Citation: Taborn, Tyrone D. “Separating Race from Technology: Finding Tomorrow’s IT Progress in the Past." *Learning Race and Ethnicity: Youth and Digital Media*. Edited by Anna Everett. The John D. and Catherine T. MacArthur Foundation Series on Digital Media and Learning. Cambridge, MA: The MIT Press, 2008. 39–60. doi: 10.1162/dmal.9780262550673.039

Separating Race from Technology: Finding Tomorrow’s IT Progress in the Past

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Saying that the Digital Divide is closing because minorities have greater access to computers is like saying minorities have a stake in the automobile industry because they drive cars.[1]

Myths, if recited often enough, become self-fulfilling prophecies. Two such myths, turned prophetic, run counter to the low participation rates of minorities in the science, technology, engineering, math (STEM), and technological arts fields. First, popular opinion holds that mathematics is a loathed subject and an area of particular weakness for students of color. However, there are studies that find more minority students rate math as their favorite subject than do their white counterparts.[2] Second, there is a familiar myth that blacks, especially, and other minority youth by extension, are slower to adopt technologies that connect them to the nation’s information infrastructure. However, the National Telecommunications and Information Administration report, which several subsequent studies support, shows that despite the divide, blacks are coming online in increasing numbers, and that they are actively keeping pace with the purchases of products that link them to the communications infrastructure.[3]

The fact that minorities have a propensity toward math raises the question about why there are so few of them in advanced math courses leading to a track in STEM careers. Other studies have revealed that a similar misperception about math incompetence among women is common as well. Young girls actually score higher in these subjects than do boys. Yet, as they advance in school, they lose interest. The point here is that we need to be more concerned with why there are, and how to prevent, such outcomes and misperceptions that have very real consequences for already underserved minority youths and girls.

It is not only the failure of organized programs to bridge the digital divide that concerns us here. There is another problem where race and technology intersect. Walk into any classroom (majority white or minority, rich or poor) and quiz students on whether they know Kobe Bryant. Then, query them on Dr. Mark Dean, the African American engineer who played a critical part in developing the modern-day IBM personal computer. Sadly, most students will not know much about the latter. This demonstrates the lack of awareness and self-knowledge minority youths show when it comes to identifying black role models in technology. Still, experiences are not identical for all minorities. The African American story—the fact that few black youths know African American computer scientist Dr. Mark Dean—has much in common with the rest.

"I Want to Be Like Mike"

The lack of visible role models in science and digital media technologies represents an enormous problem for closing the technology gap. A number of surveys indicate that many technology professionals entered the field because of a role model (ITAA).[4] For white youths, the odds are on their side for opportunities to interact with role models who reflect their values and culture in today's new information society. The situation is not the same for minorities. As our Kobe Bryant–Mark Dean example above attests, the small pool of minority technology professionals makes it very unlikely that minority youth will have meaningful and life-changing interactions or encounters with information technology (IT) role models that look like them.

A *US Black Engineer & Information Technology* magazine survey showed that 23 percent of respondents cited an advisor's role in influencing their career choices.[5] Twenty-one percent cited a family member, and 30 percent said a role model working in the IT field had influenced their choices. For minority youth, many of whom lack access to professional role models, contemporary media images and history take on critical roles in shaping their relationship to science and technology, and even their positions in the ubiquitous computing culture that defines much of their everyday lives. Underlying this problem is the fact that the significant achievements of minorities in scientific and technical fields have been obscured by history and popular culture representations. Even more sinister is that what gets erased is minority communities' historical practices of embracing technology, and their record of producing some of humanity's greatest IT innovations. So precious little of this important history is taught or documented. Therefore, having neither identifiable role models nor historical records to consult, minorities see technology and the world of science as places where very few of their kind are reflected, and spaces where none of them can enter and flourish.

Bruce Sinclair, author of *Technology and the African-American Experience*, argues that it will take more than writing blacks and other minorities back into history to remedy the problem. Understanding how whites have presented themselves is crucial as well. He says, "From the eighteenth century on, white Americans described themselves as an inventive people. They claimed to have a natural disposition for quick and novel solutions to the practical problem of life."[6] Of course, this characterization is an exaggeration. If minority youths were familiarized with their impressive IT history, they might not be so easily intimidated, or their early passions for mathematics so readily extinguished. Part of the reason for low minority participation (beyond consumerism) in science and technology, and in digital media culture, is that the technological discourse has been separated from the larger issue of race in the United States. In spite of progress in providing minority communities and schools with technology artifacts like computers, longstanding racial issues continue to be formidable obstacles to minority pipeline development for future science and technology workers and educators.

So, we ask now, why is it that black and brown students are still failing to change this technological imbalance and increase their ranks in the science and technology fields? To find answers, we now turn to other factors. One, minority youth don't feel welcome in many STEM and other IT classes. Two, negative attitudes and perceptions of instructors persist. And, three, there are very few people who look like them teaching the courses.[7] For many minority students, the consequence is a lack of self-confidence, feelings of isolation, and, finally, a loss of interest in these subjects. However, perception plays a far larger role than the academic community seems willing to acknowledge. What the research demonstrates is that among the factors that influence the low participation rates of women and minorities in science and technology are the following:

- Lack of self-confidence
- Feeling of isolation
- Lack of interest
- Financial problems
- Not being accepted into a department
- Feelings of intimidation
- Poor advising

A study at Iowa State University entitled "An Engineering Student Retention Study," by Cheryl Moller-Wong and Arvid Eide, printed in the *Journal of Engineering Education* in January 1997,[8] organized attrition factors into the following five categories:

- Background (existed for the student prior to enrollment)
- Organizational (admissions, scheduling, financial aid, academic, and social services)
- Academic and social integration (social life, friends, contact with faculty members, appropriate study skills)
- Attitude and motivation (self-confidence, sense of development, individual stress, desire)
- Institutional fit (family traditions, peer pressure, or perception of need to obtain a degree from a specific institution to be successful).

The reality is that technological growth for students of color follows a model of positive feedback; that is, it reinforces itself. Relevant feedback and reinforcement leads to technological development, which leads to newer technology skills, which, in turn, leads to technological development for the nation. Hence, the nation's need for technological development will only grow—increasingly faster and more voraciously—as larger numbers of women and minorities embrace technology opportunities. For the country to prosper internationally, and for America to ensure its leadership in the global IT marketplace and information society, the nation can't afford a culture that is content to have a population of technology have-nots. At the same time, it is important to acquaint underrepresented youths with fully articulated histories of IT pioneers, innovators, leaders, creators, entrepreneurs, artists, and activists from their racial and ethnic backgrounds. We will address some of this little-known history in what follows.

Connecting to the Past

America's minority groups share an equally insidious experience of obscuration of their contributions to earlier science and technology histories, as well as to the more contemporary histories of IT development. As Sinclair aptly puts it, "The history of race in America has been written as if [minority communities'] role in technology scarcely existed, and the history of technology as if it were utterly innocent of racial significance."[9] He supports this thesis by calling attention to the scarcity of established literature that "explores this relationship" and the nonexistent "body of teaching that unites the two subjects." For the most part, the image of minorities was unflattering, limiting their relationship to technology either to the role of consumers or of operators of the technological wizardry created by whites.[10]

Early Participation in Technology (1945–1980)

History will mark World War II (1939–1945) as the beginning of the computer information age, and the turn of the twentieth century as the moment in history when digital technology became firmly entrenched in all segments of society. Technology played an important role in helping the Allies defeat Japan and Germany. And mass production, ushered in by Henry Ford in the automobile industry, allowed high-volume manufacturing of finished goods and increased productivity. Worker gains came with huge investments in automation and mass production techniques. However, while mass production was becoming prevalent in the United States, Japan and Germany were still using slower, ineffective manual labor in their factories.

Also during World War II, military research resulted in scientific breakthroughs that would soon be of commercial value. War department investment in both research and applied sciences enabled "many major technologies [to be] used for the first time, including nuclear weapons, radar, proximity fuses, jet engines, ballistic missiles, and data-processing analog devices (primitive computers). Every year, piston engines were improved. Enormous advancement was made in aircraft, submarine, and tank designs, such that models coming into use at the beginning of the war were long obsolete by its end. One entirely new kind of ship was the amphibious landing craft."[11]

From a cursory glance, it would appear that the contributions of women, minorities, and blacks (in particular) were nonexistent during this social transformation, but nothing could be further from the truth. Take the case of Admiral Grace Hopper. The computer futurist is best known for her contribution to the invention of the compiler, the computing program that translates English instructions to a language understood by computers. Hopper paved the way for the discipline of computer science with her contributions to the Mark I and Mark II radar programs towards the end of War World II.

Another example is Grace Brewster Murray. She graduated from Vassar with a B.A. in mathematics in 1928, and worked under Oystein Ore at Yale for her M.A. (1930) and Ph.D. (1934). She began teaching mathematics at Vassar in 1931. A decade later, Murray achieved the rank of associate professor, when she won a faculty fellowship for study at New York University's Courant Institute for Mathematics.[12]

There was also the African American inventor Otis Boykin, born in Dallas, Texas, in 1920. He is responsible for inventing the electrical device used in all guided missiles and IBM computers, plus twenty-six other electronic devices, including a control unit for an artificial heart stimulator (pacemaker).[13] One of Boykin's first achievements was a type of resistor used in radios, television sets, and a variety of electronic devices. Boykin's improvement to the electrical resistors contributed to today's digital age and the growing pervasiveness of digital technology. Boykin certainly wasn't alone in contributing to the four revolutionary advancements in computer-based technology since World War II. Women and blacks played a major role in the war's industrial complex. However, in 1944, a *Saturday Evening Post* headline asked, "Are Women Doing Their Share?"[14] The tone of the article implied that women were little more than mere housewives, and it seemed to scold them about the need to do more to support the war effort. In reality, some 5 million American women, and blacks, filled the jobs vacated by men entering the armed forces. By the end of 1942, the defense workforce was composed almost entirely of women, African

Americans, and other minorities—the largest previously untapped labor pools. Their contributions to the development of technology have not been fully acknowledged or rewarded, because more than 4 million lost their jobs to GIs returning home at the end the of the war.[15]

Nonetheless, women and minorities participated in all technological advancements from automation to IT to the personal computer, and now to digital technologies. And though many of their contributions have been minimized at best and, at worst, erased from history altogether, the fact remains that without them the modern world would not enjoy the advanced technology, research, science, and telecommunications that define our current era.

The Information Age, 1960–1985: From the Factory Floor and Government to Corporate America

By the late 1950s, the information technology age had arrived. One sure sign was Bank of America's adoption of a mainframe computer system for data and check processing. This period saw computers move from being very large, energy-hogging tube technology to more effective and smaller-scale transistors. Computers were also being transformed from performing simple, repetitive operations to more complex information storage and retrieval. The information technology age would transform business and everyday life in industrial nations. ATMs were developed, information would flow at the speed of light as mainframes were networked, and financial data became accessible in real time and on demand, driving global economic growth. While the numbers of women and minorities would remain low, they continued to play an integral part just the same.

A decade later, Hispanic Engineer Edson de Castro emerged as one of the contemporary IT pioneers of his generation. His early career in the 1960s was as a design engineer at Digital Equipment Corporation (DEC), where he led the team designing the famous PDP-8 mini computer. In 1968, he left DEC to co-found Data General. He grew the company revenues to more than $3 billion and captured 11 percent of all minicomputer sales nationwide. His blunt speaking earned him a reputation for forthrightness and honesty so that the *Boston Globe* said gave him a "brash renegade" image.[16] De Castro was a prophet of technology's future. Predicting all businesses would embrace technology, de Castro said, "Most, even what we'd consider old line industries, are beginning to get themselves very involved in technology because technology is what they need to encourage the productivity to remain competitive in their industries. They're starting to work with all kinds of new things in automobile companies, such as General Motors and their Saturn Project. Those are pretty technologically intensive undertakings. I think some of our older line industries may in fact have been napping for a while. But now they're wide awake."[17] Clearly, most of de Castro's prophecies seem outdated today. GPS and other technologies are standard in automobiles, utility companies and digital technologies are morphing into one, and the list of extinctions is mounting for the old-line industries failing to bridge the technological divide.

And de Castro is largely overlooked by mainstream histories of technology development. In 1997, *Business Week* magazine made an effort to correct the story with an excerpt from *The Soul of a New Machine* by Tracy Kidder. "A chapter of DEC's official history, a technical work that the company published, describes the making of a computer called the PDP-8. DEC sent this machine to market in 1965. It was a hit. It made DEC's first fortune. The PDP-8, says the official history, "established the concept of minicomputers, leading the way to a multibillion-dollar industry." But the book doesn't say that Edson de Castro—then an engineer in his twenties—led the team that designed the PDP-8. The technical history mentions de Castro only once, briefly, and in another context. They expunged de Castro.[18]

De Castro also made two other notable contributions during his career at Data General. The company introduced one of the first portable IBM-PC portable computers. It would be a forerunner to the laptop. As innovative as that was, Data General would be one of the largest U.S. computer makers to produce its first personal computer at a Japanese plant. Ed de Castro would later explain that the business climate in Massachusetts was less than ideal for growth.

The PC Revolution (1970–2000)

Because of Mark Dean, Ph.D., the African American engineer who coinvented components of the IBM computer, the computer would move from labs to millions of desktops and homes in less than thirty years. The power of the personal computer fundamentally changed the world, as programmers, designers, and manufactures brought ideas and new business models to life. Just as important, the affordability of computing power allowed for new players in the technology field.

The personal computer revolution made technology artifacts available to countless millions, and as they came under the digital sky, technology workers were needed to implement technologies in the workplace and create services and applications. High-tech replaced blue-collar, manual occupations as being the surest path to the American dream. On average, where electrical engineers make slightly more than $62,000 per year, the information systems manager averaged $75,000. The engineering and IT fields will add more than 2 million jobs by 2014. According to the Bureau of Labor Statistics, jobs requiring technical skills will be in great demand for the foreseeable future, with rapid growth for computer engineers, analysts, and support specialists.[19]

Earl A. Pace Jr. and the late David Wimberly did not miss the significance of this burgeoning field nor its importance for minority technology workers. After a meeting in 1975 where they discussed their concerns about the low numbers of minorities in the data processing field, the two founded the Black Data Processing Association (BDPA) in Philadelphia. According to BDPA's official history, "There was a lack of minorities in middle and upper management, low recruitment and poor preparation of minorities for these positions, and an overall lack of career mobility."[20] In the intervening years, BDPA has grown from an organization of just thirty-five members to thousands of members throughout the United States. Consequently, the organization became and continues to be an important catalyst for professional growth and technical development in the IT industry.

The midseventies also saw the rise of Native Americans in the science, engineering, and technology fields. In 1977, American Indian scientists, engineers, and educators created the American Indian Science and Engineering Society (AISES) to address high dropout rates and low college enrollment and graduation rates of American Indians, along with the historical underrepresentation of American Indians in science and engineering.

AISES has a focus in helping American Indian and Native Alaskan students prepare for careers in science, technology, engineering, and business. The organization's mission reads,

> The American Indian Science and Engineering Society was founded in 1977 by American Indian scientists, engineers and educators. In view of the high dropout rates and low college enrollment and

graduation rates of American Indians compared with all other ethnic groups in the United States, and the severe under-representation of American Indians in the science and engineering fields, these Native professionals resolved to create an organization that would identify and remove the barriers to academic success for Native students.[21]

Another notable organization was the Chinese Institute of Engineers. The CIE/USA National Council, a federation organization of CIE/USA, was established in 1986, with the Greater New York and San Francisco Bay Area chapters as its founding chapters. In the following years, the National Council was expanded to include a Seattle Chapter, an Overseas Chinese Environmental Engineers and Scientists Association Chapter, a Dallas-Fort Worth Chapter, and a New Mexico Chapter.

Minority Youth as Early Adopters

Samsung's slogan, "Technology that takes your life to a higher power," captures how digital, communication, and information technologies have become pervasive in the daily life and economic activity of Americans and in other industrial nations. The personal computer unlocks a multiplicity of means for individual expression and productivity. Rather than have technology happen to the individual, individuals would now embrace technology and have a share in its developmental outcome. Thus, the pervasiveness and accessibility of digital technologies has deeply impacted young adults and teens, minority youths included. Take the Internet, for instance. According to the Pew Internet & American Life Project, some "57 percent of online teens create content for the Internet. That amounts to half of all teens ages 12–17."[22] The Pew Content Creators report mentions that teens are most involved in activities like creating blogs and personal Web pages, and doing work on Web pages for school, for friends, and/or for organizations. They also use the Web for social networking, such as sharing artwork, photos, music, and videos.

Young people use the Internet to a greater extent for leisure and research. Eighty-four percent of young, black Internet users, compared to 64 percent of older blacks, used the Internet for no particular reason except to have fun. Youth adoption rates are just as high with online chats, music downloads, multimedia browsing, and Web-based activities.[23] Internet usage hasn't been the only area in which youth of all races have been early adopters of technology. Cell phone usage and other interactive technologies have had great appeal to teens and young people. Interactive technologies, in particular, have appealed to African American youth to a larger degree than to their white counterparts.[24] Again, we find that minorities have played significant roles in advancing these consumer technologies. Take the cell and terrestrial technologies, something that is second nature to just about every American youth. Hispanics have been right in the middle of the research, development, and businesses operations sides of those technologies.

On the research side, Maria Martinez, a computer scientist, developed and patented an algorithm for managing the magnetic defects in the telephone switching hardware. When the switching hardware isn't functioning properly, calls can't reach their intended destinations, much as when the wrong Web address is entered in an Internet search. Hispanic technology workers were key players on the business side as well. In the early 1990s, Eduardo Dardet, a project manager, was partly responsible for bringing Motorola's paging services to the millions of users in the United States and abroad. Around the same period, George Foyo and Ernie Rodriquez, both vice presidents at AT&T, brought digital, stored-program control telephone systems to Latin America. These individuals were representatives both of the technology users and of the developers and implementers of that technology.

Young people are also large users of gaming, and there are growing numbers of them moving into the development end of the business. For Ntiedo Etuk, games are serious business. Etuk is CEO of Tabula Digital, Inc., a New York-based educational video game company. Etuk's company focuses on teaching algebra by using video games. In an interview with *USBE & Information Technology*, Etuk said, "Algebra is a 'gating' subject for high school and college. Statistics show that you are five times as likely to go to college if you have passed algebra. It's also something a tremendous number of students don't do very well."[25] "As a result," Etuk continued, "Tabula Digital's founders thought that playing video games, demonstrated to be one of the most compelling media for teenagers and tweens, and combining that with a critical need, you are adapting your educational tool to a format kids are used to." Etuk backs up his theory with eye-opening statistics:

> A child born today will watch 20,000 hours of television, see 400,000 commercials, and spend 10,000 hours on video games before age 21. That's a total of 416 days. For the MTV generation, a group that grows up multitasking between e-mails, IMs, homework, and listening to the radio, everything is happening at the same time. And when you go into the classroom, you're still teaching from blackboards and teaching out of textbooks. Our theory was: you're losing them. There are 145 million video game players in the U.S., about half the population; 34 percent are your K-12 population, that's 53 million people.[26]

Although analysts are still assessing opportunities in serious games markets—education, government, health, military, corporations and industry, first responders, and science—some estimates have put total figures in excess of $100 billion. More conservative estimates have put market share for serious game development work at $1 billion.[27]

Historically black colleges are taking notice. Howard University's College of Engineering, Architecture and Computer Sciences recently held its first one-day computer and video games workshop. The workshop assisted the university in positioning itself as a supplier of creative talent for the games industry and as a conductor of leading games research. Panelists Nichol Bradford, senior global brand manager of Vivendi Universal, one of the leading black females in the games industry, John Nordlinger, a Microsoft Research games evangelist, and Adam Clayton Powell III, director of the Integrated Media Systems Center of the National Science Foundation's exclusive Engineering Research Center for multimedia and Internet research, described the present and future states of the game industry in discussions about research, curriculum, and business considerations.

Mario Armstrong, of NPR technology, sees increasing participation of minority youth on the consumer side, but not on the business side. "As for who is missing," he adds, "non-profits, foundations, venture capitalists, video game publishers, and the entertainment side of the industry are all missing from the equation. I'm also concerned that the baby-boomer generation in communities of color is not paying close attention to this pivotal and profitable industry; I feel to some degree that another viable opportunity may be passing right by us."[28]

The Military as a Gateway

What few people may realize is that the U.S. military has led the nation in minority and women affairs that ultimately bear on our present discussion. Years before the civil rights activities of 1964 there was the passage of the Armed Services Integration Act of June 1948. One year later, in September 1949, Annie L. Graham became the first black female to enter the U.S. Marine Corps. Even before 1948, blacks made historical advancements unheard of outside of the military. On October 25, 1940, Benjamin O. Davis Sr. became the nation's first black general in military service. Fifteen years later, his son—Benjamin O. Davis Jr.—became the first black general in the U.S. Air Force. Others followed: Samuel L. Gravely Jr., the first black Admiral in the U.S. Navy; Frank E. Petersen, the first black general in the Marine Corps; and Hazel Winfred Johnson, the nation's first black female general. Minorities in the military also made great strides in science, engineering, and technology. Air Force General Bernard Randolph, the second black four-star general in the history of the Air Force, controlled a staff of nearly 53,000 scientists and engineers in the Air Force Research and Development program.

Benjamin F. Montoya, a Mexican American growing up in rural Indio, California, was a trailblazer for many Hispanics in the military in the late 1950s. Montoya's career took a trajectory to its full conclusion when he became one of three Hispanic Admirals in 1986 and took command of the Naval Facilities Engineering Command. Admiral Montoya would comment that it was his parents who most greatly influenced him: "There were also very strong discussions in my family about what it means to be an American. My four brothers and I were brought up with a philosophy which said, 'you are equal to anyone. Don't let anyone take advantage of you. Have self-pride. There's nothing wrong with being poor, but there's a whole lot wrong with being a thief or a liar. You might be poor, but you're clean.' As a result, all of us learned to value education."[29]

The Digital Age Pioneers (2001–)

There is another aspect of the digital divide. These are the stories of many women and minorities who have successfully "crossed" the tech divide to forge successful, valued, and influential careers. The tragedy is that these tech leaders go largely unnoticed by the nation's youth, regardless of race and ethnicity. For these minorities and women offer our best hope for pulling others across the divide. They personify the rewards and opportunities of pursuing technology-based careers and technology integration. They should serve as a testament of success in IT fields for many of the nation's youth. The point is that minority youths should become as intimately familiar with these leading scientists and technology innovators of color as they are with celebrity entertainers and athletes. The reality, of course, is that popular culture celebrates the evanescent victories and singular wealth of entertainers and athletes of color rather than the compound value acquired over decades by their engineer and IT specialist counterparts.

Let's now take the case of Katherine G. Johnson (1918–). In July 1969, the nation was spellbound when Neil Armstrong and Buzz Aldrin descended to the lunar surface. The famous moon landing comment "A giant leap for mankind" could have easily been substituted with Katherine Johnson's "It was a time when computers wore skirts." Without Johnson, who was a key contributor in the understanding of orbital dynamics, and who calculated the orbits for the Mercury series of suborbital flights for several historic space missions, there could have been a very different outcome in the U.S. space program. With the launching of Sputnik and the subsequent "Space Race," many engineers and computer scientists were occupied with defense and rocket development. That left the detailed attention and time-consuming mathematics to women. Literally and figuratively, women became the computers of the space age.

Linda Gooden: The New Global Leader

A more contemporary role model is Linda Gooden, an African American executive at Lockheed Martin. She represents the new face of minority technology trailblazers—someone whose activity is not behind the computer or technology, but who is an innovator and thinker. Gooden had the extremely rare opportunity to build a company from scratch within a large organization. She built her own team, decided which business opportunities to pursue, and watched an idea grow from a conversation to a success by any measurement. As president of Lockheed Martin Information Technology, she grew Lockheed's IT division from $22 million to $2.6 billion. With a performance like that, every company in the industry wants her.

Tianna Shaw

Tianna Shaw grew up on the Hupa Indian Reservation in northern California. She was one of the 1,732 Indians out of 2,140 of the Hupa Tribe who resided on the Reservation. The Hupa religion celebrated annual world renewal ceremonies for ten days in the fall. Today, Shaw continues that tradition of celebrating the earth, only now her celebrations include the sky. At NASA Ames Research Center, Tianna Shaw currently manages the Life Sciences Division's Facilities Utilization Office, providing oversight and leadership for a multidisciplinary team of civil servants and contractors supporting investigators' peer-reviewed science projects in the ground-based Center for Gravitational Biology Research. In English, she manages the ground test facility complex and provides expert technical direction and oversight of contractor support activities.

Shaw has always valued her tribe. She was an active promoter of Native American access to science careers, and was a founder of the first high school chapter of AISES, in which she remains active. Later, in graduate school, she cofounded another chapter and served as president. At NASA Ames Research Center, she is the founding chair of the Native American Advisory Committee and the current vice president and past president of the California Professional Chapter. Shaw majored in biomedical and electrical engineering at the University of Southern California, and went into the space program. Shaw also completed an MS program in biomedical engineering, specializing in medical instrumentation in 1994; but by that time, she had begun her career at the Jet Propulsion Laboratory and moved on to the NASA Ames Research Center. Shaw exemplifies the need for our success in marrying minority cultural values to technology skills acquisition.

Pablo Iglesias

Pablo Iglesias, Ph.D., knows the importance of growing critical technology leaders. From his classroom at the Johns Hopkins University campus in Baltimore, Maryland, Dr. Iglesias teaches students how to apply tools to problems. In a rapidly changing world, students won't always know what problems they will face, but they will be able to solve problems if they have the educational and critical literacy tools.

One innovative approach is his use of everyday model helicopters and cars to teach students how to design computerized control systems. Because of his creativity, a dry theoretical course has been turned into one in which students learn theory through practical applications. At 39 years of age, this Venezuelan engineer is at the helm of changes that will create a new generation of critical thinkers. And it is no small task. Ten years ago, the National Science Foundation responded to the high dropout rate of the nation's engineering students by funding alliances of engineering schools to explore the reasons behind students' leaving engineering. Two factors appeared on the lists of resources. One, universities needed professors who had just as much passion for teaching as for research; and two, real-world experiences should be part of the first two years of the engineering curriculum. Iglesias has turned his control systems course into a practical experience in which students explore real-world applications of control technology. Being a classroom instructor who teaches students the principles of why things work is the most important job to him.

But research is equally important to Dr. Iglesias. His current interest is the exploration of how the Internet can be used to control unmanned vehicles or robots over long distances and in telesurgery. Such research can close the distance between those in need of expert support and the experts themselves, such as having a surgeon in Baltimore perform surgery on a patient in a remote Central American village. It is critical thinkers like Dr. Iglesias who will shape America's future in the global digital marketplace and help bring along underrepresented youth into the IT education fold.

Dr. Aileen Van-Nguyen

Aileen Van-Nguyen was a ghost to countless Americans who merely gave a passing glance at the young Asian woman bagging their groceries at a supermarket back in 1975. What they did not see was that this supermarket bagger would someday be a microbiologist inventing bio-insecticides that would protect plants and the very foods they would take home to prepare for their families. Aileen Van-Nguyen came to the United States as a war refugee, making the perilous boat pilgrimage over the Pacific at the end of the Vietnam War in 1975. After mastering English, Van-Nguyen worked her way up the job ladder, continuously pursuing education.

By 1982, she had a B.S. in microbiology from the University of Illinois at Champaign-Urbana. She joined the DuPont Company, working in the Plant Disease Group, and then stepped up to DuPont's Discovery Program, where she managed an effort to develop *Bacillus thuringiensis* (Bt) bio-insecticides. She also managed risk-assessment studies, identified research collaborations with institutions around the world, and led commercialization of Bt products.

Then Van-Nguyen crossed the Atlantic to complete her Ph.D. in molecular biology and biochemistry at Cambridge University in England. Back home in Delaware, Dr. Van-Nguyen rose to senior research microbiologist, and then to alliance manager and contract administrator in the Regulatory Sciences Department. She has won awards for her research on sulfonylurea soils, development of a microbial insect control discovery program, genetic engineering of *Helicoverpa zea* nucleopolyhedro virus for insecticidal control of Heliothine pests in cotton and vegetable crops, and leading the registration effort for four Dupont Crop Protection products.

A Nation at Risk and Some Historical Milestones

For the first time since the Second World War, America's position as global market leader is not guaranteed. Increasingly, political leaders are acknowledging that, in a knowledge-based economy, it will be the nation with the best-trained people that will lead the global economy. With the worldwide competition for talent, will America at last come to appreciate the vast untapped pool of talent in minority communities, and finally muster the will and financial resources to encourage and train underrepresented youth to enter and excel in science and technology fields? Appearing on the April 23, 2006, edition of NBC TV's *Meet* *the Press*, Senator Ted Kennedy (D-MA) addressed aspects of these concerns and warned that America could be a second-rate country within 25 years. An excerpt of that show's transcript follows, and bears quoting at length:[30]

Mr. Russert: You also, in your book, say this about education: "I propose that every child in America, on reaching eighth grade, be offered a contract. Let students sign it, along with their parents and Uncle Sam. The contract will state that, if you work hard, finish high school, and are accepted for college, the federal government will guarantee you the cost of earning a degree."

Sen. Kennedy: Right. That's right.

Mr. Russert: Where are we going to get that money?

Sen. Kennedy: Well, we don't have an alternative, Tim, in the areas of education. The Chinese now are graduating 650,000 engineers a year; the Indians, 350,000 engineers a year. We're at 72,000, and half of those are foreign students. We're either going to equip every young person in this country to be able to deal with globalization, every worker to get continuing training, or we're going to be a second-level country in another 25 years. And that's going to take education; it's going to take investment on that. *If we are spending* $*10 billion dollars a month* $*10 billion dollars a month*—on Iraq, if we're going to spend a trillion dollars, which is Mr. Schultz's estimate, who's the Nobel Laureate, he says it's going to cost a trillion dollars, we ought to be able to educate every child, provide continuing training, and make sure that our American young people and older people are going to be ably equipped for globalization.

In his 2006 State of the Union Address, President Bush said,

> We need to encourage children to take more math and science, and to make sure those courses are rigorous enough to compete with other nations. . . . Tonight, I propose to train 70,000 high school teachers to lead advanced-placement courses in math and science, bring 30,000 math and science professionals to teach in classrooms, and give early help to students who struggle with math, so they have a better chance at good, high-wage jobs. If we ensure that America's children succeed in life, they will ensure that America succeeds in the world.[31]

On one level, President Bush and Senator Kennedy are correct: At a time when the use of technology is growing exponentially, and the nation's need for technology workers has never been greater, fewer students are pursuing science, engineering, and technology studies. African American engineer and scientist John Brooks Slaughter points to the chronic shortage of technology workers facing America.[32] Each year, nearly half of a million minority students graduate from high school. Only 32,000 will complete the necessary math and science courses to be considered for entry into engineering schools. Of that number, 15,000 will enroll. At the end of four or five years, only 4,000 will graduate and add to the ranks of the 72,000 U.S. college engineering graduates.

In recent years, several major reports have warned of the United States' diminishing technology leadership. Three factors have contributed to this. One, the dwindling supply of immigrant technology workers; two, the retiring of the baby-boomer scientists and engineers; and, three, the steady decline of American students in the science and technology pipeline.[33]

Lockheed Martin Chief Executive Officer Robert J. Stevens argues that America's preeminence in technology is declining because of the United States' shrinking technology workforce. Stevens predicts that, in three years, Lockheed will need to add 44,000 engineers per year to its talent base. American colleges and universities are currently producing only 62,000. Stevens warns, "The blooming tech talent shortfall will have an impact far beyond any single firm or sector. Science and engineering aren't just crucial for national security; they're critical for economic growth."[34] The loss of the immigrant technology worker has had profound consequences on U.S. industry. Prior to 1970, Asians represented 2 percent of all scientists and engineers in the United States. By 1990, that percentage had jumped 7 percent from 21,000 to 150,000. Of all the Asian scientists and engineers, 83 percent were foreign-born. In Silicon Valley, Asians made up 21 percent of the workforce at top technology companies.[35]

Like industry, the federal government is facing a wave of retirement, and there are few technology workers to replace those who are retiring. Within the next 10–15 years, more than 40 percent of the federal technology workforce will retire from the payroll.[36] In the current heightened security climate, augmenting the workforce with foreign workers is not likely. One solution for meeting the growing need seems obvious: Turn to the nation's minority population, just as the country has done throughout history. Only this time, the country will not exploit their skills and labor, but finally make space for minorities as full partners in society. Minorities are well positioned to seize these emerging opportunities, but it doesn't seem to resonate. This must change or, as Senator Kennedy said, America will be a "second-level country in another 25 years." America can ill afford to leave this talent pool underdeveloped as the global economy becomes more competitive. The question, though, is how to get minority youth to embrace a STEM career path in greater numbers. The answers are in our past and in our future. If we fail, the costs are grave for them and for industry.

At this point we might begin to recognize that many answers to problems of the future often can be found in such experiences of the past, as we have been discussing. This truism is especially pertinent as we strive to move beyond the digital divide, comprehend the limitations of the government's approach to closing the technology gap, and grasp the consequences of the continuing underrepresentation of racial and ethnic minorities in STEM education and career paths. This is equally true for underrepresented racial minorities in IT-based humanities and arts education. The problem becomes quite clear when we realize that, despite billions of dollars spent by American school systems for the acquisition of digital technology infrastructures, students of color are not pursuing or utilizing humanistic and science-related educational paths, career options, and cultural practices in sufficient numbers to keep pace with today's information society. So the pertinent questions that must be raised include (a) what intrinsic value has digital technology added to further or increase technology pedagogy for students of color; (b) why are these students failing to grasp the relevancy of STEM opportunities and information communication technologies (ICTs) in the arts and humanities; and (c) why, at this historical moment, should we, as a country, care? The short answer: Our future will surely depend on it.

In recent years, the campaign to close the digital divide galvanized the nation and spurred hope that technology would diminish or minimize the gap between the information haves and have-nots.[37] Some scholars argue persuasively that the availability of information from the Internet and peer-to-peer technology systems would empower the have-nots, leading to improvements in educational, health, and various other class and social spheres. Government reports, such as the U.S. Department of Commerce's "Falling Through the Net,"[38] corroborate this position. The Department of Commerce's report, a cross-cultural survey that documented the disparity in telephone and computer ownership and Internet access between whites and racial minorities, explained that, "While a standard telephone line can be an individual's pathway to the riches of the Information Age, a personal computer and modem are rapidly becoming the keys to the vault. The robust growth recently experienced in Internet usage illustrates this promise as new and individual subscribers gravitate to on-line services."[39] In 1999, another NTIA report went further, declaring that information tools, such as the popular personal computer and Internet, were becoming progressively critical to economic success and personal advancement.[40]

Responding to disturbing reports such as "Falling Through the Net," the federal government launched a number of initiatives to address the computer technology imbalance in the nation's poorest or underserved schools. One program charged with making a difference, the E-rate, has provided upwards of $2.25 billion per year to needy schools, specifically for the acquisition of digital technology infrastructures.[41] In appropriating these funds, special consideration was given to rural and urban schools that had limited computer and Internet access. Closing the digital divide by providing computer technology to underserved minorities was intended to enhance the methods of teaching technology and information-age skills to minority students. On paper, these technology programs appear to be closing the gap steadily. However, on closer inspection, the numbers tell a very different story. It is true that billions of dollars are poured into low-income urban and rural school systems and their inadequate to nonexistent computer programs, bringing into existence functional technology infrastructures of sorts where none had existed before. Yet, black, Hispanic, and Native American students' participation in STEM and digital media arts careers remains less than impressive.

The Engineering Workforce Commission survey, for example, revealed that African American freshman engineering majors dropped from a high of 8,924 in 1992 to 8,192 in 2001. Latinos/Latinas had a slight increase during that same period, from 5,624 to 6,157. Native Americans went slightly down from 633 to 629. Overall, minority participation in engineering programs during the Clinton–Gore administration (1993–2001) declined from 16.3 to 14.9 percent. Given these apparently little-known statistics, it is easy to see how rhetoric on the digital divide would lead to the mistaken belief that more potential minority technology professionals are emerging from the nation's schools in substantial numbers to justify such expenditures. But as troubling as it is, the facts indicate otherwise, the major consequences of which now confront us as a society. There is much to answer for in our nation's lackluster commitment to bridge the digital divide for youths of color.

Symptomatic of this denial are people I call "tricknologists"—those who narrow the definition of the divide by saying that mere computer ownership and Internet usage are somehow effective measures of minority participation in the new, high-tech economy. They claim, further, that the divide is closing, pointing to statistics which show that minorities are closing the gap in becoming consumers of technology, even though they are not producers of or equal partners in the nation's technological revolution. In fact, some "tricknologists" miss the mark when they attempt to shift the focus away from this important collective problem by merely highlighting contemporary examples of individual minority successes, which is important. They fail, however, to provide larger historical, and especially culturally specific, frameworks for these minority successes—an important omission that I address above in my own survey of minority technology pioneers and visionaries. For example, they will name Roy Hoth, a Native American inventor at IBM; Nancy Stewart, Wal-Mart's African American vice president of information technology; Jim Padilla, the Hispanic engineer and the chief operating officer and chairman of Ford Motor Corporation Worldwide Auto Operations; and Duy-Loan T. Le, the first Asian woman to be named a TI-Fellow at Texas Instruments Inc. This is an impressive list, to be sure. But, out of context, it masks the true reality of America's growing paucity of up-and-coming minority talent. The unimpressive numbers speak plainly to the fact that simply providing minority students with classroom access to computers and the Internet does not result in getting more minorities to choose careers in science, technology, engineering, or academia. The reality counters and undermines the views of "many technologists and educators [who] argue passionately that computers and Internet connection in schools would be the great equalizer in American education."[42]

Understanding why these programmatic provisions of technology assistance to underrepresented minorities fail to develop a sector of minority technology providers requires a thorough investigation into what digital divide efforts did not accomplish, more so than what minor or exceptional results occurred, as outlined above. For example, although the Clinton administration intended to wire every poor and underserved school, it failed to forge connections between modern technology systems and the culturally rich pasts of minority students, thus rendering worthless skills accrued for a digital age without ties to a culturally relevant curriculum. As Bonnie Bracey, author of *Harnessing the Potential of ICT for Education: A Multistakeholder Approach*, cogently puts it, "Many of today's schools may have a wire that does not connect to anything."[43]

This is not to say that the gains in the Clinton administration's goals for universal access to information technologies were not commendable; far from it. Appearing with Bill Gates at the Microsoft Government Leaders' Forum Africa in Cape Town, South Africa, on July 11, 2006, former President Bill Clinton was clear about his objectives for his administration's efforts at the end of the millennium:

> This is a question that consumed a lot of my time when I was president. I worked very hard on increasing Internet access, for example, and bridging the divide between rich and poor and middle class within the United States. We had about 35 percent of our schools on some sort of Internet connection when I became president. We were at almost 100 when I left. We went from 30 percent to 63 percent of our classrooms being connected.[44]

However, Adam J. Banks, author of *Race, Rhetoric, and Technology: Searching for Higher Ground*, argues that these limited "material access" gains in hardware may have come at the cost of teacher development. Banks observes that educators invested in grant writing and program creation to connect their schools in anticipation that these networked computers would help to improve classroom teaching and create added motivation for students. They quickly discovered, however, that few resources actually existed for teacher and student training and technology implementation plans. As it turns out, this was a costly oversight. Bracey echoes this conclusion and remarks, "Many teachers have little meaningful professional development. . . . In many cases there is a tech person, but the teacher has had minimal training in technology use, at whatever level there is technology for their use."[45]

Clearly, then, accessing information is not the same as acquiring useful knowledge and advancing technological literacy. Access to the Internet opened the door to an explosion of information services and Web sites, but it did not inevitably mean that students of color or their teachers were able to turn that information into useful and practical knowledge, apply new analytical skills, or make successful inroads in the digital economy. Furthermore, we recognize that providing digital artifacts (i.e., computers and Internet connectivity) has not necessarily changed the way students of color are being taught. In fact, it could be argued that networked computers in schools and Internet access perpetuated the same ineffectual classroom practices, only now with the aid of faster media. In fact, renowned African American scientist Carter G. Woodson advanced the argument of the futility of educational methods that disconnect students from their heritage early in the twentieth century. Woodson was a vocal critic of an educational system that considered the dissemination of information to students more important than the development of their critical thinking skills. In his influential book *The Mis-Education of the Negro*, Woodson is scathing in his criticism of mainstream educational practices exerted on African Americans more than a century ago. Unfortunately, his words still ring with just as much truth today. He viewed mainstream or Eurocentric educational models and approaches as tools that disconnected the Negro or African American from his history, cultural moorings, and surroundings. According to Woodson:

> The same educational process that inspires and stimulates the oppressor with the thought that he is everything and has accomplished everything worthwhile, depresses and crushes simultaneously the spark of genius in the Negro by making him feel that his race does not amount to much and never will measure up to the standards of other peoples. The Negro thus educated is a hopeless liability of the race.[46]

Woodson's arguments apply with equal veracity to other minority groups, when we consider the failures of digital divide programs targeted at underrepresented minority youths. In fact, he points out that the system also fails Europeans. Woodson writes:

> Education, like religion, is conservative. It makes haste slowly only, and sometimes not at all. Do not change the present order of thinking and doing, many say, for you disturb too many things long since regarded as ideal. The dead past, according to this view, must be the main factor in determining the future. We should learn from the living past, but let the dead past remain dead.[47]

Years later, Postman and Weingarner observed that the advantaged student has a financial interest in willingly engaging, because there are more tangible payoffs that are unavailable to disadvantaged students. Postman and Weingarner postulate that schools offer little encouragement in the development of youth who can "question, doubt, or challenge any part of society in which they live." In other words, the prevailing views rely on the notion that closing the digital divide is primarily about providing technological artifacts, not creating technological literates. The attention paid to the digital divide was not effective in addressing the significant matters that created the divide in the first place—race and class disparities.

An educational system undergirded by the benefits of wealth and, conversely, the liabilities of race has stacked the deck against upward mobility for the poorest citizens—racial and ethnic minorities. In *The Shame of the Nation: The Restoration of Apartheid Schooling in America*,[48] Jonathan Kozol explains how little has changed in minority education, even with improved technological access. In light of the billions of dollars invested in digital technologies, the findings of Kozol's study are disturbing. At a South Bronx school with a predominantly minority population, only twenty-eight of the fifty faculty members had ever taught a class before assuming teaching duties that year. One fourth-grader had four different teachers in one year. Reports like Maisie McAdoo's "Just Passing Through . . . A Look at Teacher Retention" (United Federation of Teachers)[49] highlight the challenge in retaining public school teachers. These cases point out that there is the direct link between poverty and racial, as well as economic, segregation. Some 86 percent of schools in predominantly black and Latino neighborhoods qualified for free or reduced lunches, while only 15 percent of majority white schools qualified.[50] In addition, researcher Barbara Monroe reminds us that no matter how much equipment is placed in underserved schools, the poorest students will still be at a material disadvantage compared to those with historical and entrenched material wealth.[51]

In this context, it is worthwhile to consider the value of technology in the classroom. As a result of inadequate computer infrastructures, poorly trained instructors, and insufficient technical supports, urban students generally use computers for the most basic tasks: typing and word processing, skills that are now redundant for any high-level technology career. By comparison, in majority white schools, computers are used for sophisticated, collaborative projects and social networking that require high-level technological skill sets which prepare white youths for the most challenging positions in industry and society. Therefore, higher levels of technology use are grooming whites for better-paying jobs in the workforce, while minorities are destined for menial jobs in the digital world. Both Kozol and Moore suggest that it is "oxymoronic" to believe that poor children can receive a good education in high-poverty schools where more of the nation's blacks, Hispanics, and Native Americans attend. To reiterate, in often-misguided efforts to bridge the digital divide, we often overlook the reality that providing schools with digital technology does not address or change, in meaningful ways, the systems that limit minority youth and, ultimately, the well-being of our society.

Answers and Solutions

George Santayana, the Spanish-born philosopher, said, "Fanaticism consists in redoubling your effort when you have forgotten your aim."[52] In many ways, that describes most of the political contributions to the discourse on meeting our future workforce needs. Senator Kennedy's proposal meets the financial obstacles that many disadvantaged students face. But the nation must go farther than promoting the European cultural values of individualism and pulling oneself up by the bootstraps. To increase minority participation, programs that reach the entire community and helps minorities and women connect to their heritages is critical.

The same is true for President Bush's plan to hire 70,000 high school and science teachers. This is another important step, and will undoubtedly add value to the nation's teaching workforce, which consists of many poorly trained and overworked teachers. Quite ironically, according to a recent survey, it is at elementary and middle school levels that many minority technology professionals decide on technology careers.[53] Of the survey respondents, some 74 percent made their decisions to enter engineering between the ages of 12 and 21, and 46 percent made the decision between the ages of 12 and 18. Also significant is the role informal science education programs had on their career choices. Forty-six percent of minority engineers participated in precollege engineering or science programs as students (*US Black Engineer*, 2005[54]).

New media offers promising new techniques that have the potential to change the paradigm of how educators can connect to minority youth and women in moving beyond the digital divide. As the above examples of successful minority technology workers reveal, racial and ethnic minority students may be empowered to move between two cultures without sacrificing their cultural core values.

Digital Media Cultural Mentoring (A Useful Exemplar)

Mentoring takes on an expanded and more relevant purpose with the integration of virtual technology and traditional mentoring methods. Traditionally, mentoring has been a one-on-one experience, and the dissemination of information from mentor to the protégé. But again, there is a huge lack of minority professionals available to make meaningful, personal connections with the nation's 50 million K–12 students. To connect with today's students, we must change our concept of mentoring, look to the past, and use today's real, living technology innovators to help students move beyond the digital divide.

Digital media cultural mentoring uses the environment of the student to convey positive images of their cultural connection to science and technology. The technology provides on-demand cultural content aligned with curricula introduced in the classroom; it focuses on organizing the community, village, or tribe members into active participants in the mentoring process by providing easy-to-implement life-skills methodologies; it helps students make the connection between knowledge and real life; and, lastly, it builds a sense of worth for self, family, and community.

Ying-Shao Hsu, assistant professor in the Department of Earth Sciences at National Taiwan Normal University, has shown that computer hypermedia and networking technology can be powerful tools in stimulating students' "motivation, scientific attitude and learning efficiency."[55] Hsu's research centers on the thesis that learning occurs when students are successful in connecting the real-world situation with the academic theories. Students' interest in science increases when they make the real-world connections. Two parts of Hsu's research have direct relevancy to digital media cultural mentoring. The first is animation design that displays the students' realistic life situations. In this digitally mediated environment, students see representations of themselves that help in the connection of theory. The second is online collaboration that promotes communications and exchange of information. Here again, the concept of a virtual community that is representative of the youth stimulates their interest in science and technology. This program is called cyber mentoring.

When used effectively, cyber mentoring has produced promising results in students' academic achievement. The cyberspace mentoring project, Journeying into the Rain Forests, gives a glimpse of the possibilities that digital media cultural mentoring might offer students. This team of cyber mentors consists generally of student teachers that interact with participating first- and second-graders located more than 45 miles away from the university campus. The student teachers are linked to the elementary school students through the university's project database. FileMaker Pro software was used to capture writing assignments from the grade school students and comments from the cyber mentors. The goal of the classroom teacher was to raise the performance level of the students with an interactive collaborative project with university students. The project "demonstrated the ability to address several reading and writing strategies within a single online activity."

The first contact was social in nature. Cyber mentors exchanged greetings with the students with friendly personal introductions. Students were then encouraged to post their essays to the database. The cyber mentors avoided making editing and grammar corrections to the essays. They engaged the students with probing questions about the direction and content. As the exercise progressed, students embraced the collaboration and looked forward to the interaction with their cyber mentors. Cyber mentoring seemed to excite and motivate students about their writing assignments. The academic improvement was also noteworthy, with 95% of the class achieving GPAs of 3.8 out of 4.0. The cyberspace mentoring project Journeying into the Rain Forests revealed that cyberspace could bridge the geographic distance between students and mentors, and enhance the educational experience of the students.

George Santayana's words cry out to us, "Those who cannot remember the past are condemned to repeat it."[56] And regarding the future, Terry Tempest Williams, naturalist, pleads, "The eyes of the future are looking back at us and they are praying for us to see beyond our own time."[57]

Notes

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