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US Indigenous STEM Report

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Introduction

In the 21st century there is a high demand for U.S. science, technology, engineering and mathematics (STEM) professionals who can compete globally. There also is a call to diversify the STEM workforce in order to capitalize on the reality of US ethnic plurality, and to align with philosophies of multiculturalism. National reports amassed over recent years (e.g., BEST 2004a, b, c; Jackson, 2002; National Academies 2007, 2010, 2011) attest to the continuing rapid growth of racial and ethnic minority populations as well as the serious underrepresentation of minorities and women in STEM fields.

Disparities in representation in STEM education and careers

A recent report by the U.S. Department of Commerce Economics and Statistics Administration (USDCESA, 2011) examines demographic disparities in STEM education by analyzing labor market outcomes and gender disparities among STEM workers. The report finds that educational attainment likely impacts equality of opportunity in future critical, high quality STEM employment areas. Higher college graduation rates are associated with higher proportions of workers with STEM jobs regardless of race. However, non-Hispanic Whites and Asians are far more likely than other minority groups, including American Indian and Alaska Native (AI/AN) groups, to earn a bachelor's degree. Only 17 percent AI/AN have bachelor's degrees (p. 3). Moreover, AI/AN groups are less likely to major in STEM fields and therefore less likely to obtain STEM jobs.

The situation is even bleaker with regard to AI/AN women. For instance, in engineering, Native women are not only the most likely to leave the university but also the least likely of women from any group to persist in the programs they have begun (Lord, Camacho, Layton, Long, Ohland, and & Wasburn, 2009). As a result they all earn significantly less compared to their STEM-employed counterparts (U.S. Department of Commerce Economics and Statistics Administration, 2011, p. 8).

For those underrepresented minority women who do persist through the education system and workforce and achieve tenured faculty positions in STEM, Towns (2010) finds that the numbers in each ethnic group for every science discipline (chemistry, mathematics and statistics, computer science, astronomy, physics, biological sciences, earth sciences) were less than 1 percent of the total number of faculty. Further, she makes the point that the less than one percent of African American, Hispanic, and Native American women represented at the top 100 universities is far lower than the entire population of women in the country comprising these ethnic groups.

In 2009, of the 17 percent AI/AN who held bachelor's degrees (noted above), only three percent were in STEM careers (USDCESA, 2011, p. 1)—a figure lower than the 5.3 percent holding STEM jobs in the overall population and higher in relation to Hispanics holding these jobs at two percent. In contrast, Asian, non-Hispanics held 15 percent and White non-Hispanics six percent. One in five STEM workers is foreign born, of which 63 percent come from Asia.

When the distribution of the STEM workforce is examined across ethnic groups, the statistics for American Indians and Alaska Natives become even more stark. American Indians and Alaska Natives *and all others* who do not count as White, Asian, Hispanic, or Black constitute 2% of STEM workers. Non-Hispanic Whites (who constitute 68% of the workforce) hold 72% of all STEM jobs; Asians (who constitute 5% of the workforce) hold 14%. Hispanics (14% of the workforce) hold 6% of STEM jobs; and Blacks (11% of the workforce) hold 6% of STEM jobs.

Similarly, in summarizing 15 years of public opinion research about timely issues related to science and technology, science education, science literacy and more recently STEM diversity and underrepresentation, the Bayer Corporation (2012) details the persistence of discrimination and bias in the education system, workplace and social culture. These institutionalized biases, which actively discourage women and minorities from taking interest in and pursuing STEM subjects, are especially detrimental to AI/AN students' persistence in these areas. According to the Bayer report, 'Significant numbers of women and underrepresented minorities are missing the U.S. STEM workforce today because they were not identified, encouraged or nurtured to pursue STEM studies early on' (p. 7).

In March 2012 Dr. Irving McPhail, President and CEO of the National Action Council for Minorities in Engineering, Inc. (NACME) supported this assertion in strong oral testimony before the House Commerce, Justice, Science Appropriations Subcommittee. He verified American corporations' high need to compete globally in STEM fields. He also emphasized that the American public education system does not produce the talent pools necessary to meet this challenge in a sustainable way. He argues that increasing the numbers of highly qualified underrepresented minorities in STEM careers can address this problem and federal funding can help (McPhail, 2012).

Urgency of the problem

Numerous studies have focused on ways to foster STEM success across multiple groups (e.g., Bayer Corporation, 2012; Espinosa, 2011; Leggon & Pearson, 2008; Museus, Palmer, Davis & Maramba, 2011; Winkelby, Ned, Ahn, Koehler & Kennedy, 2009). This body of research centers on explaining why disparities exist, and how to increase the interest and enrolment of minority students in STEM courses and careers. Museus et al. point to alarming higher education statistics to illustrate the urgency of these actions. According to NCES 2010 statistics, for example, only 16% of African American, Latino and Native American college students who pursue STEM degrees graduate within five years, a statistic that points to the need for interventions that increase persistence among these groups once they enter the higher education system. The need to increase the number of AI/AN students entering higher education to pursue STEM degrees, graduating from college in STEM majors and joining the STEM workforce with adequate preparation is especially urgent (see for example, Lord et al, 2009; USDCESA, 2011).

To illustrate, the significant growth of Native American populations since the 1980s has meant an increase in the proportion of Native youth, college-bound or college-going students. Yet K-12 participation and performance rates in STEM subject areas remain below average. Although college attendance has increased since the 1990s (owing almost entirely to the increased participation of women), Native youth are more likely than any other racial/ethnic group to attend a two year institution than a four-year school, and are least likely to persist to college graduation. When they do attend college, they are more likely to major in the social or behavioral sciences, and are disproportionately underrepresented in science and engineering fields (Babco, 2003, p.

10), something that Babco attributes to their having been underserved in the K-12 system.

Tribal leaders attending the 2012 White House Tribal Nations Summit assert that ‘Regardless of where they attend school, Native students are not receiving an education steeped in their language or culture. They are very unlikely to receive instruction or be taught in a classroom/school climate that is appropriate for them’ (NCAI, 2012, p.32). They affirm that ‘Native education is in a state of emergency,’ (p. 32).

Insights from the National Assessment of Educational Progress/National Indian Education Study

The highly respected National Assessment of Educational Progress (NAEP) offers some insights about indigenous students’ K-12 experiences in mathematics (National Center for Education Statistics, 2012). The NAEP is the single, ongoing vehicle for assessment of American students nationally, yielding longitudinal performance data on sub-populations of students. NAEP data are now even more useful for AI/AN communities since they are linked to survey data gathered through the National Indian Education Study (NIES) on AI/AN, their teachers, and their schools (Grigg, Moran, & Kuang, 2010; Mead, Grigg, Moran & Kuang, 2010; Moran & Rampey, 2008; Moran, Rampey, Dion & Donahue, 2008).

The 2012 NIES reports present findings on the educational experiences of AI/AN students in grades 4 and 8 based on responses to the NIES student, teacher and school questionnaires, and on their NAEP reading and mathematics assessment results. Nationally representative samples of 5,400 AI/AN fourth graders and 4,200 AI/AN eighth-graders participated in the 2011 NAEP mathematics assessment designed to measure content across five areas. Analysis of results concluded that the mathematics score gap between AI/AN students and non-AI/AN students is wider today than it was in 2005. On average, they scored 16 points lower in mathematics at grade 4 and 19 points lower at grade 8 (p. 3). The score gaps were not significantly wider than in 2009, however. Variations in mathematics performance exist within AI/AN student groups as well. Overall, scores were lower for students eligible for free lunch than those who were not, and for those who live in urban or rural locations, as opposed to those who live in suburban communities, paralleling trends for other ethnic groups. Finally, mathematics scores were higher at both grades 4 and 8 for those attending public schools than those attending Bureau of Indian Education (BIE) schools (p. 4).

Several limitations to this study exist. NAEP cannot interpret the causes of, changes or differences in student achievement characteristics, nor can it control for the many factors that may influence changes in student achievement score averages. Scores are, no doubt, affected by educational policies and differential access to resources. In addition, average scores mask important differences within the small AI/AN student population sampled.

The enduring achievement gap

Plucker, Burroughs and Song (2010) further elucidate the growing K-12 math and reading achievement gaps between mainstream and underrepresented minorities. They include national and state student performance data from the NAEP in their analyses. Since 2003 the academic scores of underrepresented groups either stagnated or increased slightly, while mainstream groups increased in educational performance (p. 28). The authors attribute these growing achievement gaps largely to federal policy at the time (No Child Left Behind [NCLB] legislation), which focused on minimum competency and neglected achievement gaps at advanced levels of education (p. 24). Very few federal dollars target gifted education, and even when such dollars are available, they often are not fairly allocated across ethnic groups (National Research Council, 2002). 'There has been little progress in substantially reducing excellence gaps since the passage of NCLB … there is little existing evidence to support claims that NCLB-mandated accountability systems are increasing excellence gaps (Plucker, et al, 2010, p. 28).'

According to these authors, solutions to closing the excellence gap are straightforward:

- Make closing the excellence gap a national and state priority. The detrimental impact of underachievement on low-income, minority students has been well documented, and as such the national discussion about the implication of policy on educational excellence, including the STEM pipeline, must be addressed. This means changing the national discussion and asking questions about the impact of policy on the brightest of students, and how policy can help other students begin to achieve at high levels.

- Acknowledge that both minimum competency and excellence can be addressed simultaneously. This means getting policymakers to acknowledge that little financial incentive exists for high achievement, and that policy falsely separates the issue of excellence and minimum competency (struggling students).

- Set realistic goals to shrink gaps, as opposed to pledging the eradication of excellence gaps. It is likely that any education policy reform will improve the performance of groups who already stand to benefit.

- Determine the appropriate combination of local, state and federal policy interventions that will best promote high levels of achievement and shrink excellence gaps, which include solutions like ability groups, academic acceleration, dual credit programs, and Advanced Placement and International Baccalaureate programs. It is important to note that most decisions about gifted education programs are made at the local level and they are the first to go when funding becomes tight.

- Incorporate advanced student performance in discussions about common standards. This recommendation translates to collecting data, which allows school to track the performance of high achievers. Doing so should encourage state and local education agency accountability and create a platform upon which to develop comprehensive excellence policies.

- Begin the change process by immediately identifying the policies at the state level that may help or hinder the promotion of high achievement in K-12 schools.

- Conduct more research on advanced learning and talent development to balance the education research that exists in comparison to other areas. It is important to note that federal support of research on high achievement does not need new funding, as money from existing U.S. DOE and NSF programs could be used to research high-end learning (pp. 30-33).

Low persistence in engineering education and careers

Equitable access to premium education is clearly at the heart of any diversification challenge. Engineering, for example, has a huge diversity problem (Chubin, May & Babco, 2005; NACME, 2012). National baccalaureate and Master's degrees awarded to African Americans, Latinos and American Indians are on the decline (Chubin et al, 2005, pp. 74-75). Women are marginally if not infinitesimally represented in engineering. Although contrary to popular assumptions, Lord, et al (2009) find in their analysis of more than 79,000 students who graduated with engineering degrees at nine universities from the former Southeastern University and College Coalition for Engineering Education between 1984 and 2004 that women persist in engineering at approximately the same rates as men, even when disaggregated by race. However, as noted earlier, Native American women are the exception.

Native American women are most likely to leave the university and least likely to persist in engineering among all underrepresented minority groups (Lord, et al, p. 182). Persistence of Native American women compared to Native American men is particularly low, which cannot be attributed to STEM GPA (they are higher than those of men), but may be explained by a lack of 'critical mass', institutional tokenism, and other biases. 'Although other ethnicities do not reach parity either, they may have enough women to mitigate the isolation, the end result being comparable persistence. For Native American women, however, this threshold is never reached, and the likelihood that they can somehow overcome the negative consequences of being subjected to racial and gender stereotyping will remain remote' (Lord, et al, p. 183). Overall results about the *rate* of persistence of women and minority groups in engineering is not to be conflated with the fact of low *representation* at the time of matriculation. It should also be noted that for each racial group, women are more likely than men to switch from engineering than leave the university.

Increasing minority STEM participation: Potential solutions

McPhail (2012) recommends a multifaceted and comprehensive strategy and initiatives converging around the higher education experience and ventured by NACME in partnership with universities and colleges. He reports, 'Through our partnerships with college and universities from around the country, we have leveraged our scholarship grants with institutional activities that provide academic and intellectual support, including: mentoring, peer mentoring, internship experiences, supplemental instruction, and bridge programs that improve students' preparation for pre-requisite mathematics and science courses prior to enroling' (p. 2).

McPhail urges the federal government to launch a national experiment in post-secondary mathematics. Such an experiment could be situated at community colleges. African American, American Indian and Latino student groups are more likely to attend community colleges than their counterparts, where the 'math gap is particularly onerous' (p. 2). For example, 52 percent of American Indians are served by these community colleges where math gaps continue to exist. Finally, he recognizes the need to recruit students along the STEM pathway with substantial community and family involvement. He describes ‘Project Lead The Way,’ developed in partnership between NACME and the National Academy Foundation as an exemplary program taking this approach. ‘Project Lead the Way’ launched a national network of open enrolment, high school level engineering academies to equip students with the math and science skills necessary for college-level STEM courses.

What are other strategies for preparing and diversifying the next generation of STEM innovators? The National Science Board (2010) outlines key indicators of need and recommendations to deliver equitable STEM education among low-income, minority K-12 students, including American Indian/Native Alaskan learners, who are underrepresented in K-12 gifted and talented programs, score lower on standardized tests and are less likely to enrol in AP or mathematics courses.

According to the National Science Board schools must: (1) offer intentional, coordinated and sustainable interventions at both the formal and informal level to develop students’ potential for learning through STEM disciplines. This means accommodating student learning in ways that allow for talent, interests and capacities (i.e. pace and depth), and that elicit engagement, intellectual curiosity and creative problem solving; (2) implement wider-ranging talent assessments at multiple grade levels and among all demographics of students, and train educators to recognize potential, particularly among those students who have not been given the opportunity to transform their potential into academic achievement; and (3) create a community that supports excellence and innovative thinking among educational professionals, parents, peers and students themselves.

In 2004 a public-private partnership, Building Engineering and Science Talent (BEST), had been tasked by Congress to identify STEM programs that are effective for underrepresented groups in Pre-K through 12, in higher education, and in the workplace. Blue Ribbon panels assembled to identify and propose programs for consideration. For example, after screening 200 proposed Pre-K-12 programs, BEST and American Institutes for Research (AIR) conducted an in-depth evaluation of 34 promising K-12 programs, assessing existing research-based evidence for the effectiveness of these programs on student outcomes. Depending upon the number of high quality studies of acceptable rigor, programs were rated *verified* (5 rigorous studies), *probable* (two rigorous studies) or *potential* (one rigorous study). *Notable* indicated at least one acceptably rigorous substantially positive study and none with substantially negative results. BEST/AIR also considered qualitative information and noted programs that would benefit from additional data gathering.

The BEST/AIR approach found the quality of research evidence uneven. In fact, no program earned the *verified* rating. However, two earned *probable* and seven *notable*. Eleven programs were found to have less than rigorous evidence and would benefit from further research (BEST, 2004c, p.40). BEST/AIR acknowledges that impact studies are expensive and schools might not be in position to commit resources at the level of rigor required by this study. Still, their *User’s Guide to Programs Serving Underrepresented Students in Pre-K-12 Mathematics and Science* (2004) offers a framework of design principles that capture essential characteristics of the effective programs:

- *Defined outcomes* drive the intervention and are successfully accomplished for the entire target population. Students and educational staff agree on goals and desired outcomes. Success is measured against intended results. Outcome data provide both quantitative and qualitative information. Disaggregated outcomes provide a basis for research and continuous improvement.

- *Sustained commitment* enables effective interventions to take hold, produce results and adapt to changing circumstances. Its components are proactive leadership, sufficient resources and steadfastness in the face of setbacks. The minimum conditions for assuring sustained commitment are continuity of funding and of support at the individual school and school district levels.

- *Personalization* acknowledges that the goal of intervention is the development of students as individuals. Student-centered teaching and learning methods are core approaches. Mentoring, tutoring and peer interaction are integral parts of the learning environment. Individual differences, uniqueness and diversity are recognized and honored.

- *Challenging content* provides the foundation of knowledge and skills that students master. Curriculum is clearly defined and understood. Content is related to real-world applications, goes beyond minimum competencies, and reflects local, state and national standards. Students understand the link between the rigor of the content they study and the career opportunities that await them later in life. Appropriate academic remediation is readily available.

- *Engaged adults* who believe in the potential of all students provide support, stimulate interest and create expectations that are fundamental to the intervention. Educators play multiple roles as teachers, coaches, mentors, tutors and counselors. Teachers develop and maintain quality interactions with students and each other. Active family support is sought and established (p.27).

In a similar analysis, Chubin et al (2005) draw recommendations from the BEST public-private partnership, which rated the goals, impact, growth, sustainability and effectiveness of 124 U.S. higher education-based programs. Of the 36 programs that qualified for further analysis, 12 were identified as *exemplary* and *promising* (p. 78). The authors highlight eight key steps to promote minority participation in STEM fields at the university level: (1) institutional leaders (commitment to inclusiveness); (2) target recruitment (investing in a K-20 feeder system); (3) engaged faculty (reward faculty for developing student talent); (4) personal attention (mentoring, tutoring); (5) peer support (student interaction opportunities across cohorts, disciplines and professions); (6) enriched research experience (hands-on opportunities and internships outside the classroom); (7) bridging the next level (build institutional relationships to ensure pathways to careers); and (8) continuous evaluation of support processes and outcomes (p. 78). In addition, the authors make recommendations for how the broader education system can support all students along the engineering pathway, including pre-college preparation programs in K-12, undergraduate and graduate transition assistance (i.e. dual-degree programs that link recruitment and retention, mentoring programs, financial aid), and the purposeful diversification of faculty in the higher education setting.

In an effort to increase the number of underrepresented students of all backgrounds who can successfully complete a degree and enter the professional field in any of the

STEM subject areas, the Meyerhoff Scholars Program at the University of Maryland-Baltimore County (UMBC) (est. 1988) seeks to better understand the components and characteristics of effective interventions. It considers all high achieving high school seniors with interest in doctoral study in the sciences or engineering and who wish to contribute to a diverse workforce. The National Science Foundation acknowledges UMBC as having one of the largest concentrations of high-achieving African American students majoring in science (p.14). For example, of the 214 students enroled in the program in 2003, 65 were freshmen with average SAT scores of 1310.

Bridglall and Gordon's (2004) study of the program follows three strands of inquiry: (1) characteristics of African American and Caribbean American students who are high achievers; (2) environmental and life conditions associated with high academic achievement; and (3) characteristics of educational interventions and specified contexts associated with high levels of academic achievement among ethnic minority students (p. 7). Reviews of extant literature on high achievement, ethnography, quantitative and hermeneutic methods, and surveys are used to evaluate the components of exemplary programs and their contexts, to understand the conditions that support the programs, to identify processes used to evaluate the programs, and to examine the feasibility of using these methods to intervene at the middle and secondary school levels (p.7).

This research shows that interventions address student financial need, social and academic isolation, student perceptions of the STEM disciplines, and the need for extra-curricular supports/environments. The program boasts 10 objectives executed through 14 integrated components, which converged in significant ways around four core areas: (1) academic and social integration, (2) knowledge and skill development, (3) support and motivation, and (4) monitoring and advising. The program director was quoted as saying 'academics are the easy part; it's the other things that are involved with being a young intellectual growing up that requires their […leadership, program staff and faculty's] time and attention' (p. 30).

The authors further report that the Meyerhoff Scholars Program is validated by pre-existing research on productive methods for teaching, learning development and assessment. The program promotes active learning and analytical thinking, provides learner-centered environments mindful of students' cultural orientations, exposes students to mentors in the various STEM fields, provides counseling and peer-group supports, assesses student learning to expose their ways of thinking, and develops classrooms into communities by promoting intellectual and social cohesion. Furthermore, the program's positive outcomes are impressive. 'Both internal and external evaluations show that Meyerhoff students are nearly twice as likely to persist and graduate in mathematics, engineering, and the sciences than their peers who declined offers of admission to the program and enroled at other universities' (p. 41). What has been instrumental in the production of these outcomes is the significant role of research and evaluation in conceptualizing, implementing, and institutionalizing the Meyerhoff Scholars Program (p. 41).

It should be noted that these findings do not represent low-income students alone, but at all economic levels, and account for the over prediction of undergraduate success based on college admissions test scores. 'Combined, these findings suggest pervasive problems in the quality of opportunities to learn and in the reciprocal adaptive behaviors of these students and the institutions that serve them' (p. 3).

Ultimately, however, offering accommodations for diverse students at the university level will not itself fully address the challenge of increasing diversity in STEM courses and careers. There are changes that need to happen within STEM fields themselves. In 2012 the National Science Board completed an analysis of trends and indicators of change within the science and engineering field as they relate to the participation of minority student groups since 2000. Data used to conduct these analyses were obtained from federal and non-federal sources, primarily the National Science Foundation (NSF) and the National Center for Science and Engineering Statistics (NCSES). Due to minority population increases in the U.S. (especially among Hispanics/Latinos) and workforce globalization, the number of minority group members receiving degrees in science and engineering is on the increase. The only exception to this upward trend is among Native American groups. Rates of Native American degree attainment in science and engineering fields remain largely unchanged between 2000 and 2009. The proportion of science and engineering bachelor's degrees has decreased for minority groups in computer sciences, math and engineering. For graduate education, the number of science and engineering doctoral degrees earned by women, African-Americans and Hispanics grew faster than the number of degrees earned by white men from 2000-2009, while the numbers of Native American degrees has been largely unchanged.

Other select studies, published and unpublished, evaluate programs designed to improve the participation of underrepresented U.S. minority groups in STEM disciplines across the undergraduate, graduate, postdoctoral and junior faculty levels. The imperative to improve participation is not driven solely by population/demographic shifts and the commonly iterated 'supply and demand' argument, but also the need to enhance the quality of science by bringing new perspectives to STEM fields. Responding to prevalent findings in the field, many programs geared towards this outcome attempt to improve access of opportunity for underrepresented minorities. But access to STEM education and careers is affected by availability of financial support and awareness of such availability. For instance, the National Science Foundation reported that 'American Indian and Black doctoral students are more likely to rely on their own resources to finance their doctoral education than are Whites and Hispanics; Asians are the least likely to do so' (NSF, 2004 in Leggon & Pearson, 2008, p. 21).

Leggon and Pearson (2008) found that overall gains made by underrepresented minority groups in STEM fields are modest despite the proliferation of efforts to encourage their participation across higher education and professional fields. Reasons for this vary from the program perspective, which include inadequate funding for program evaluation, problems with program structure (unclear and therefore difficult to measure goals and indicators, impediments to data collection and interpretation) and the tendency among stakeholders to confound the meaning of rigorous evaluation with assessment activities (pp. 7-8).

In reviewing programs like the National Consortium for Graduate Degrees for Minorities in Science and Engineering (GEM), Leadership Alliance, Meyerhoff Scholars Program, Compact for Faculty Diversity and Preparing Future Faculty, Leggon and Pearson (2008) also made determinations about best practices most likely to advance the goal of enhanced underrepresented minority participation in STEM education and careers. These success indicators include (1) enhancing substantive knowledge and technical skills; (2) providing and maintaining a comprehensive support network; (3) facilitating the formation of networks; (4) providing extensive and intensive professional socialization; (5) tracking program participants internally and externally (including mentors); and (6) providing bridge experiences between one educational milestone and the next (pp. 28-29). In sum, programs that take a holistic approach in addressing the needs of these participants are most effective.

Other areas in need of more evaluation and evidence to support sustainable program interventions include: (1) the role and value of social support among students pursing graduate degrees in STEM fields to increase faculty diversity; (2) the relevance of race, ethnicity and gender to pinpoint effective policies and practices; and (3) the impact of faculty mentors on student experiences, with the goal of transferring and scaling-up best practices (pp. 30-31).

A 2005 National Research Council evaluation of the NIH minority research and training programs implemented between 1970 and 1999 centered on (a) the most and least successful programs and program features, (b) extrinsic factors that contributed to program success, (c) improvements to assessment systems, and (d) possible policy implications for the NIH. Among others, the report features a case study program, R25 Bridges to the Doctorate, designed to recruit and train Native Americans at the master's level in the field of nursing. Successes of the program were identified in the oversight and mentoring of the trainees. The program was tied to an external/bridge support program in each school the trainees attended, which was run through the Indian Health Service. They practiced 'intrusive monitoring' which involved regular and intensive oversight. The other source of support occurred through academic mentoring, which helped trainees become more proactive in their educational and career planning.

Challenges discovered in the program pertained to the combination of increased academic load and the enrolment of trainees in clinical programs, which reduces overall motivation for students to select the fields of research, teaching, or medical practice. Another key issue for the Native American trainees was the need to move away from family, community and/or tribe to participate in the program, making adjustment difficult (p. 121). This issue, which is deeply related to the unspoken role of culture in students' interactions with education, needs to be taken seriously in any effort to make STEM education and careers more accessible to Native students (NRC, 2005).

Two caveats: Culture must be considered, and more accurate data must be gathered.

Native American cultures, contexts and STEM participation

We cannot underestimate the ways in which students' positioning as 'underrepresented minorities' impacts the many dimensions of their STEM learning experiences. '[G]aps in mathematics and science start in kindergarten and widen over time among under-represented minorities generally, and especially among children with such risk factors as poverty, having a mother whose highest level of education was less than a high school diploma, or a home language other than English' (USDCESA. 2011, p. 60). In addition, 'family and community differences, school context, low expectations, and lack of exposure to role models, information about career opportunities, and advanced courses affect minority students' success in mathematics and science' (National Academy of Sciences, et. al, 2011, p.5). All students acquire community-based values, beliefs, and perspectives that are expressed in their preferences for thinking and interacting (Nelson-Barber, 1999; Greenfield, Suzuki, & Rothstein-Fisch, 2006). The point here is that the heritage communities that produce Native American students are often very distinct ethnolinguistically and culturally when compared to mainstream American settings. And the culturally-shaped aspects of their lives influence not only their learning, but also how they approach schooling itself. Ultimately such contextual and cultural elements impact the ways in which students make sense of STEM education. (See for example, Cajete, 2001; NACME, 2012; NCAI, 2012; Rodriguez, Kirchner & Hale, 2005). Several ongoing programs address the kind of family-community-school alignment so important to the trajectory of indigenous students' academic success.

Carroll, Mitchell, Tambe and St. John (2010) conducted a three-year exploratory landscape study centered on supports and resources that help Native students in South Dakota maintain interest in mathematics and science as they transition from high school to college. Combinations of interviews, site visits, mathematics and science classroom observations and focus groups were carried out with government officials, university and Tribal College students and faculty, school district administrators, program leaders, teachers, students and parents. Issues clustered around sustainable education financing, academic support and personal/cultural expectations, all of which overlap with the findings of other reports.

> Students clearly articulated the types of math and science experiences that work best for them. These include active, field-based learning experiences; small-scale, more personal learning environments; and direct access to and close working relationships with instructors. They identified important supports that contributed to success in school, namely family members, mentors, or guidance counselors who value education and encourage them to continue; small community structures within the college setting; and understanding, culturally sensitive professors (pp. 30-31).

Like the students of African descent in the Meyerhoff Scholars Program, indigenous high school students from close-knit families and communities expressed that they needed to adjust to college settings that were remarkably different from their home contexts - larger campuses, more people, and more people from outside their experience, for instance. But some of the potential negative impact of these differences was balanced by students' intrinsic motivation to take advantage of opportunities in order to reinvest their STEM learnings at home. 'The complex system and cultural barriers to overcome are not insignificant. There are multiple tribes, multiple types of school systems … and the cultures of each to be navigated. Creating additional opportunities where these different cultures can intersect successfully - where they can be understood, valued, nurtured and co-exist - is an important step in addressing this issue' (p.32).

Gilbert's (2010) Native Science Connections Research Project (NSCRP) is a culturally relevant science curriculum that integrates Native American students' traditional cultural knowledge with Western science for fifth grade students in public, contract and BIA schools on the Navajo, Hopi, San Carlos Apache and Zuni reservations. NSCRP is action- and inquiry-oriented and designed to strengthen teacher and student confidence in native language, culture and ways of knowing. It also promotes community involvement in education. The author contends that 'culturally based science curriculum … may not only improve student academic achievement in science education and other content areas, but also change the students' attitudes in a positive direction …' (p. 54). Culture-based learning reduces the alienation often induced by NCLB/Western schooling, which compartmentalizes subject matter, and creates an 'either/or' position between the learning of science and the learning of language (Gilbert, 2010).

The most robust research supporting the notion that indigenous student performance improves when local linguistic and cultural practices are employed in the classroom is documented in longitudinal studies conducted by a research team in Alaska composed of elders, local teachers, university faculty and other researchers (e.g., Lipka & Adams, 2004; Lipka, Parker-Webster, & Yanez, 2005; Nelson-Barber & Lipka, 2007). Over nearly two decades of development, this group has produced culturally relevant supplemental elementary level mathematics curricula - *Math in a Cultural Context* (MCC) - that connect local knowledge to school knowledge, integrating literacy, geography, and science. Rigorous experimental and quasi-experimental designs used in numerous studies found that students who experience MCC make statistically significant gains in learning as measured by conventionally designed pre- and post-tests (see for example, Lipka & Adams, 2004; Nelson-Barber & Lipka, 2008). These studies are yielding interesting findings about the power of including culture and context for increasing achievement among *all* students. In Alaska, students from *all* backgrounds who engage with Yup'ik culture-based curriculum are showing statistically significant gains in achievement over peers using conventional curricula. It is important to note that MCC is one of the programs that was not rated by the BEST/AIR evaluation and merited *further research* because only one rigorous study had been completed at the time of its nomination for consideration as a successful program.

As evidenced in observations of STEM programming at several Tribal Colleges and Universities (TCU), Nelson-Barber (2008) finds a relationship between student academic success and the extent to which the colleges integrate cultural traditions and ways of being into students' daily experiences. In her experience studying TCU STEM education she notes that in these contexts, students acquire STEM competencies that are required for the mainstream workforce but also utilize skill sets that reinforce STEM competencies within their own place-based knowledge systems. TCUs are equipped to capitalize on strong community ties to their surroundings as they make use of systems of teaching and learning that are intentionally indigenous-centric. As an example, faculty bring together elders, who have deep and longstanding knowledge of the natural environment, with students and local youth, just as intergenerational heritage education would naturally occur. This approach mirrors the relationships of *extended family* customary in student communities. Pedagogically, science faculty might take into account more holistic world views and begin teaching at the level of the ecosystem, working their way to the molecular level, whereas in a mainstream setting they would begin teaching component parts and sequence material in the opposite direction (see for example, Rodriguez, et al, 2005; Cajete, 1999).

Schmidke (2010) affirms these findings in an article that looks to identify ways to improve American Indian retention and success in college. The author elaborates on factors contributing to American Indian college persistence based on observations of math and science instructors at Great Plains Technical College (GPTC), a sub-baccalaureate technical institution in Oklahoma reflecting average graduation rates for American Indian groups. Results suggest that low college completion rates among

American Indians are not linked to academic ability, but rather, related to the dominant (White) institutional cultures and the inability among faculty to understand, respect and/or respond to the needs of Native students.

According to the instructors questioned in the study, (a) attendance and (b) class participation stood out as reasons for lower than average college retention among American Indian students. The instructors reported frequent absences due to family obligations as a major barrier, which include the need to return home to celebrate family/community events, mediate family conflicts, manage financial and medical issues, and negotiate family dissatisfaction with their college attendance. The issue of class participation was linked to a common or 'typical' style of learning among American Indian students, which involves 'observation, asking few questions, further observation, private practice and performance' (p. 15).

What further research may reveal has much to do with the higher persistence rate among American Indian students who study math and science than their peers at GPTC. This suggests that there may be elements of the science and math classroom that make students comfortable enough to remain in college and complete their degree programs. The author hypothesized some of these elements based on previous literature about American Indian learning preferences.

Given the way GPTC organizes instruction, students may be able to see the direct value of what they are studying in science and math and therefore be more motivated to persist. Additionally, science and math class sizes tend to be smaller, creating more supportive community environments that better align with American Indian student comfort zones. Smaller class sizes may lead to more caring relationships between instructors and students, which is considered a predictor of American Indian success in previous literature. As GPTC offers technical degrees that lead to immediate employment, the author also suggested that students in math and science related programs might have a higher level of maturity and clearer direction for what they want to do with their lives. Research also suggests that those who are more familiar with mainstream (White) culture are more prone to succeed. Math and science career tracks may provide better career counseling than strictly academic tracks, and finally, math and science pedagogy may be more compatible with American Indian learning styles. The field would benefit from further study of these variables.

As detailed in the National Science Foundation's (NSF) Strategic Plan FY 2006-2011, *Investing in America's Future*, the NSF encourages research of this nature as well as outreach via its myriad programs that center on broadening participation and improving education and workforce development in STEM. In addition to funding research, programs create opportunities and develop innovations among diverse individuals, institutions and geographic regions. The NSF recently created a Comprehensive Broadening Participation of Undergraduates in STEM program to increase minority participation in the STEM fields. For indigenous students, the Tribal Colleges and Universities Program (TCUP) funds Tribal Colleges and Universities, Alaska Native-serving institutions, and Native Hawaiian-serving institutions (mostly two-year and community colleges) with support for planning, instructional capacity building, and STEM research and education.

NSF offers opportunities for minority-serving institutions/programs to partner with one another. In addition to TCUP there are the Historically Black Colleges and Universities

Undergraduate Program (HBCU-UP) and the Louis Stokes Alliances for Minority Participation (LSAMP). An early iteration of such a collaboration, Model Institutions of Excellence (MIE), offered an approach that contributed to increased STEM achievement among Native, African American and Latino students (Rodriguez, et al, 2005). Critical MIE elements included: precollege initiatives, student support, undergraduate research, faculty development, curriculum development, physical infrastructure and graduate program and science career initiatives.

Building from these successes, the NSF initiated the Model Replication Institutions (MRI) Program in 2006 to aid in mobilizing minority-serving institutions to enlarge the pipeline. According to the National Science Board (2004), HBCUs, TCUs, and Hispanic-serving institutions successfully educate and graduate their students, awarding about one-third of STEM degrees to minority students. Many believe this success results from an ability to respond to the kinds of conditions raised by the Meyerhoff Scholars Program. Minority-serving institutions

> … have a long history of helping students overcome the major financial and academic barriers to degree completion. MSIs provide educational opportunities tailored to students who have been denied access to adequate elementary and secondary school preparation, particularly first-generation and low-income students …. MSIs are well-positioned to reach students of color and to leverage the strategic resources provided by the MRI project to assist these students (Cullinane & Leegwater, 2009, p.3).

Building on best practices identified by MIE, the MRI program capitalizes on the strengths of minority-serving institutions to replicate successful NSF initiatives (Cullinane & Lacey, p.3).

Finally, alliances with industry facilitate development of the next generation of STEM experts. Several of the numerous examples in Indian country are outlined here. New Mexico's Sandia Labs' American Indian Outreach Committee (AIOC), which has aligned with the American Indian Science and Engineering Society (AISES), has had great success honing the STEM interests of indigenous students. Recruitment begins as early as elementary school and students participate in conferences and other educational events, network socially, and eventually work with seasoned mentors in engineering, science and STEM research. Sandia's Dream Catcher Science Program is a long-standing mentorship effort for Native students grades 6 through 12, which paves the way for positive experiences in college-level STEM courses and careers (USDOER, 2011).

Together with AISES and the American Indian Higher Education Consortium (AIHEC), the U.S. Department of Energy Resources has created the American Indian Research and Education Initiative 'to develop the energy literacy of future American Indian leaders by providing scientific and technological skills to help their communities manage their lands and develop energy resources' (USDOER, 2011, p.1). Over a period of three years, six institutions are connecting student and faculty teams with National Laboratories to promote interest in STEM through education, research and career development.

The U.S. Department of Energy, the NSF, and the NASA Office of Education's Minority University Research and Education Program for the Tribal Colleges and Universities

Project, are examples of tier one agencies and programs looking to increase STEM career opportunities for indigenous students.

Differences among Indigenous groups must be acknowledged and educational data collected accordingly

Special focus on Native Hawaiian and Pacific Islander participation in STEM

This essay has focused on the experiences of 'Native Americans', referring to the indigenous populations of the mainland U.S. and the state of Alaska -- American Indians and Alaska Natives. These groups are not the only indigenous populations with U.S. affiliation. Also among such populations are Native Hawaiians and Pacific Islanders from former U.S. territories that make up the U.S. affiliated Pacific Islands (USAPI). The USAPI region includes the state of Hawai'i; the territories of American Samoa, Guam, and the Commonwealth of the Northern Mariana Islands (CNMI); and the Freely-Associated States (FAS) that constitute independent nations possessing Compacts of Free Association with the U.S.: the Republic of the Marshall Islands (RMI); the Republic of Palau; and the four Federated States of Micronesia (FSM), Chuuk, Kosrae, Pohnpei, and Yap. As American education has remained the persistent model in this region since WWII, the USAPI indigenous populations diaspora also surface as underrepresented in STEM.

When considering performance and participation statistics for Pacific Islanders, it is important to note that Asian Americans and Pacific Islanders are often considered members of a single affinity group, when, in fact, various Asian groups as well as Pacific Island groups represent distinct cultures with distinct needs. The tendency to statistically group Asian Americans and Pacific Islanders together leads to underestimation of the achievements of some subpopulations and overestimation of the success of others (AAPI, 2003, p. 4). In too many cases, such broad labeling obscures the abysmal and crisis-level statistics of indigenous Pacific Islanders in education generally, and in STEM in particular.

National Assessment of Educational Progress reports offer good examples of this phenomenon. The 2010 *Nation's Report Card: Mathematics 2009* demonstrates that for 4th and 8th graders, all racial/ethnic groups showed higher average mathematics scores in 2009 than in 2007 and 1990. It also offers that Asian/Pacific Islander 4th grade scores were the highest followed by those of whites. The same year American College Testing (ACT), a standardized test for high school achievement and college admissions in the U.S., reported that three benchmarks were met by at least 50 percent of Asian American/Pacific Islander and white students, while one was met by at least 50 percent of American Indian/Alaska Native students (ACT, 2009).

Herein lies the paradox of the apparent educational success of Pacific Islanders. There are far more Asians in U.S. schools than Pacific Islanders. This alone skews Pacific Islander data toward high performance levels. The collective educational success of Asians in mathematics and science over time has led to the identification of this 'group' as a 'model minority', a designation which bypasses the realities of myriad ethnolinguistic distinctions, historical experiences, and diverse socioeconomic conditions - meaning that not all 'Asians' have access to high quality education, nor do they all excel in STEM. Although American Indians and Pacific Islander populations are also quite distinct, there is a rationale for collapsing these groups as indigenous peoples versus collapsing Pacific Islanders and Asians, who have much less in common.

As reports begin to disaggregate Asian American and Pacific Islander data, a range of issues emerge. For instance, the 2011 National Academies report, *Expanding Underrepresented Minority Participation,* shows that at one end of the STEM courses-to-careers continuum, just 26 percent of African Americans, 24 percent of Native Americans and Pacific Islanders, and 18 percent of Hispanics and Latinos in the 25- to 34-year-old cohort have attained at least an associate's degree (p. 35). At the other end of this continuum, of the Principal Investigators awarded NSF research grants 2.2 percent were African Americans, 4.0 percent were Hispanic, and 0.3 percent were Native American/Alaska Native/Native Hawaiian/Pacific Islander (p. 49). A 2010 report compiled by the National Center for Education Statistics reveals that of the pool of underrepresented minorities and women enroled in postsecondary institutions, Asians/Pacific Islanders had the fastest rate of increase between 1976 and 2008 (561 percent with enrolment increasing from 169,000 to 1,118,000). American Indian/Alaska Native enrolment increased from 70,000 to 176,000 - a 151 percent increase. Clearly, reporting remains uneven (and misleading), as not all studies make the important differentiations among these constituencies.

These figures continue to support the finding that minorities are underrepresented and underutilized in STEM education and careers. This is true at the secondary, doctoral, faculty and federal research grant recipient levels. Appropriate conditions to sustain far-reaching STEM success among U.S. indigenous populations are not yet in place.

Policy implications

Observations from Indian Country

December 2, 2011, President Obama issued Executive Order 13592: Improving American Indian and Alaska Native Educational Opportunities and Strengthening Tribal Colleges and Universities as part of the White House Initiative on American Indian and Alaska Native Education. An excerpt from Section 1 states, 'It is the policy of my Administration to support activities that will strengthen the Nation by expanding educational opportunities and improving educational outcomes for all AI/AN students in order to fulfill our commitment to furthering tribal self-determination and to help ensure that AI/AN students have an opportunity to learn their Native languages and histories and receive complete and competitive educations that prepare them for college, careers, and productive and satisfying lives'.

Many activities had already begun following the President's November 2009 release of an Executive Memorandum on consultation and coordination with tribal governments under President Clinton's Executive Order 13175. Among the many federal agency consultations with tribes, the USDOE canvassed indigenous communities across the country speaking with community members and leaders, gathering information for a report on the state of Indian Education (USDOE, 2011), as described in their plan of action (USDOE, 2010).

Many of the issues raised were specific to Indian and Alaska Native education, of course: the government's inattention to trust responsibilities and overall inter- and intra-governmental relations. However, the remaining concerns resonate with the areas of high need identified in earlier sections as articulated across ethnic and racial groups. First and foremost, all groups plead for proper funding to produce high quality education. Teachers must be intellectually and culturally qualified, have access to appropriate curricular resources, be able to deliver the most meaningful pedagogy, and to understand how assessments can best capture student excellence. Better data systems for collecting and analyzing information about American Indian/Alaska Native education will better inform decision-making. In fact, more coordination and leveraging of efforts across local, state and federal agencies is needed for improved accountability. These efforts and more are believed to contribute in order to expect equal participation in the *cradle to career pipeline*.

At the recent White House Tribal Nations Summit (2012) tribal leaders recommended that the President separate out and reissue the original stand-alone Executive Order and Initiative on Tribal Colleges and Universities, now folded into the broader Executive Order 13592 on Native Education. They believe this higher level of focus and effort is needed to appropriately address the needs of TCUs, as do stand-alone EOs for African American education and historically black colleges and universities (NCAI, 2012, p.33). They also await details of the USDOE's consultation policy regarding how Native perspectives will be integrated into decisions affecting Native students and schools (p. 33).

Implications for all

Important policy and practice considerations must coalesce to meet the challenge of underrepresentation of minorities and women in STEM fields. BEST (2004), the Congressional Research Services (2008, 2012), the National Academies (2010), NACME (2012), NCAI (2012) and other analyses recommend that jointly educators, policy makers, business and industry can tackle the diminished representation of these populations, including indigenous students, in STEM courses and careers. The directive to broaden all aspects of the pipeline requires a systemic approach, much of which can be found in the specifications detailed by the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act [America COMPETES Act] of 2007 (P.L. 110-69) and America COMPETES Reauthorization Act of 2010 (P.L. 111-358) (see for example, Gonzales, 2010; Gonzalez & Kuenzi, 2012; Kuenzi, 2008).

The pathway begins in K-12 education with efforts to identify talent, improve elementary and secondary preparation in math and science and an eye toward lowering drop-out rates and increasing rates of high school completion. More well-trained STEM teachers are needed, meaning investment in teacher preparation as well as professional growth opportunities for seasoned elementary and secondary math and science educators. The National Academies and others call for expanded development of specialty high schools, summer internships and research opportunities to pursue additional innovations. Increased numbers of high school graduates with STEM interests will require an expanded base of undergraduate STEM programs. There will be graduate study and eventual entrée into STEM fields via internships, post-graduate work, fellowships and STEM professions, all of which require adequate funding. Competitive grants made available to postsecondary institutions will help create programs that align university STEM programs with K-12 education. For instance, needs- and merit-based scholarships will support students who earn certification as K-12 STEM teachers along with their 4-yr STEM degrees. College and University scholarships and fellowships are needed to support graduate education. One strategy is to recruit current STEM teachers (with or without STEM bachelor's degrees) to their master's degree programs and train current teachers to provide AP/Honors instruction. Maintaining direct connections with business and industry (e.g., the National Laboratory initiatives such as the Sandia program noted above) build capacity and lead to career placement and economic growth for diverse communities and the nation, completing the circle.

According to Bridglall and Gordon (2004), improving overall academic performance in STEM for underrepresented students means maintaining a supportive and rigorous academic program with high expectations, active community service and a 'moral and ethical imperative to promote minority student academic success' (p.42). Combining an expanded base of effective programs with increased funding for national research efforts centered on teaching and learning, we are sure to develop technical talent pools representative of the diversity of the U.S. According to Bridglall and Gordon (2004), improving overall academic performance in STEM for underrepresented students means maintaining a supportive and rigorous academic program with high expectations, active community service and a 'moral and ethical imperative to promote minority student academic success' (p.42). Combining an expanded base of effective programs with increased funding for national research efforts centered on teaching and learning, we are sure to develop technical talent pools representative of the diversity of the U.S. It bears re-emphasizing that if broad policies are to have high impact, they must be backed by teacher preparation and teacher professional development that provide STEM teachers with a deep understanding of the sociocultural foundations of AI/AN students' learning.

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