provide recognition and incentives for collaboration.*

The Anchor Institutions Task Force 2009 report to HUD, for example, includes recommendations calling for federal government to utilize financial incentives, awards, and the bully pulpit to help colleges and universities realize their public mission through local, collaborative engagement. The Task Force specifically calls for creating federal awards to universities and their community partners that recognize outstanding contributions to improving the quality of life in the local community, as well as advancing knowledge. It also calls for establishing a federal commission to produce recommendations that might lead to a "National Summit or White House Conference on the Civic Responsibility of Higher Eds and Meds." Perhaps most importantly, the Anchor Institutions Task Force proposes that federal support be based on the "Noah Principle"—that is, "funding given for building arks (producing real change), not for predicting rain (describing the problems that exists and will develop if actions are not taken)."[81]

4. *Community engagement can be a driver and champion for human resource development through building the scientific workforce.*

As previously referenced, the Learning Subgroup of the Advisory Committee for GPRA Performance Assessment of NSF states, "Connecting a major research project with a highly successful community program and outreach efforts to school children is extraordinarily innovative, creative, and significant."[82] An example cited in this assessment report is an NSF-sponsored collaboration between the Harlem Children's Zone, a major school and community improvement program, and the research of Cornell Professor Itai Cohen, who focuses on understanding materials properties through experimentation with colloidal materials. Professor Cohen engages first grade students in hands-on science exploring the characteristics of everyday and unusual materials. The Subgroup's report concludes, "The project offers a model for integrating frontier research with frontier educational and community outreach involving STEM and underrepresented minorities." [83]

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[80] Task Force on Anchor Institutions, "Anchor Institutions as Partners in Building Successful Communities and Local Economies," in *Retooling HUD for a Catalytic Federal Government: A Report to Secretary Shaun Donovan*, by Paul C. Brophy and Rachel D. Godsil (Philadelphia: Penn Institute for Urban Research, 2009), 147-169. The global reach of the anchor institution concept is noteworthy. At a 2014 Global Forum hosted in Belfast on "Higher Education and Democratic Innovation," for example, Snežana Samardžić-Marković, the Director General of Democracy for the Council of Europe, called for the creation of a network of anchor institutions in Europe.
[81] Task Force on Anchor Institutions, "Anchor Institutions," full report and quote on p. 154.
[82] Spencer and Dawes, *Report*, 35.
[83] Spencer and Dawes, *Report*, 35.

5. Build cross-sector partnerships as an ecosystem that allows for full inclusion.

For example, Building Engineering & Science Talent (BEST) is an independent, public-private partnership established in 2001 at the recommendation of the Congressional Commission on the Advancement of Women in Science, Engineering, and Technology. BEST's 2004 report states that "community-based collaborations of industry, government, education and the nonprofit sectors must work together to create long-term, coordinated, adequately funded, fiscally stable partnerships in math and science education."[84]

Cross-sector partnerships promote learning in both formal and informal settings. They also provide multiple educational pathways that are responsive to higher education, communities, and individual styles of learning, covering the wide spectrum of STEM literacy to proficiency. In particular, K-12 schools, as centers of community, have been crucial sites for more inclusive and effective STEM education.

As previously cited, the National Academies' *Expanding Underrepresented Minority Participation*, a study led by Freeman A. Hrabowski, III, Chair of the Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline, provides recommendations for broadening participation that "span the entire educational system and full spectrum of stakeholders."[85] Nancy Cantor and Peter Englot further highlight the benefits of cross-sector partnerships:

> As we become steeped in the value of working on complex challenges, from K–12 education, to environmental degradation, to intercultural conflict, in these diverse communities of experts—filled with citizens, professionals, and academicians alike—we come to much more authentically and organically understand the hard work it takes to navigate across difference (defined on many dimensions).[86]

Such partnerships begin to realize what Susan Sturm calls "the architecture of inclusion."[87]

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[84] Building Engineering & Science Talent, *A Bridge for All: Higher Education Design Principles to Broaden Participation in Science Technology, Engineering, and Mathematics* (San Diego: BEST, February 2004), 32.

[85] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, *Expanding Underrepresented,* 12. The study particularly recommends improved academic, social, and financial support to increase retention and completion of underrepresented minorities in STEM, as well as emphasizes improved K-12 teacher preparation and secondary school programs that better prepare students for STEM education in college.

[86] Nancy Cantor and Peter Englot, "Beyond the 'Ivory Tower': Restoring the Balance of Private and Public Purposes of General Education," *The Journal of General Education: A Curricular Commons of the Humanities and Sciences* 62, no. 2-3 (2013):122.

[87] Sturm, "The Architecture." Like Sturm, we particularly recognize NSF's ADVANCE program for strategically investing in institutional change strategies that remove barriers and increase inclusion and advancement of women in academic science and engineering careers.

6. Envision a new community, a rich ecosystem that includes both higher education and the community, for producing social cohesion, equity, diversity, and inclusion.

Through this lens of a rich ecosystem, community engagement is the appropriate venue for STEM learning, social cohesion, equity, diversity, and inclusion, providing environments that effectively foster creativity, innovation, and inventiveness. In order to build a sense of social cohesion, this new community must be explicitly inclusive. It must also be built on trust, reciprocity, mutual learning and understanding, as well as include paradigmatic changes in the approach to research and knowledge generation (more details below). The BEST report describes community engagement as one of four building blocks for a national strategy to increase higher education's contributions to broadening participation in STEM. The report claims:

> Communities can provide a strong foundation for capacity-building partnerships across the nation for three reasons. First the prosperity of every community in America hinges on the quality of its workforce. Second, all of the major institutional stakeholders in technical workforce development are community-based: pre-K-12 schools, community colleges, teacher's colleges, technical degree-granting institutions and employers of scientists and engineers. Third, many communities have large populations of underrepresented minorities. While these are not the only talent pools that need to be further developed, they are nation's fastest-growing groups….The inherent diversity among U.S. communities is the scaffolding on which higher education can build a more diverse science and engineering workforce.[88]

The report further argues for the importance of higher education engagement. It points out that "America's colleges and universities are still place-based. The marshaling of key resources within a community will develop its local workforce and, thereby, contribute to the national production of talent." [89]

Globalization and technological advances, including online learning, are certainly changing the way that higher education course material is delivered. At the same time, higher educational institutions, as the BEST report states, "are still place-based." The globalization strategy proposed here is a place-based one, in which each partnership focuses on locally manifested universal problems, including poor schooling, educational attainment gaps, eroding environments, inadequate healthcare, poverty, high levels of economic inequality, and a lack of social cohesion.[90]

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[88] Building Engineering & Science Talent, *A Bridge*, 6.
[89] Building Engineering & Science Talent, *A Bridge*, 24.
[90] For an impressive discussion of the local and global nature of higher educational institutions prior to the rapid advance of online learning, see Edward Shils, "The University, the City, and the World: Chicago and the University of Chicago," in *The University and the City: From Medieval Origins to the Present*, ed. Thomas Bender (New York: Oxford University Press, 1988), pp. 210-30.

As noted above, this new community includes paradigmatic changes in the approach to research and knowledge generation, shifting:

- From a project/program to an ecological system (the new community is an end in itself)[91]
- From zero-sum competition and conflict to expanded resources (e.g., federal and other research dollars) through cooperation and collaboration focused on real-world community problem solving—this includes decreased competition/increased collaboration among individual scientists, within institutions (intra-institution), and between institutions (inter-institution)[92]
- From neutral observation to active participation, including researchers' involvement with the community from problem definition through implementation[93]
- From the academic periphery to the core of the academic institution and therefore integrated into the institution's teaching and research.[94]

7. *A core component of the new community would be a conceptualization that moves beyond competition to collaboration as necessary for developing an innovative society.*

In 2005, Joseph Bordogna, then Deputy Director of NSF, spoke of the importance of collaboration for innovation to a seminar hosted by the French-American Foundation and the France's National Association for Research and Technology, where he references Vannevar Bush's vision: "The NSF process—how we select and support research at the frontier—is based on three integrative strategies: develop intellectual capital; integrate research and education; and promote partnerships." Bordogna continues, "The third strategy, promote partnerships, is at the core of the NSF process. *Science – The Endless Frontier* stressed the importance of partnership from the onset by declaring, 'Science can be effective… only as a member of a team.' This concept of teamwork, of partnership and collaboration, underpins all of NSF's operations today."[95]

Promoting interdisciplinary research is a key means for advancing the integrative strategies Bordogna identifies. In his article, "Ethnocentrism of Disciplines and the Fish-Scale Model of

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[91] Nancy B. Grimm et al., "Integrated Approaches to Long-Term Studies of Urban Ecological Systems, *BioScience* 50, no. 7 (July 2000): 571-584. Grimm et al. discuss the importance of the study of urban ecological systems, and the need to integrate social, behavioral, and economic sciences to understand urban ecosystems and how they change.

[92] For an example of multi-institution and multi-sector partnerships that have attracted outside resources, see the case study of Syracuse University in Rita A. Hodges and Steve Dubb, *Road Half Traveled: University Engagement at a Crossroads* (East Lansing: Michigan State University Press, 2012).

[93] William F. Whyte, Davydd J. Greenwood, and Peter Lazes, "Participatory Action Research: Through Practice to Science in Social Research," in "Action Research for the 21st Century: Participation, Reflection, and Practice," ed. William F. Whyte, special issue of *American Behavioral Scientist* 32, no. 5 (May 1989): 513-551; Davydd J. Greenwood, William F. Whyte, and Ira Harkavy, "Participatory Action Research as a Process and as a Goal," *Human Relations* 46, no. 2 (February 1993): 175-192.

[94] Ernest L. Boyer, *Scholarship Reconsidered*; Bok, *Universities and the Future*.

[95] Joseph Bordogna, "The Promotion of Excellence in Research: The Experience of the National Science Foundation," (speech, FAF/ANRT Seminar, Paris, April 8, 2005), http://www.nsf.gov/news/speeches/bordogna/05/jb050408_frenchamerica.jsp.

Omniscience," Donald Campbell discusses the challenges of interdisciplinary work and offers a model to facilitate collaboration:

> The "fish-scale model of omniscience" represents the solution advocated, a solution kept from spontaneous emergence by the ethnocentrism of disciplines. The slogan is collective comprehensiveness through overlapping patterns of unique narrownesses. Each narrow specialty is in this analogy a "fish-scale." … Our only hope of a comprehensive social science, or other multiscience, lies in a continuous texture of narrow specialties which overlap with other narrow specialties. Due to the ethnocentrism of disciplines, what we get instead is a redundant piling up of highly similar specialties, leaving interdisciplinary gaps. Rather than trying to fill these gaps by training scholars who have mastered two or more disciplines, we should be making those social-organizational inventions which will encourage narrow specialization in these interdisciplinary areas.[96]

Regardless of the validity of his specific proposal, Campbell persuasively describes the necessity of collaboration for innovation and the generation of new knowledge:

> What must be recognized is that this integration and comprehensiveness is a collective product, not embodied within any one scholar. It is achieved through the fact that the multiple narrow specialties overlap, and that through this overlap a collective communication, a collective competence and breadth, is achieved. This approach is our only hope for a unified and complete behavioral science. The present social organization of science impedes it.[97]

Building upon, but offering a very different approach than Campbell, William Trochim calls for an "evaluation culture [that] will need to be an *interdisciplinary* one, doing more than just grafting on discipline onto another through constructing multi-discipline research teams [emphasis in original]." Trochim further specifies, "We'll need such teams, of course, but I mean to imply something deeper, more personally internalized—we need to move toward being nondisciplinary, consciously putting aside the blinders of our respective specialties in an attempt to foster a more whole view of the phenomena we study."[98]

A recent powerful example of collaboration for scientific discovery is the "Prevent Alzheimer's Disease 2020" project, which makes the case for the organization of a worldwide cooperative research network to better understand and treat aging-related neurodegenerative diseases.[99] A classic example of collaboration with practitioners is Kurt Lewin's work with the Commission on Community Interrelations (C.C.I.), begun in 1944, which involved action research on community affairs, focusing on minority problems, ethnocultural conflict, and discriminatory

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[96] Donald T. Campbell, "Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience," in *Interdisciplinary Relationships in the Social Sciences*, eds. Muzafer Sherif and Carolyn W. Sherif, (Piscataway, NJ: Aldine, 1969), 328.
[97] "Ethnocentrism," 330.
[98] William M. Trochim, *The Research Methods Knowledge Base, 2nd Edition* (version current as of October 20, 2006), under "An Evaluation Culture," para. 7, http://www.socialresearchmethods.net/kb/.
[99] John Q. Trojanowski et al., "Design of Comprehensive Alzheimer's Disease Centers to Address Unmet National Needs," *Alzheimer's and Dementia* 6, no. 2 (March 2010): 150-155.

attitudes and behaviors. As described by Alfred Marrow, "[Lewin] stated that, whenever possible, C.C.I. should conduct its studies in cooperation with other agencies carrying on programs of action against prejudice." Marrow further claims, "At every step of his investigation, he would have to bear in mind the attitudes of his lay collaborators and sponsors, as well as those of the general public. The research staff would have to consider the community as seriously as it took its own research."[100]

8. Establish a community of practice through a systems-thinking approach that embeds teaching/learning, research, and community engagement holistically.

A "community of practice," defined by Jean Lave and Etienne Wenger, describes a group of people who have a shared interest and develop a variety of activities and shared resources focused on that issue.[101] Wenger emphasizes the power of communities of practice: "As a locus of engagement in action, interpersonal relations, shared knowledge, and negotiation of enterprises, such communities hold the key to real transformation—the kind that has real effects on people's lives."[102]

For example, NSF's ADVANCE program directly supports Partnerships for Learning and Adaptation Networks (PLAN) to create a "community of adapters" that identifies and documents the effectiveness of ADVANCE activities for adaptation into different institutional contexts.[103] Imagining America also promotes a "scholarly community of practice" that "work[s] with the public—with community partners, in collaborative problem-solving groups, through projects that connect knowledge with choices and actions."[104]

Civic scientists, as described by Neal Lane, former director of NSF and science advisor to the president of the United States, would serve as important members of the community of practice, working with others to increase understanding of and support for science.[105] According to Lane:

> A 'civic scientist' is a scientist who uses his or her knowledge, accomplishments, and analytical skills to help bridge the gaps between science and society. They do this in many ways: by advising and serving in government, by working in national

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[100] Alfred J. Marrow, *The Practical Theorist: The Life and Work of Kurt Lewin* (New York: Basic Books, 1969), quotes on pp. 192 and 200.
[101] Jean Lave and Etienne Wenger, *Situated Learning: Legitimate Peripheral Participation* (New York: Cambridge University Press, 1991); Etienne Wenger, *Communities of Practice: Learning, Meaning, and Identity* (New York: Cambridge University Press, 1998).
[102] Wenger, *Communities*, 85.
[103] See National Science Foundation, *ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE)*, NSF 14-573 Program Solicitation (Arlington, VA: printed by author, 2014), http://www.nsf.gov/pubs/2014/nsf14573/nsf14573.htm.
[104] Julie Ellison and Timothy K. Eatman, *Scholarship in Public: Knowledge Creation and Tenure Policy in the Engaged University* (Syracuse, NY: Imagining America, 2008), p. x.
[105] Building upon Lane's idea of civic scientist, NSF sponsored a "civic science" workshop in October 2014. As described in the abstract, "This workshop will bring together scientists, philosophers, administrators, community organizers, policy makers, and legislators to examine civic science. The main goals are to delineate what civic science is, to specify how it differs from citizen science and activist street science, and to generate best practices for civic science. Available at http://www.nsf.gov/awardsearch/showAward?AWD_ID=1352822.

> laboratories or in industry to directly connect discovery with use, and by educating the general population about science and technology—what it is, and how it impacts people's lives.[106]

New Approaches to Research and Knowledge Generation

1. *Knowledge generation is what is being described (rather than knowledge production); knowledge can be effectively developed through a new paradigm, one that emphasizes multi-generational co-learning, co-teaching, and co-generation of knowledge.*

The infrastructure for generating knowledge typically resides in the university, but we must broaden this understanding to include a community of practice, as described above. Nancy Cantor, Peter Englot, and Marilyn Higgins describe the importance of "[moving] beyond the one-way flow of intellectual capital (and technology transfer) independently generated within the ivory tower and given to (or perhaps foisted upon) communities."[107] Instead, they argue, broad and diverse "communities of experts" should be created that include those "from within and outside the academy that draw on diverse collective expertise to make a difference. If universities want to take on the economic, environmental, educational, social, and health challenges of metropolitan America, and revive the nation's urban cores, they must merge *innovation* and *full participation* [emphasis in original]."[108]

Cantor, in an interview with Satya Mohanty, further describes the approach this way: "We can all partner and collaborate in deep and sustained ways with a diverse 'community of experts'—residents, business leaders, elected officials, school children and grandmothers, faith leaders, social activists and entrepreneurs, together change the odds for individuals, neighborhoods, and whole cities and regions." Cantor also discusses the local and global significance of this approach: "And, when we do it close at home, we find that though all work is local, there is much that resonates and ripples across the nation's and the globe's geographies of opportunity."[109] Moreover, Scott Page's research on the power of diversity suggests that broad and diverse communities of experts produce the best conditions for truly innovative problem solving and will enrich science.[110]

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[106] Neal Lane, "Science and Technology Policy: Advice in Government Panel" (paper presented at Bridging the Gap Between Science and Society: The Relationship Between Policy and Research in National Laboratories, Universities, Government, and Industry, Rice University, Houston, TX, November 1-2, 2003), 187-188.
For Lane's introduction of the concept of civic scientist, see his, "Benjamin Franklin, Civic Scientist," *Physics Today* 56, no. 10. (October 2003), 41-46.

[107] Nancy Cantor, Peter Englot, and Marilyn Higgins, "Making the Work of Anchor Institutions Stick: Building Coalitions and Collective Expertise," *Journal of Higher Education Outreach & Engagement* 17, No. 3 (June 2013): 20-21.

[108] Cantor, Englot, and Higgins, "Making," 20-21. For discussion of engaging community partners as co-creators of public goods, see David Scobey, "Putting the Academy in its Place," *Places* 14, no. 3 (Summer 2002), 50-55.

[109] Satya Mohanty and Nancy Cantor, "Why Diversity is not a Luxury," *ZNET*, January 17, 2014, http://zcomm.org/znetarticle/why-diversity-is-not-a-luxury-an-interview-with-nancy-cantor/.

[110] Page, *The Difference*.

2. *New forms of research and evaluation are needed to assess the multi-faceted, multi-domain aspects of this approach.*[111]

There should be an ecological approach to research and evaluation. The complexity of this approach involves specialized researchers and evaluators who are grounded in this type of work.[112] Furthermore, there is a radical difference between researching as a detached observer versus as an active participant. As participants, researchers have access to insider knowledge that only can be gained by developing trust through partnership.[113]

In the *Structure of Science: Problems in the Logic of Scientific Explanation*, the distinguished philosopher of science Ernest Nagel highlights the limitations of a narrow, dogmatic application of traditional scientific method—which involves formulating a hypothesis and conducting a structured experimental model that controls for extraneous variables.

> The difference just described can be expressed by the dictum that the conclusions of science, unlike common-sense beliefs, are the products of scientific method. However, this brief formula should not be misconstrued. It must not be understood to assert, for example, that the practice of scientific method consists in following prescribed rules for making experimental discoveries or for finding satisfactory explanations for matters of established fact. There are no rules of discovery and invention in science any more than there are such rules in the arts. Nor must the formula be construed as maintaining that the practice of scientific method consists in the use in all inquiries of some special set of techniques (such as the techniques of measurement employed in physical science), irrespective of the subject matter or the problem under investigation. Such an interpretation of the dictum is a caricature of its intent; and in any event the dictum on that interpretation is preposterous.[114]

In a similar vein, Donald Schön, in discussing the dilemma of rigor or relevance faced by practitioners, argues that finding solutions to different kinds of problems requires different approaches and methods:

> In the varied topography of professional practice, there is a high, hard ground over looking a swamp. On the high ground, manageable problems lend themselves to solution through the use of research-based theory and technique. In the swampy lowlands, problems are messy and confusing and incapable of technical solution. The irony of this situation is that the problems of the high ground tend to be relatively unimportant to individuals or to society at large,

[111] Schön, "Knowing-in-Action."
[112] Eugene J. Webb et al., *Unobtrusive Measures: Revised Edition* (Thousand Oaks, CA: Sage Publications, 2000).
[113] Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1985) and "Knowing-in-Action;" Lewin, "Problems;" William F. Whyte, "Advancing Scientific Knowledge through Participatory Action Research," *Sociological Forum* 4, no. 3 (September 1989): 367-385; Whyte, Greenwood, and Lazes, "Participatory Action Research."
[114] Ernest Nagel, *The Structure of Science: Problems in the Logic of Scientific Explanation* (Indianapolis, IN: Hackett Publishing, 1979), 12-13.

> however great their technical interest may be, while in the swamp lie the problems of greatest human concern.[115]

Providing an alternative to the traditional scientific research process, William Foote Whyte describes the methodology of Participatory Action Research (PAR): “In PAR the researcher combines participant observation with explicitly recognized action objectives and a commitment to carry out the project with the active participation in the research process by some members of the organization studied.”[116] Davydd Greenwood, William F. Whyte, and Ira Harkavy further describe PAR as “a form of action research in which professional … researchers operate as full collaborators with members of organizations in studying and transforming those organizations. It is an ongoing organizational learning process, a research approach that emphasizes co-learning, participation, and organizational transformation.”[117]

As previously referenced, Trochim envisions a new “evaluation culture” that builds on the work of Campbell’s 1969 article, “Methods for the Experimenting Society.”[118] Trochim’s proposed approach to research and evaluation would “embrace an *action-oriented* perspective that actively seeks solutions to problems, trying out tentative ones, weighing the results and consequences of actions, all within an endless cycle of supposition-action-evidence-revision that characterizes good science and good management [emphasis in original].”[119] Trochim also emphasizes the importance of broadened participation in research:

> Our evaluation culture will be *diverse, inclusive, participatory, responsive and fundamentally non-hierarchical*. World problems cannot be solved by simple "silver bullet" solutions. There is growing recognition in many arenas that our most fundamental problems are systemic, interconnected, and inextricably linked to social and economic issues and factors. Solutions will involve husbanding the resources, talents and insights of a wide range of people. The formulation of problems and potential solutions needs to involve a broad range of constituencies [emphasis in original].[120]

3. Sustainability is achieved through long-term, dynamic engagement and continuous problem-solving.

John Dewey, in his development of the theory of instrumental intelligence, advanced an approach based on continuous problem-solving and ongoing learning.[121] Kurt Lewin further

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[115] Schön, “Knowing in Action,” 28.
[116] Whyte, “Advancing Scientific Knowledge,” 369.
[117] Davydd J. Greenwood, William F. Whyte, and Ira Harkavy, “Participatory Action Research as a Process and as a Goal, *Human Relations* 46, no. 2 (February 1993): 175-192.
[118] David T. Campbell, “Methods for the Experimenting Society,” *American Journal of Evaluation* 12, no. 3 (October 1991): 223-260.
[119] Trochim, *Research Methods*, under “An Evaluation Culture,” para. 3.
[120] Trochim, *Research Methods*, under “An Evaluation Culture,” para. 5.
[121] Benson, Puckett, Harkavy, *Dewey’s Dream.*

advanced that approach and applied it within the field of social psychology. Lewin famously wrote that, “If you want to truly understand something, try to change it.”[122]

Building upon the insights of Dewey and Lewin, Donald Schön sharpened this theory of learning and extended it to a number of fields and disciplines. Schön provides a particularly clear summary of this process, described in the extended quotation below:

> The process of reflection-in-action begins when a spontaneous performance—such as riding a bicycle, playing a piece of music, interviewing a patient, or teaching a lesson—is interrupted by surprise. Surprise triggers reflection directed both to the surprising outcome and to the knowing-in-action that led to it. It is as though the performer asked himself, “What is this?” and at the same time, “What understandings and strategies of mine have led me to produce this?” The performer restructures his understanding of the situation—his framing of the problem he has been trying to solve, his picture of what is going on, or the strategy of action he has been employing. On the basis of this restructuring, he invents a new strategy of action and tries out the new action he has invented, running an on-the-spot experiment whose results he interprets, in turn, as a “solution,” an outcome on the whole satisfactory, or else as a new surprise that calls for a new round of reflection and experiment.[123]

In effect, Dewey, Lewin, and Schön argue that the best way to understand a problem (or any phenomenon) is to actively work to change that condition and to reflect on what has been accomplished—in other words, to engage in a process of continuous active and reflective problem-solving.

4. Through engagement in their local communities, researchers and higher education institutions can see whether or not their ideas actually work in practice and adapt solutions more quickly.

Scholars and practitioners who write on participatory action research emphasize the importance of including community members as full participants in the process, as well as focusing on a particular problem in a local context.[124] William F. Whyte, Davydd Greenwood, and Peter Lazes, for example, write: "In participatory action research, some of the people in the organization or community under study participate actively with the professional research through the research process form the initial design to the final presentation of results and discussion of their action implications.”[125]

Lee Benson, Ira Harkavy, and John Puckett describe the many benefits of a local community focus for college and university engagement generally: “Ongoing, continuous, interaction is

[122] Kurt Lewin, quoted in James Neill, “Field Theory - Kurt Lewin,” Wilderdom, last updated April 20, 2004, http://www.wilderdom.com/theory/FieldTheory.html.
[123] Schön, “Knowing in Action,” 30.
[124] Francis E. Johnston and Ira Harkavy, *The Obesity Culture: Strategies for Change—Public Health and University-Community Partnerships* (London: Smith-Gordon & Co., 2009), 39.
[125] Whyte, Greenwood, and Lazes, “Participatory Action Research,” 514.

facilitated through work in an easily accessible location. Relationships of trust, so essential for effective partnerships and effective learning, are also built through day-to-day work on problems and issues of mutual concern." In addition, they state, "The local community provides a convenient setting in which a number of service-learning courses, community-based research courses, and related courses in different disciplines can work together on a complex problem to produce substantive results." This work, therefore, facilitates significant opportunities for interdisciplinary learning. The authors conclude that the local community is "a democratic real-world learning site in which community members and academics [can] pragmatically determine whether the work is making a real difference, and whether both the neighborhood and the institution are better as a result of common efforts."[126]

The BEST report (2004) also identifies the importance of implementing STEM projects locally: "Strategies need to be built on the back of tested theory and controlled research. But they need to be implementable locally, tested, and tweaked until they work within that community environment…. This information can then be shared and used both locally and nationally."[127]

5. The integration of community engagement into research leads to new learning and insights, including "creative surprises," unexpected findings and conclusions.[128]

In describing the set of assumptions for Participatory Action Research, Whyte argues, "The standard model does not represent the one and only way to advance scientific knowledge." Instead, he encourages a "research strategy that maximizes the possibility of encountering creative surprises." He emphasizes, "Those creative surprises are most likely to occur if we get out of our academic morass and seek to work with practitioners whose knowledge and experience is quite different from our own."[129]

6. Higher Education-Community Engagement work is academic at its core.[130]

In the first report produced by what is now known as The Research Universities and Civic Engagement Network (TRUCEN), Cynthia Gibson argues, "Engaged scholarship is predicated

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[126] Lee Benson, Ira Harkavy, and John Puckett, "Democratic Transformation through University-Assisted Community Schools," in "*To Serve a Larger Purpose": Engagement for Democracy and the Transformation of Higher Education*¸ eds. Matthew Hartley and John Saltmarsh (Philadelphia: Temple University Press, 2011), 50-81, quotes on page 70.
[127] Building Engineering & Science Talent, *A Bridge*, 27.
[128] Whyte, "Advancing Scientific Knowledge," 383-384.
[129] Whyte, "Advancing Scientific Knowledge," 383-384.
[130] Boyer, *Scholarship Reconsidered*; Bok, *Universities and the Future*; Benson, Harkavy, and Puckett, "Democratic Transformation;" Cynthia M. Gibson, *New Times Demand New Scholarship: Research Universities and Civic Engagement: Opportunities and Challenges: A Leadership Agenda* (Medford, MA: Tufts University and Campus Compact, 2006), http://www.compact.org/wp-content/uploads/initiatives/research_universities/conference_report.pdf; Ira Harkavy and John L. Puckett, "Lessons from Hull House for the Contemporary Urban University," *Social Service Review* 68, no. 3 (September 1994): 299-321; Timothy K. Stanton, *New Times Demand New Scholarship II: Research Universities and Civic Engagement: Opportunities and Challenges*, (Los Angeles: University of California, 2007), http://www.compact.org/wp-content/uploads/initiatives/research_universities/Civic_Engagement.pdf.

on the idea that major advances in knowledge tend to occur when human beings consciously work to solve the central problems confronting their society." TRUCEN scholars further emphasize that "engaged scholarship is not concerned with results that benefit communities instead of academic rigor; rather, it is concerned with beneficial results *in addition to* academic rigor [emphasis in original]."[131]

These ideas build on the work of Ernest Boyer in what he envisioned as the "New American College," as well as his presentation of a broader definition of scholarship in *Scholarship Reconsidered*.[132] Boyer's definition shifted the paradigm of academic work, emphasizing the scholarship of not only discovery, but also integration, communication, and application.

John Gardner, arguably the leading spokesperson for the democratic, engaged university during his years as Secretary of Health, Education, and Welfare in the 1960s until his death in 2002, emphasized that university engagement is necessary for solving the problems of communities, and that such engagement results in important academic benefits for the university and society.[133] Derek Bok, President of Harvard from 1971 to 1991, echoed this theme in his 1990 book, *Universities and the Future of America*.[134] The intellectual case presented by Boyer, Gardner, Bok, as well as others, argues, in effect, that universities would better fulfill their core academic functions, including advancing learning, research, and teaching, if they increased their focus on real-world, collaborative, problem solving in their local communities.

Harkavy and Puckett also explicitly recognize the advancement of knowledge as a rationale for higher education-community engagement: "The benefits that can emerge from this approach are the integration of research, teaching, and service; the interaction of faculty members and graduate and undergraduate students from across the campus; the connections of projects involving participatory action research…; and the promotion of a civic consciousness… among undergraduates." They further claim, "The separation of universities from society, their aloofness form real-world problems, has deprived universities of contact with a necessary source of genuine creativity and academic vitality." [135]

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[131] Gibson, *New Times*, quotes on pp. 8; 14.
[132] Ernest L. Boyer, "Creating the New American College," *Chronicle of Higher Education,* March 9, 1994, p. A48; and *Scholarship Reconsidered*.
[133] John W. Gardner, "Remarks to the Campus Compact Strategic Planning Committee," (speech, Campus Compact, San Francisco, February 10, 1998).
[134] Bok, *Universities and the Future*.
[135] Harkavy and Puckett, "Lessons," quotes on p. 300.

7. *The purpose of this approach is to develop and implement a particularly powerful way to get to and advance the frontiers of knowledge—good higher education-community engagement can drive not only broader participation, but also better science.*[136]

Lazarsfeld and Reitz, in their influential *Introduction to Applied Sociology*, emphasized the potential for advancing science through focusing on a complex practical problem.[137] Broadening participation through higher education-community partnerships would certainly qualify as such a problem.

Moreover, diversity itself, which is promoted in the higher education-community engagement approach, is crucial for better science.[138] This idea is grounded in Dewey's theories about the social nature of education, as well as research by Pat Gurin and colleagues on the impact of diverse learning environments.[139] It has been advanced by Scott Page who argues that diversity fuels innovation, which enriches the intellectual environment:

> Innovation provides the seeds for economic growth, and for that innovation to happen depends as much on collective difference as on aggregate ability. If people think alike then no matter how smart they are they most likely will get stuck at the same locally optimal solutions. Finding new and better solutions, innovating, requires thinking differently. That's why diversity powers innovation.[140]

8. *The "product" of knowledge should be redefined to include: (1) scholarly papers, (2) new methodologies and tools ("technology transfer"), and/or (3) direct impact to participants (broader participation, better science, better communities and social cohesion, and change of practice within institutions).*[141]

Members of Imagining America's Tenure Team Initiative effectively describe "the range of scholarly products" that emerge as a result of engaged scholarship, including policy recommendations, broadly accessible publications, and new programs that aim to change higher education itself.[142] In the second TRUCEN report, Timothy Stanton discusses three dimensions of engaged research—purpose, process, and product—and defines the product as the "range of possible outcomes of engaged research" that result in both "advancing knowledge and improving community/public life."[143]

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[136] Committee on Equal Opportunities in Science and Engineering, *2011-2012 Biennial Report*; Spencer and Dawes, *Report*.
[137] Lazarsfeld and Reitz, *Applied Sociology*.
[138] Spencer and Dawes, *Report*.
[139] Mohanty and Cantor , "Why Diversity."
[140] Page, "Diversity Powers," para. 15.
[141] Stanton, *New Times*, 11.
[142] Ellison and Eatman, *Scholarship*, pp. iii; 39.
[143] Stanton, *New Times*, 11.

The higher education-community engagement approach also calls for flexibility in methods—going beyond controlled experiments to solutions in the real world. Kurt Lewin's approach to research has particular relevance here. As described by Marrow, his "basic hypothesis, and methodology could not be confined within the neat traditional boundaries of any specialized field, school of thought, or established system. His research undertakings were problem-oriented, cutting across and mobilizing the theoretical knowledge and the technical resources of all relevant disciplines." Marrow further emphasizes that in Lewin's well-known work in participant action research "responsibility would not end with finding out what methods work; it also had to be concerned to see that its results were put into action." [144] Described previously, NSF's I-Corps program is an example of the recursive, iterative, ongoing approach to problem-solving described here—taking science from the lab to society and back to the lab.

Producing social cohesion, equity, diversity, and inclusion could well serve as a central product of scientific research conducted through a higher education-community engagement strategy. Evaluating science through its impact on improving human life has roots in the Enlightenment, most particularly the work of Francis Bacon. For Bacon, "knowledge is power" for human ends. He criticized ancient science, and instead called for the scientific organization of collective, collaborative, interactive groups of workers, which would make them capable of developing the knowledge and power needed to continually improve all aspects of human life—what he termed the "relief of man's estate."[145]

Benjamin Franklin, an intellectual heir of Bacon, took this concept further by creating two organizations designed to realize in practice "the relief of man's estate"—one eventually became the present-day American Philosophical Society for Promoting Useful Knowledge, and the other the University of Pennsylvania. The college envisioned by Franklin would promote the pursuit of learning and knowledge for the betterment of humanity, seeking to instill in students "an *Inclination* join'd with an *Ability* to serve Mankind, one's Country, Friends, and Family [emphasis in original]."[146] Elizabeth Flower and Murray G. Murphey summarize Franklin's emphasis on promoting useful knowledge: "Knowledge is wisdom only if it is useful for the satisfaction of [human] needs: hence in all his schemes for the promotion and diffusion of knowledge, Franklin emphasized 'useful knowledge.' "[147]

C. West Churchman and Ian Mitroff extended the Baconian-Franklinian idea, placing implementation (positive change in the world) as the central goal of science:

> Implementation assumes top priority because it is one of the most difficult problems humans ever face.… Thus, truth is defined accordingly: "Truth" is the

[144] Marrow, *The Practical Theorist*, quotes on pp. 176; 191.
[145] Sir Francis Bacon, *Religious Meditations, Of Heresies* (1597), quoted in "Quotation #2060 from *Laura Moncur's Motivational Quotations*," The Quotations Page, accessed August 21, 2014, http://www.quotationspage.com/quote/2060.html. Francis Bacon, *The Advancement of Learning, Book 1, v. 11* (1605).
[146] Benjamin Franklin, *Proposals Relating to the Education of Youth in Pensilvania* [sic]. University of Pennsylvania Archives and Records Centers, Philadelphia, 1749, Accessed November 13, 2013, http://www.archives.upenn.edu/primdocs/1749proposals.html.
[147] Elizabeth Flower and Murray G. Murphey, *A History of Philosophy in America*, Vol. 1 (New York: G.P. Putnam's sons: 1977), 110.

> result/outcome of knowledge that is gained through the "successful" implementation of a proposed, ethical solution to a significant world problem. In other words, knowledge cannot be separated from the problem of its implementation. To repeat, "Truth" is knowledge that is gained through the process of implementation. Truth is thereby not only equated with implementation, but it is only said to have occurred, or resulted, when implementation has occurred.[148]

In summary, the strategy sketched above is one in which theory is integrated with practice, and the test of knowledge is the ability of human beings to improve the world. It is an approach designed to produce significant change, advance intellectual work, and develop new discoveries at the frontier. It assumes that human beings learn from and through implementation. It also assumes that science designed to realize large societal goals through developing and implementing programs on the ground, studying these programs, improving these programs, and engaging in an iterative process of study and change, leads to significant learning and high-level theoretical advances.

New Global Community

1. *Issues of knowledge generation, STEM equity, and social cohesion are faced by societies all over the world; they are universal problems that are manifested locally, which no single society can solve.*

For example, the universality of the issue of STEM equity is illustrated in the white paper written by colleagues in Zhejiang University on "The State of Community Engagement in Science, Technology, Engineering and Mathematics (STEM)," which expresses similar concerns as the ones posed in this paper on STEM in the United States. The white paper emphasizes the urgency of improving STEM education:

> Promoting the development of science, technology, engineering, and mathematics (STEM) education has never been as important as it is today. Nowadays, STEM education has become the strategy of many countries. In China, the development of STEM education over the past 60 years has made great contributions to the nation's overall progress. However, [a] knowledge society and globalization have raised continuous demands for STEM. The Chinese government needs to identify the STEM education as a major priority and significantly improve the quality of STEM education, so as to better promote human capacity building, knowledge production, technology transfer, social cohesion and equity.[149]

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[148] C. West Churchman and Ian Mitroff, "The Management of Science and the Mismanagement of the World," *Knowledge, Technology & Policy* 7, no. 2 (Summer 1994): 75.

[149] Zhejiang University, "The State of Community Engagement in Science, Technology, Engineering and Mathematics (STEM): The National Landscape" (paper prepared for The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration, University of Pennsylvania, Philadelphia, PA, February 2012), 21.

2. An ongoing, global learning community focused on STEM diversity and equity is needed.

To realize his goal that knowledge contributes to the progressive, continued betterment of the human condition, Bacon, among other things, called for "a closer connection and relationship between all the different universities of Europe."[150] The need for collaboration among universities and scholars, of course, is no longer restricted to Europe. Neal Lane, for example convincingly makes the case that "international scientific collaborations…promote the diversity and sharing of ideas that can lead to realistic solutions to global problems."[151]

A similar idea was expressed in Zhejiang University's white paper. The paper concludes with discussion of the National Natural Science Foundation of China's listing of "the improvement of international cooperation" in its "Twelfth Five-Year Plan." The authors state, "With the improvement in the cooperation systems and mechanisms, the global partnership will play a more and more important role in leading the development, responding to crisis and reducing the inequities in STEM."[152] Although we come to a different conclusion than our Chinese colleagues as to whether U.S. higher education has "effective cooperation mechanisms…to meet the development needs of STEM," their argument for a collaborative partnership approach between countries with differing strengths and deficiencies is most persuasive:

> Different countries have different deficiencies in STEM education. As far as China is concerned, the deficiencies are mostly in higher education, such as lack of innovation, laggard curriculum design and so on. But the cultivation of the student's scientific literacy in basic education is outstanding. On the contrary, the deficiency of STEM education faced in the United States is located in the stage of basic education (K-12), such as a lack of qualified teachers, students' lack of interest and sufficient attention to basic scientific subjects. While in higher education, with the involvement of the government, industry and the universities, effective cooperation mechanisms have been established to meet the development needs of STEM. On this issue, China and the United States could establish a comprehensive partnership, carrying out communication and cooperation on the entire educational system.[153]

The white paper by the National Research Foundation of South Africa also concludes with the importance of a global partnership:

> In recent years there have been, as a result of government policy, institutionalization of community engagement within all twenty one (21) universities. Investments in supporting community engagement initiatives, better understanding and research about or in community engagement is increasing as reflected by the dedicated funding programmes *[sic]* of the NRF and DST, and

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[150] Rose-Mary Sargent, ed., *Francis Bacon: Selected Philosophical Works* (Indianapolis, IN: Hackett 1999), 53-54.
[151] Christopher Bronk et al., *Baker Institute Policy Report 42: Science Collaboration Across Borders* (Houston: Rice University, August 2009), 2.
[152] Zhejiang University, "The State," 21.
[153] Zhejiang University, "The State," 19.

> generally universities themselves. At the same time South Africa recognizes its STEM “crisis” in school and higher education. However, there is no deliberate attempt to specifically use community engagement to address the STEM problems…. The lessons that South Africa’s Universities and the NRF can learn from partner countries and funding institutions of the United States of America and China, the National Science Foundation and the National Science Foundation of China, respectively in using community engagement for improving STEM education from P to 20+ will [be] beneficial in addressing the “crisis.”[154]

The approach described by our Chinese and South African colleagues could powerfully contribute to effectively achieving Vannevar Bush’s goal of a fully inclusive, fully diverse scientific and engineering workforce. Moreover, the two international workshops in 2012 illustrated great potential for advancing the work through an ongoing, global learning community.

[154] Andrew M. Kaniki and Candice Steele, “Community Engagement Landscape in South African Higher Education and Critical Issues of Science, Technology, Engineering and Mathematics (STEM)” (Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration, University of Pennsylvania, Philadelphia, PA, February 2012), 14.

Conclusion: Creating a Global Partnership through Higher Education-Community Engagement to Advance Scientific Knowledge and STEM Equity in the 21st Century

As stated in the introduction, the purpose of this white paper is to present a promising approach to advancing equity in science, technology, engineering, and mathematics (STEM) through higher education-community engagement.

We have proposed a recursive, iterative approach that is based on the following propositions:

1. Significant societal problems cannot be solved without full inclusion.
2. Inclusion, in turn, will result in better science and a better society.
3. Higher education-community engagement focused on locally manifested universal problems is an effective strategy for realizing full inclusion and for producing better science and a better society.
4. Issues of knowledge generation, STEM equity, and social cohesion are faced by societies all over the world; they are universal problems that are manifested locally, which no single society can solve. An ongoing, global learning community focused on higher education-community engagement and STEM equity is needed to produce better science, broaden participation, reduce inequalities, and improve societies.

The type of innovative partnership approach discussed above is needed to broaden the nation's leadership and social base, enlarging the sources of intellectual and human capital so that the United States can remain a leader in this global knowledge-intensive economy. Challenges in STEM demand a global and community engagement-driven approach. STEM research and development issues and the complexities of science as a means to contribute to economic growth, career opportunities, knowledge generation, and overall social well-being of citizens worldwide are compelling reasons for a global partnership. STEM diversity is affected by global, as well as national, conditions. Moreover, opportunities to learn across cultures and societies increase understanding of global conditions and national experiences.[155]

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[155] For example, Huber's and Harkavy's *Higher Education and Democratic Culture: Citizenship, Human Rights and Civic Responsibility* and Bergan, Harkavy, and van't Land's *Reimagining Democratic Societies: A New Era of Personal and Social Responsibility* are both part of the Council of Europe's (CoE) higher education series and emerge from its partnership with the International Consortium for Higher Education, Civic Responsibility and Democracy (IC). The International Consortium seeks to explain and advance the contributions of higher education to democracy on college and university campuses, their local communities, and the wider society. The IC works in collaboration with the CoE and its 47 member countries through its Department of Education; the IC is comprised of the United States (represented by a Steering Committee from the American Association of State Colleges and Universities, American Council on Education, Association of American Colleges and Universities, Campus Compact, Democracy Commitment, and NASPA-Student Affairs Administrators in Higher Education), and representatives from other countries throughout the world. The Netter Center at the University of Pennsylvania houses the executive offices of the International Consortium. At the time of its formation in 1999, the IC decided to undertake a data-gathering, international research project on "Universities as Sites of Citizenship and Civic Responsibility." The project was a cross-national study comparing universities in Europe and the United States. It assessed the actual activities of institutions of higher education that support democratic values and practices, and promoted the dissemination of those activities to increase the contributions of higher education to democracy on campus and in the local community and wider society. The National Science Foundation funded the U.S.-portion of the pilot project. As of 2014, the IC-CoE collaboration had resulted in seven books (an eighth is in process), several articles, and a video, as well as sponsorship of four global forums and three symposiums. Although not focused on

An ongoing, global learning community focused on STEM diversity is needed. Such a community will also help build trusting relationships over time, create an honest interchange for ongoing learning, sharing, and adapting each other's approaches, and develop creative and innovative solutions nationally and globally.

The U.S. and South Africa workshops serve as promising examples of such international collaboration and could be important steps toward sharing information and knowledge, as well as designing specific collaborative activities to help effectively address STEM challenges. Moreover, the two international workshops resulted in a deeper understanding of STEM challenges and opportunities and the potential for broadening participation, advancing STEM equity, and producing better science through a higher education-community engagement strategy. In the judgment of the authors, these workshops have made a contribution to the ongoing work of promoting STEM equity, serving as indicators of the value of global collaboration. In combination, the specific findings derived at the workshops, we believe, illustrate a potentially powerful approach to significantly reducing inequalities and increasing diversity in STEM in communities and societies throughout the world.

STEM specifically, the IC-CoE's activity and publications illustrate and highlight the value of collaboration among higher educational institutions across Europe, the United States, as well as other countries across the globe.

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• Dr. Ira Harkavy, Associate Vice President and Founding Director, Netter Center for Community Partnerships, University of Pennsylvania • Dr. Myra Burnett, Interim Provost and Vice President for Academic Affairs, Spelman College • Dr. Nancy Cantor, Chancellor, Rutgers University-Newark	• Dr. Wanda E. Ward, Head of the Office of International and Integrative Activities, National Science Foundation (NSF) [observer] • Dr. Machi Dilworth, (Retired) Director, International Science & Engineering, NSF [observer]

<u>South Africa Delegation:</u>

Higher Education Leaders	*Funding Officials*
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Bibliography

American Association for the Advancement of Science. *AAAS Report XXXVIII: Research & Development FY 2014.* Washington, DC: printed by author, 2013.

Amey, Marilyn J., Dennis F. Brown, and Lorilee R. Sandmann. "A Multidisciplinary Collaborative Approach to a University-Community Partnership: Lessons Learned." *Journal of Higher Education Outreach and Engagement* 7, no. 3 (Spring/Summer 2002): 19-26.

Anderson, Charles W. *Prescribing the Life of the Mind.* Madison: University of Wisconsin Press, 1993.

Bacon, Francis. *The Advancement of Learning, Book 1, v. 11*. 1605.

Beede, David, Tiffany Julian, Beethika Khan, Rebecca Lehrman, George McKittrick, David Langdon, and Mark Doms. *Education Supports Racial and Ethnic Equality in STEM.* ESA Issue Brief 05-11. Washington, DC: U.S. Department of Commerce, Economics and Statistics Administration, September 2011.

Benson, Lee, Ira Harkavy, and John Puckett. "Democratic Transformation through University-Assisted Community Schools." In *"To Serve a Larger Purpose": Engagement for Democracy and the Transformation of Higher Education*¸ edited by Matthew Hartley and John Saltmarsh, 50-81. Philadelphia: Temple University Press, 2011.

Benson, Lee, Ira Harkavy, and John Puckett. *Dewey's Dream: Universities and Democracies in an Age of Education Reform*. Philadelphia: Temple University Press, 2007.

Benson, Lee, Ira Harkavy, and John Puckett. "An Implementation Revolution as a Strategy for Fulfilling the Democratic Promise of University-Community Partnerships: Penn-West Philadelphia as an Experiment in Progress." *Nonprofit and Volunteer Sector Quarterly* 29, no.1 (March 2000): 24-45

Bergan, Sjur, Ira Harkavy, and Hilligje van't Land, eds. *Reimagining Democratic Societies: A New Era of Personal and Social Responsibility.* Strasbourg: Council of Europe Publishing, 2013.

Bok, Derek. *Universities and the Future of America*. Durham, NC: Duke University Press, 1990.

Bordogna, Joseph. "The Promotion of Excellence in Research: The Experience of the National Science Foundation." Speech given at the FAF/ANRT Seminar, Paris, France, April 8, 2005. Accessed September 23, 2011. http://www.nsf.gov/news/speeches/bordogna/05/jb050408_frenchamerica.jsp.

Bowman-James, Kristin, David Benson, and Tom Mallouk. *Workshop on Excellence Empowered by a Diverse Academic Workforce: Chemists, Chemical Engineers, and*

Materials Scientists with Disabilities. Arlington, VA: National Science Foundation and the National Institutes of Health, 2009.

Boyer, Ernest L. "Creating the New American College." *Chronicle of Higher Education,* March 9, 1994, p. A48.

Boyer, Ernest L. *Scholarship Reconsidered: Profiles of the Professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching, 1990.

Bronk, Christopher, Kirstin R.W. Matthews, Neal F. Lane, and Steven W. Lewis. *Baker Institute Policy Report 42: Science Collaboration Across Borders.* Houston: Rice University, August 2009.

Building Engineering & Science Talent. *A Bridge for All: Higher Education Design Principles to Broaden Participation in Science Technology, Engineering, and Mathematics.* San Diego: BEST, February 2004.

Campbell, Donald T. "Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience." In *Interdisciplinary Relationships in the Social Sciences*, edited by Muzafer Sherif and Carolyn W. Sherif, 328-348. Piscataway, NJ: Aldine, 1969.

Campbell, Donald T. "Methods for the Experimenting Society." *American Journal of Evaluation* 12, no. 3 (October 1991): 223-260.

Cantor, Nancy and Peter Englot. "Beyond the 'Ivory Tower': Restoring the Balance of Private and Public Purposes of General Education." *The Journal of General Education: A Curricular Commons of the Humanities and Sciences* 62, no. 2-3 (2013): 120-128.

Cantor, Nancy, Peter Englot, and Marilyn Higgins. "Making the Work of Anchor Institutions Stick: Building Coalitions and Collective Expertise." *Journal of Higher Education Outreach & Engagement* 17, No. 3 (June 2013): 17-46.

Century Foundation Task Force on Preventing Community Colleges from Becoming Separate and Unequal. *Bridging the Higher Education Divide: Strengthening Community Colleges and Restoring the American Dream.* New York: The Century Foundation Press, 2013.

Chubin, Daryl E. and Wanda E. Ward. "Building on the BEST Principles and Evidence: A Framework for Broadening Participation." In *Broadening Participation in Undergraduate Research: Fostering Excellence and Enhancing the Impact*, edited by Mary K. Boyd and Jodi L. Wesemann, 21-30. Washington, DC: Council on Undergraduate Research, 2009.

Churchman, C. West and Ian Mitroff. The Management of Science and the Mismanagement of the World. *Knowledge, Technology & Policy* 7, no. 2 (Summer 1994): 64-80.

Clewell, Beatriz Chu, Clemencia Cosentiono de Cohen, Lisa Tsui, and Nicole Deterding. *Revitalizing the Nation's Talent Pool in STEM: Science, Technology, Engineering, and Mathematics.* Washington, DC: The Urban Institute, 2006.

Cole, Jonathan R. *The Great American University: Its Rise to Preeminence, Its Indispensable National Role, Why It Must Be Protected*. New York: Public Affairs, 2009.

Committee on Equal Opportunities in Science and Engineering. *2011-2012 Biennial Report to Congress: Broadening Participation in America's STEM Workforce*. CEOSE 13-01. Arlington, VA: National Science Foundation, 2013.

Dewey, John. *The Public and Its Problems.* New York: Holt, 1927.

Ellison, Julie and Timothy K. Eatman. *Scholarship in Public: Knowledge Creation and Tenure Policy in the Engaged University.* Syracuse, NY: Imagining America, 2008.

Fitzpatrick, Edward J. *McCarthy of Wisconsin.* New York: Columbia University Press, 1944.

Flower, Elizabeth. and Murray G. Murphey. *A History of Philosophy in America*. Vol. 1. New York: G.P. Putnam's Sons, 1977.

Franklin, Benjamin. *Proposals Relating to the Education of Youth in Pensilvania* [sic]. University of Pennsylvania Archives and Records Centers. Philadelphia, 1749. Accessed November 13, 2013. http://www.archives.upenn.edu/primdocs/1749proposals.html.

Gardner, John W. "Remarks to the Campus Compact Strategic Planning Committee." Speech, Campus Compact, San Francisco, February 10, 1998.

Gibson, Cynthia M. *New Times Demand New Scholarship: Research Universities and Civic Engagement: Opportunities and Challenges: A Leadership Agenda*. Medford, MA: Tufts University and Campus Compact, 2006. http://www.compact.org/wp-content/uploads/initiatives/research_universities/conference_report.pdf.

Greenwood, Davydd J., William F. Whyte, and Ira Harkavy. "Participatory Action Research as a Process and as a Goal." *Human Relations* 46, no. 2 (February 1993): 175-192.

Grimm, Nancy B., J. Morgan Grove, Steward T. A. Pickett, and Charles L. Redman. "Integrated Approaches to Long-Term Studies of Urban Ecological Systems. *BioScience* 50, no. 7 (July 2000): 571-584.

Harkavy, Ira and Rita A. Hodges. "The State of Community Engagement in Science, Technology, Engineering, and Mathematics: A View from the USA." Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration. University of Pennsylvania, Philadelphia, PA, February 2012.

Harkavy, Ira and John L. Puckett. "Toward effective university-public school partnerships: An analysis of a contemporary model." *Teachers College Record* 92, no. 4 (Summer 1991): 556-581.

Harkavy, Ira and John L. Puckett. (1994). "Lessons from Hull House for the Contemporary Urban University." *Social Service Review* 68, no. 3 (September 1994): 299-321.

Harkavy, Ira and Harmon Zuckerman. *Eds and Meds: Cities' Hidden Assets*. Washington, DC: The Brookings Institution Center on Urban & Metropolitan Policy, 1999.

Harper, William Rainey. *The University and Democracy.* Chicago: University of Chicago Press, 1899.

Hess, Frederick M., Andrew P. Kelly, and Olivia Meeks. *The Case for Being Bold: A New Agenda for Business in Improving STEM Education*. Washington, DC: U.S. Institute for a Competitive Workforce and Chamber of Commerce, April 2011.

Hodges, Rita A., and Steve Dubb. *Road Half Traveled: University Engagement at a Crossroads.* East Lansing: Michigan State University Press, 2012.

Huber, Josef and Ira Harkavy, eds. *Higher Education and Democratic Culture: Citizenship, Human Rights and Civic Responsibility.* Strasbourg: Council of Europe Publishing, 2007.

Jackson, Shirley A. *Envisioning a 21st Century Science and Engineering Workforce for the United States*: *Tasks for University, Industry, and Government.* Washington, DC: The National Academies Press, 2003.

Johnston, Francis E. and Ira Harkavy. *The Obesity Culture: Strategies for Change—Public Health and University-Community Partnerships.* London: Smith-Gordon & Co., 2009.

Kaniki, Andrew M. and Candice Steele. "Community Engagement Landscape in South African Higher Education and Critical Issues of Science, Technology, Engineering and Mathematics (STEM)." Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration. University of Pennsylvania, Philadelphia, PA, February 2012.

Kawachi, Ichiro and Lisa Berkman "Social Cohesion, Social Capital, and Health." In *Social Epidemiology*, edited by Lisa F. Berkman and Ichiro Kawachi, 174-190. Oxford: Oxford University Press, 2000.

Ladner, Richard E. *CEOSE Mini-Symposium on Institutions Serving Persons with Disabilities in STEM—October 15, 2007 Report*. Arlington, VA: National Science Foundation, February 2008.

Lane, Neal. "Benjamin Franklin, Civic Scientist." *Physics Today* 56, no. 10. (October 2003): 41-46.

Lane, Neal. "Science and Technology Policy: Advice in Government Panel." Paper presented at Bridging the Gap Between Science and Society: The Relationship Between Policy and Research in National Laboratories, Universities, Government, and Industry. Rice University, Houston, TX, November 1-2, 2003.

Lave, Jean and Etienne Wenger. *Situated Learning: Legitimate Peripheral Participation*. New York: Cambridge University Press, 1991.

Lazarsfeld, Paul F. and Jeffrey G. Reitz. *An Introduction to Applied Sociology.* New York: Elsevier Publishing, 1975.

Lewin, Kurt. "Problems of Research in Social Psychology." In *Field Theory in Social Science*, edited by Dorwin Cartwright, 155-169. New York: Harper & Row, 1951.

Marcus, Emilie. "Science, Gender and the Balanced Life." *Issues in Science and Technology*, Spring 2013. Accessed November 20, 2013. http://issues.org/29-3/perspectives-2/.

Marrow, Alfred J. *The Practical Theorist: The Life and Work of Kurt Lewin*. New York: Basic Books, 1969.

Mason, Mary A., Marc Goulden, and Karie Frasch. *Keeping Women in the Science Pipeline*. Berkeley, CA: Center on Health, Economic, and Family Security, 2010.

McCarthy, Charles. *The Wisconsin Idea*. New York: MacMillan, 1912.

Mohanty, Satya and Nancy Cantor. "Why Diversity is not a Luxury: An Interview with Nancy Cantor." *ZNET*. January 17, 2014. http://zcomm.org/znetarticle/why-diversity-is-not-a-luxury-an-interview-with-nancy-cantor/.

Moon, Nathan W., Robert L. Todd, David L. Morton, and Emily Ivey. *Accommodating Students with Disabilities in Science, Technology, Engineering, and Mathematics (STEM): Findings from Research and Practice for Middle Grades through University Education.* Atlanta: Georgia Institute of Technology, 2012.

Moss-Racusin, Corinne A., John F. Dovidio, Victoria L. Brescoll, Mark J. Graham, and Jo Handelsman. "Science faculty's subtle gender biases favor male students." *Proceedings of the National Academy of Sciences* 109, no. 41 (October 9, 2012): 16474-16479. Pre-Published September 17, 2012. doi: 10.1073/pnas.1211286109.

Nagel, Ernest. *The Structure of Science: Problems in the Logic of Scientific Explanation.* Indianapolis, IN: Hackett Publishing, 1979.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *Expanding Underrepresented Minority Participation: America's Science and Technology Talent at the Crossroads*. Washington, DC: The National Academies Press, 2011.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* Washington, DC: The National Academies Press, 2007.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5.* Washington, DC: The National Academies Press, 2010.

National Science Board. *Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Human Capital*. Arlington, VA: National Science Foundation, 2010.

National Science Board. *Science and Engineering Indicators 2014*. NSB 14-01. Arlington, VA: National Science Foundation, 2014.

National Science Foundation. *ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers (ADVANCE).* NSF 14-573 Program Solicitation. Arlington, VA: printed by author, 2014. http://www.nsf.gov/pubs/2014/nsf14573/nsf14573.htm.

National Science Foundation. *Empowering the Nation through Discovery and Innovation. NSF Strategic Plan for Fiscal Year (FY) 2011-2016*. Arlington, VA: printed by author, 2011.

National Science Foundation. *Graduate Research Fellowship Program (GRFP).* NSF 14-590 Program Solicitation. Arlington, VA: printed by author, 2014. http://www.nsf.gov/pubs/2014/nsf14590/nsf14590.htm.

National Science Foundation. *Innovation Corps Teams Program (I-Corps Teams)*. NSF 12-602 Program Solicitation. Arlington, VA: printed by author, 2012. http://www.nsf.gov/pubs/2012/nsf12602/nsf12602.pdf.

National Science Foundation. *Investing in America's Future: Strategic Plan FY 2006-2011*. Arlington, VA: printed by author, 2006.

National Science Foundation. *Math and Science Partnership Program: Strengthening America by Advancing Academic Achievement in Mathematics and Science.* Arlington, VA: printed by author, 2005.

National Science Foundation. *National Science Foundation Research Traineeship (NRT) Program.* NSF 14-548 Program Solicitation. Arlington, VA: printed by author, 2014. http://www.nsf.gov/pubs/2014/nsf14548/nsf14548.htm.

National Science Foundation. *NSF Graduate STEM Fellows in K-12 Education.* NSF 09-549 Program Solicitation. Arlington, VA: printed by author, 2009. http://www.nsf.gov/pubs/2009/nsf09549/nsf09549.htm.

National Science Foundation. *Science, the Endless Frontier.* A Report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development. Washington, DC: United States Government Printing Office, July 1945.

National Science Foundation. *STEM-C Partnerships: Computing Education for the 21st Century (STEM-CP: CE21).* NSF 14-523 Program Solicitation. Arlington, VA: printed by author, 2013. http://www.nsf.gov/pubs/2014/nsf14523/nsf14523.pdf.

National Science Foundation, National Center for Science and Engineering Statistics. *Women, Minorities, and Persons with Disabilities in Science and Engineering: 2013.* Special Report NSF 13-304. Arlington, VA: printed by author, 2013. http://www.nsf.gov/statistics/wmpd/2013/.

Organization for Economic Co-operation and Development. *Perspectives on Global Development 2012: Social Cohesion in a Shifting World*. Paris: OECD Publishing, 2011. doi: 10.1787/persp_glob_dev-2012-en.

Page, Scott E. *The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies*. Princeton, NJ: Princeton University Press, 2007.

Page, Scott E. "Diversity Powers Innovation." Center for American Progress. January 26, 2007. http://www.americanprogress.org/issues/economy/news/2007/01/26/2523/diversity-powers-innovation/.

Patton, Madeline, ed. *ATE Centers Impact 2014: Partners with Industry for a New American Workforce*. Tempe, AZ: Maricopa Community Colleges, 2014.

Peters, Scott. *Democracy and Higher Education: Traditions and Stories of Civic Engagement*. East Lansing: Michigan State University Press, 2010.

Pinsker, Eve C. and Michael D. Lieber. "Anthropological Approaches to the Evaluation of University-Community Partnerships." *NAPA Bulletin* 24, no. 1 (May 2005): 107-124.

President's Council of Advisors on Science and Technology. *Report to the President: Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.* Accessed February 8, 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-engage-to-excel-final_feb.pdf.

Quality Education for Minorities Network. *Effective Institutional STEM Instructional Strategies at HBCU-UP Grantee Institutions*. December 2012. http://qemnetwork.qem.org/Major_QEM_Reports.htm.

Ross, Earle D. *Democracy's College, The Land-Grant Movement in the Formative Stage.* Ames: Iowa Stage College Press, 1942.

Saltmarsh, John and Matthew Hartley, eds. *"To Serve a Larger Purpose": Engagement for Democracy and the Transformation of Higher Education*. Philadelphia: Temple University Press, 2011.

Sargent, Rose-Mary, ed. *Francis Bacon: Selected Philosophical Works*. Indianapolis, IN: Hackett, 1999.

Schön, Donald A. "Knowing-in-Action: The New Scholarship Requires a New Epistemology." *Change* 27, no. 6 (November-December 1995): 26-34.

Schön, Donald A. *The Reflective Practitioner: How Professionals Think in Action.* New York: Basic Books, 1985.

Scobey, David. "Putting the Academy in its Place." *Places* 14, no. 3 (Summer 2002): 50-55.

Spencer, David B. and Sharon Dawes. *Report of the Advisory Committee for GPRA Performance Assessment FY 2009*. NSF 09-068. Arlington, VA: National Science Foundation, 2009.

Stanton, Timothy K. *New Times Demand New Scholarship II: Research Universities and Civic Engagement: Opportunities and Challenges*. Los Angeles: University of California, 2007. http://www.compact.org/wp-content/uploads/initiatives/research_universities/Civic_Engagement.pdf.

Stark, Jack. *The Wisconsin Idea: The University's Service to the State*. Reprinted from the *State of Wisconsin Blue Book, 1995-1996.* Accessed June 18, 2014. www.legis.state.wi.us/lrb/pubs/feature/wisidea.pdf.

Sturm, Susan. "The Architecture of Inclusion: Advancing Workplace Equality in Higher Education." *Harvard Journal of Law and Gender* 29, no. 2 (Summer 2006): 248-334.

Task Force on Anchor Institutions. "Anchor Institutions as Partners in Building Successful Communities and Local Economies." In *Retooling HUD for a Catalytic Federal Government: A Report to Secretary Shaun Donovan*, by Paul C. Brophy and Rachel D. Godsil, 147-169. Philadelphia: Penn Institute for Urban Research, 2009.

Taylor, Henry and Gavin Luter. *Anchor Institutions: An Interpretative Review Essay*. Anchor Institutions Task Force, 2013. Accessed June 3, 2013. http://www.margainc.com/files_images/general/Literature_Review_2013.pdf.

Trochim, William M. *The Research Methods Knowledge Base, 2nd Edition*. Version current as of October 20, 2006. http://www.socialresearchmethods.net/kb/.

Trojanowski, John Q., Steven E. Arnold, Jason H. Karlawish, Kurt Brunden, Mark Cary, Christos Davatzikos, and John Detre, et al. "Design of Comprehensive Alzheimer's Disease Centers to Address Unmet National Needs." *Alzheimer's and Dementia* 6, no. 2 (March 2010): 150-155.

Webb, Eugene J., Donald T. Campbell, Richard D. Schwartz, and Lee Sechrest. *Unobtrusive Measures: Revised Edition*. Thousand Oaks, CA: Sage Publications, 2000.

Wenger, Etienne. *Communities of Practice: Learning, Meaning, and Identity.* New York: Cambridge University Press, 1998.

Whyte, William F. "Advancing Scientific Knowledge through Participatory Action Research." *Sociological Forum* 4, no. 3 (September 1989): 367-385.

Whyte, William F., Davydd J. Greenwood, and Peter Lazes. "Participatory Action Research: Through Practice to Science in Social Research." In "Action Research for the 21st Century: Participation, Reflection, and Practice," ed. William F. Whyte. Special issue of *American Behavioral Scientist* 32, no. 5 (May 1989): 513-551.

Wildavsky, Ben. *The Great Brain Race: How Global Universities are Reshaping the World.* Princeton, NJ: Princeton University Press, 2010.

Zhejiang University. "The State of Community Engagement in Science, Technology, Engineering and Mathematics (STEM): The National Landscape." Paper presented at The First International Workshop on the Role of Higher Education: Fostering P-20+ Community Engagement Through Knowledge Production, Human Capacity Building, Innovation and Social Cohesion: A US-China-South Africa Collaboration. University of Pennsylvania, Philadelphia, PA, February 2012.