REFLECTING ON OUR OWN CAREER MENTORING PEDAGOGY AND STRATEGIES AS THEY IMPACT RETENTION OF WOMEN AND PERSONS OF COLOR IN "NON-TRADITIONAL" (SCIENCE) CAREER FIELDS

A Presentation given to the 9th Annual ISU CTLT Teaching and Learning Symposium:
Teaching and Learning in a Diverse Community of Scholars
on
January 7, 2009
by

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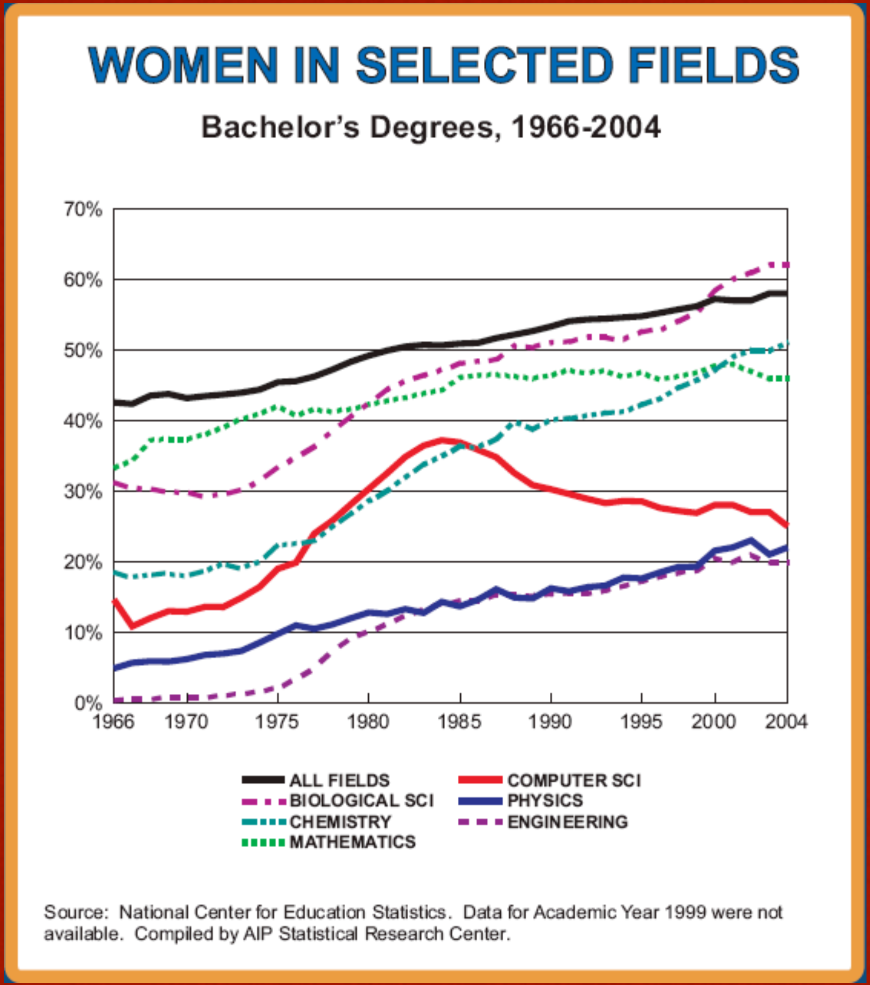
Johns' ongoing STEM career mentoring equity and diversity dissertation research and outreach projects were awarded a YWCA of McLean County WINGS Award in May 2008 that also includes some research funding support.

100 YEARS ywca mclean county
eliminating racism
empowering women

Why Retention is important: The U.S. is in danger of losing its technological competitive edge

- Preston (2004) states that the "magnitude of attrition from scientific jobs is especially troubling at a time when, even outside the scientific community, there is a growing awareness that a productive and well-trained scientific workforce is essential to maintain a technologically sophisticated, competitive, and growing economy".
- Articles by other authors and national organizations and agencies concur (College Board, 2008; NSF, 2007).
- One way to increase the talent pool is to turn to historically underrepresented groups in the sciences—women and persons of color (Czjuko et al, 2008; Nicholson & Mulvey, 2008; American Institute of Physics, 2007; NSF, 2007).



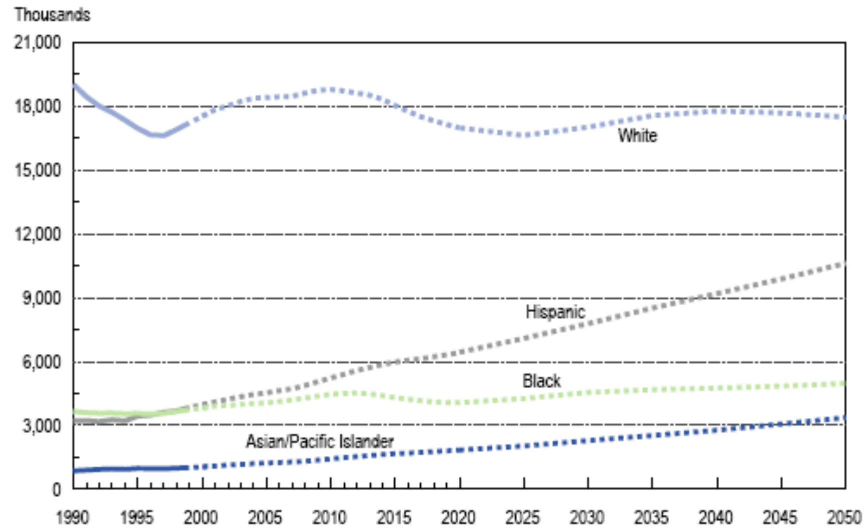
UNDERGRADUATE RESEARCH: MENTORING THE NEXT GENERATION OF SCIENTISTS

A 2007 NSF study on the population demographics in the U.S. changing to favor an increasing population of non-white racial and ethnic groups.

As educators, the changing demographics of our student populations reveals our best source of potential scientists to be previous underrepresented groups including women and persons of color (see chart at right).

National Science Foundation
WHERE DISCOVERIES BEGIN

FIGURE A-1. U.S. population 18–24 years old, by race/ethnicity: July 1990–99 and projections to 2050



NOTE: Hispanics may be of any race. Data for American Indians/Alaskan Natives are not shown but can be found in table A-2.

SOURCE: U.S. Bureau of the Census, Current Population Survey, annual series; and U.S. Bureau of the Census, *Projections of the Total Resident Population by 5-Year Age Groups, and Sex With Special Age Categories: Middle Series, 1999 to 2100*, NP-T3, http://www.census.gov/population/www/projections/natsum-T3.html

The proportion of the U.S. population that is minority will continue to rise in the first half of the 21st century.

- According to the latest population projections, minorities (Asians/Pacific Islanders, blacks, Hispanics, and American Indians/Alaskan Natives) are expected to be more than half (52 percent) of the resident college-age (18–24 years old) population of the United States by 2050, up from 34 percent in 1999.
- By 2050, whites would constitute 48 percent of the U.S. population 18–24 years old, down from 66 percent in 1999.
- The greatest growth among minority groups is projected for Hispanics and Asians/Pacific Islanders, reflecting immigration trends.
- Relatively little growth is projected for college-age blacks and American Indians/Alaskan Natives; these populations would remain 14 and 0.9 percent, respectively, of all U.S. 18–24-year-olds in 2050.

Mentoring the Next Generation of Scientists:

- Mentoring students in science and scientific research is a quest to instill in them the skills necessary to become a scientific professional. Or, as one faculty member put it, in my study of university science faculty mentors, to "grow" the next generation of scientists (Johns, 2005). Therefore, faculty mentoring students is a professional development activity they engage in to build the scientific workforce. Faculty in many disciplines recognize the need for strong faculty and student mentoring relationships (Fugate et al, 2001).

- Often, the format of mentoring is relegated to successful one time programs, science fairs, or summer camps—especially at the precollege level—rather than viewing it as an ongoing relationship (Templin, 1999; Rodia, 2004; and National Academy of Science, 1997).

- However, more research is being conducted about ongoing mentoring programs that provide student assistance as well as role models (O'Neill, 1996; Johns 2004 and 2005). The need for ongoing and more formalized mentoring programs is primarily recognized when institutions focus on improving the representation and retention of underrepresented groups (women and ethnic minorities) in the sciences (Preston, 2004; Lundmark, 2004; Haynes, 2002; Thompson, 2002; Wood, 1999; and Rop, 1998).

- As the number of scientists from underrepresented groups (especially women and African-American undergraduates) grow, more attention, research, and assessment is also paid to the importance of mentoring at the undergraduate level (Harding, 1993; Fields, April 1998; Fields, October 1998; Fields, April 1998; Fields, October 1996; and Fields, March 1998). However, the gender equity research is more developed and some of its lessons can be applied to other underrepresented groups.

Some Early Mentoring Tips from the Trenches:

What follows are some Mentoring tips from other researchers that educators can use with their students:

- In Harding (1993), the chapter by Shirley Malcom on "Increasing the Participation of Black Women in Science and Technology." Professor Malcom speaks with a public policy voice as a member of the national office of the American Association for the Advancement of Science. She summarized some of the intervention strategies found in successful mentoring programs (p. 252-253):
  - starting early [in terms of exposure to science enrichment programs]
  - a continuing focus on rigorous preparation in science and especially mathematics through the pipeline
  - promoting hands-on involvement through activities such as science fairs and projects
  - contact with role models who are minority women availability of appropriate career information
  - early exposure to research [in their chosen field]
  - directly addressing gender and race specific issues, such as combining marriage and family, addressing clash of culture
  - an opportunity for early work experience in science-related employmen

In general, what works educationally for underrepresented groups (women and minorities), also works for everyone else—we just need to remember to include women and minorities in these enrichment activities.

Whether the under-representation of women in science career fields has to do with institutional barriers or socialization and the need for better social networks, educators must understand the complex systemic factors at work in the mentoring process through reflection and assessment. It is the hope that initiating assessment projects such as this one will add to our knowledge about what works and what does not work in recruiting and retaining undergraduate science majors—especially individuals from under-represented populations such as women and persons of color.

Student Participation in Undergraduate Research

In an early pilot study I conducted, I examined best practices in mentoring as a potential factor in persistence in earning a B.S. degree in science. Science students interviewed at a large Midwestern university all pointed to undergraduate research as being a key factor in their development and retention (Johns, 2004).

- "I would encourage people to do research. I think that is a very important thing to do." Get involved in a research project earlier.—Ann, Mary, Rachel
- find a faculty mentor in your major early on—Katie
- Males, also, identified that early opportunities to work on research helped them in their long range career plans—including realizing that they did not want to do research.
- "Alex" said "I've done things in the lab that will pertain directly to my future career…present[ing] at research symposia;
- "Sheila" said that her faculty mentor would offer her help and encourage her;
- "Mary" said that "doing research with [name of her male professor]…is a very valuable experience.
- In general, male student responses tended to be more positive on ratings and in their general comments —one student said that his department "is like a family".
- "Katie" said that being one of only a handful of women in that field made them feel special , but that there were challenges ("you have to hold yourself to a higher standard" [than males].

Results of IRB 2005-0111 Research Project

Follow-up studies of a diverse group of faculty science mentors and then their undergraduate research students of both genders at this same large Midwestern university also revealed the importance of undergraduate research opportunities and career mentoring to student retention (Johns, 2005a; Johns, 2005b).

What was revealed in extensive interviews of the seven science faculty undergraduate research mentors (one of whom was African American and another was of Latino heritage) was an emerging theory of career mentoring pedagogies enacted by the faculty:

Table 1. Process Model of Best Practices in Mentoring

Best Practices in Faculty Mentoring Philosophies	Best Practices in Faculty Careering Mentoring Strategies (involving undergraduate research)	Women (and Men) Science Undergraduate Learning Outcomes
1. Mentoring is an essential part of what they do—developing the next generation of scientists. 2. Mentoring is focused on student needs first and their own research agenda second. 3. Faculty recognize and attend to differing student needs (based on career plans and developmental stages).	1. Mentoring by faculty is an understood requirement (an intrinsic reward)—they also teach graduate students to be mentors. 2. Faculty adapt research projects to fit student needs and interests. 3. Faculty provide research experiences that develop student skill sets—letting students make some mistakes so they realize that science is about regrouping after dead ends, engaging them in group discussions about their projects, requiring them to write and present their work	1. To develop broadly trained scientists—who can work independently and in a team--ready to meet the challenges of graduate school or industry. 2. To nurture an enthusiasm for science in students by addressing their career interests. 3. To nurture students' skills—lab, problem solving skills, presentation, writing, problem, and self confidence.

Some Undergraduate Career Mentoring (CM) Trends that Emerged were in Three Areas of:

(Take 5 minutes to reflect and share on how you would respond to each of these areas)

- ✓ **Purpose of CM**
- ✓ Strategies faculty/ staff used in CM
- ✓ CM Student Learning Goals

MORE ON LOSING OUR TECHNOLOGICAL EDGE AND GENDER: WOMEN'S UNDERREPRESENTATION IN PHYSICS CREATES A GENDER IMBALANCE

- Although increasing strides are being made, after a high of 18% of Ph.D graduates in Physics being women in 2002—since more foreign born women added to that high--"the representation of women among physics PhD's has dropped for the second year in a row" in terms of 2005 graduation statistics (Mulvey and Nicholson, 2007).

- A report by the Special Conference of the International Union of Pure and Applied Physicists held in Paris, France in 2000 focused on the U.S. lagging behind other countries (including Turkey) in educating women in science and technology (Urry, 2002).

- More than half of the international graduation rates of women in physics exceed U.S. rates. The chart at right lists graduation rates by country from the International Study of Women Physicists (Ivie and Czujko, & Stowe, AIP, 2001).

Country-Level Data

The country-level data (Table 1) were compiled from external, reliable sources such as government agencies and physics societies that routinely collect data such as these. In order to be included in the country-level data, countries had to provide accurate numbers of physics graduates broken down by year, level of degree, and gender.

TABLE 1. Percentages of Physics Degrees Awarded to Women in Selected Countries, 1997 and 1998 (2-year averages).

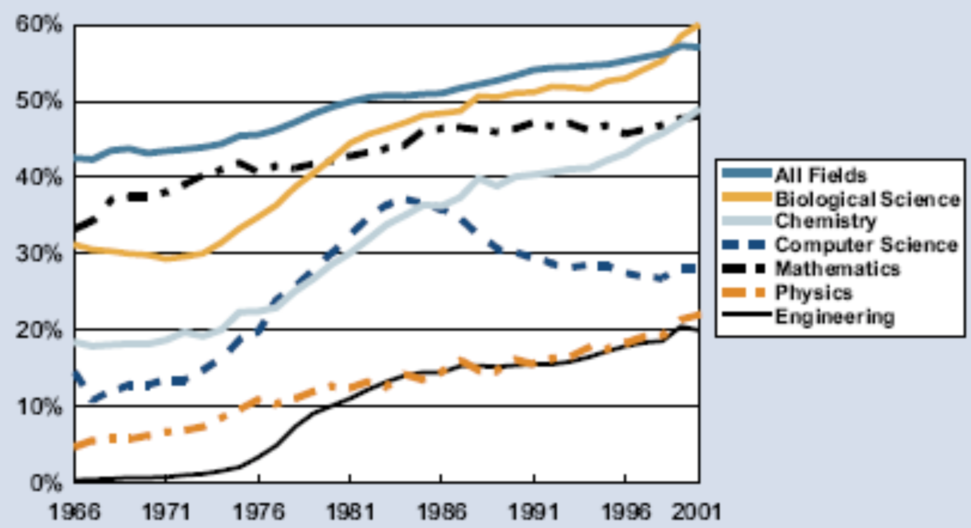
Country	Ph.D.'s %	First-Level %
France	27	33
Poland[a]	23	36
Norway[b]	23	20
Ukraine[c]	23	—
Australia[d]	22	20
Turkey	21	37
India[e]	20	32
Columbia[f]	—	28
Denmark	17	19
Lithuania[g]	17	—
United Kingdom	16	20
China-Taipei	13	19
United States	13	18
Sweden	13	17
Canada	12	22
Mexico[h]	10	18
Germany[i]	9	10
Switzerland[j]	9	9
The Netherlands	9	5
South Korea	8	30
Japan	8	13

[a] Poland: 1998 data only.
[b] Norway: 1996-2001 data.
[c] Ukraine: 2000-2001 data.
[d] Australia: Ph.D. data include some master's degrees (higher degree by research).
[e] India: Partial data from the Registrar General of India, 1998.
[f] Columbia: 1998 and 1999 data.
[g] Lithuania: 1996-2001 data.
[h] Mexico: Ph.D. data for 1998 only. Bachelor's data for 1998 and 1999.
[i] Germany: Includes astronomy and astrophysics.
[j] Switzerland: 1999-2000 data.

MORE ON LOSING OUR TECHNOLOGICAL EDGE—GENDER IMBALANCES

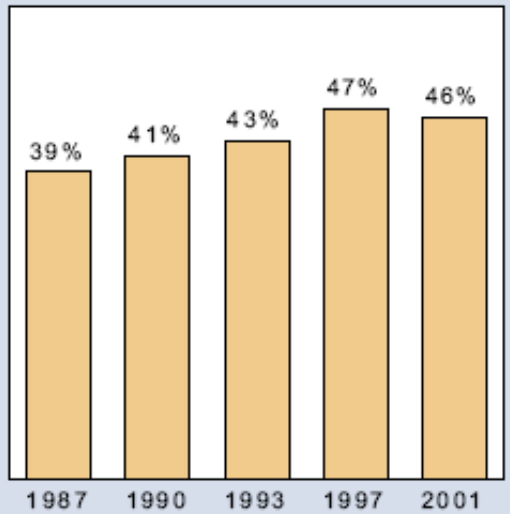
- The American Institute of Physics (Ivie & Ray, 2005) reported on the incidence of women completing bachelor's degrees by discipline (see right):

Figure 8. Percent of bachelor's degrees earned by women in selected fields, 1966-2001.



National Center for Education Statistics. Data for academic year 1999 not available. Compiled by AIP Statistical Research Center.

Figure 2. Girls as a percentage of total enrollment in high school physics over time.

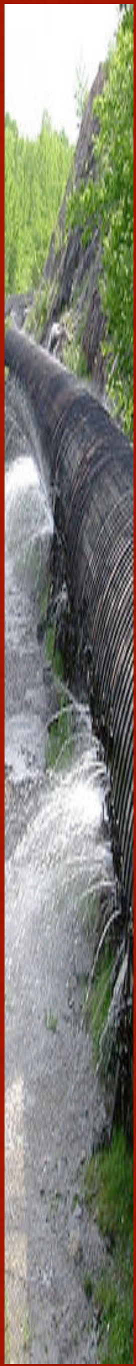


AIP Statistical Research Center: 1986-87, 1989-90, 1992-93, 1996-97 & 2000-01 High School Teacher Surveys.

- Yet note that AIP (Ivie & Ray, 2005) also found that in 2001, 46% of the students taking HS physics were women (see left).
- So, why are less than half of those women obtaining bachelor's degrees in physics women?

Why Women and Persons of Color are Underrepresented in the Sciences: A Leaky Pipeline

- Our Leaking Pipeline (Ivie and Ray, 2005; Ivie, Czujko, and Stowe, 2001) and negative climate issues (Settles, 2007):
- "Amid a few signs of recent progress towards more diversity in education and the workplace, underrepresentation persists. For example, women and minorities continue to **take fewer high-level mathematics and science courses in high school**; they still earn fewer bachelor's, master's and doctoral degrees in science and engineering (S&E); and they remain less likely to be employed in S&E jobs than are white males." (NSF, 1996)
- A study by Muller, Kinzie, and Stage (2001) using the NELS 88 data revealed that students who were not "tracked" into college prep math and sciences—despite their abilities—usually were from **lower income groups** whose parents were less able to afford outside of school enrichment activities or *amenities* (home computers). Others concurred on the impact of family income (Okpala, 2001; NSF, 1996; Hall, Davis, Bole, & Chia, 1999; Hortascu, 1995).
- **Parental educational attainment** (Hall, Davis, Bolen, & Chia, 1999; Marjoribanks, 1996; NSF, 1996) and parental expectancy of their child's profession (Preston, 2004; Kaplan, Xiaoru, and Kaplan, 2001; Fan, 2001) were also found to be factors.
- Students who would be first generation for attending college also have **self-confidence issues**: ***Self-efficacy*** of their skills and abilities (Taylor, 2007; Pajares & Schunk, 2001). ***Expectancy*** *(Pintrich & Schunk, 1996)* refers to students not wanting to try "a task whey they expect to fail" and is also part of the self-efficacy issue. This *fear of failure* concept is found in all students, not just women and minorities.



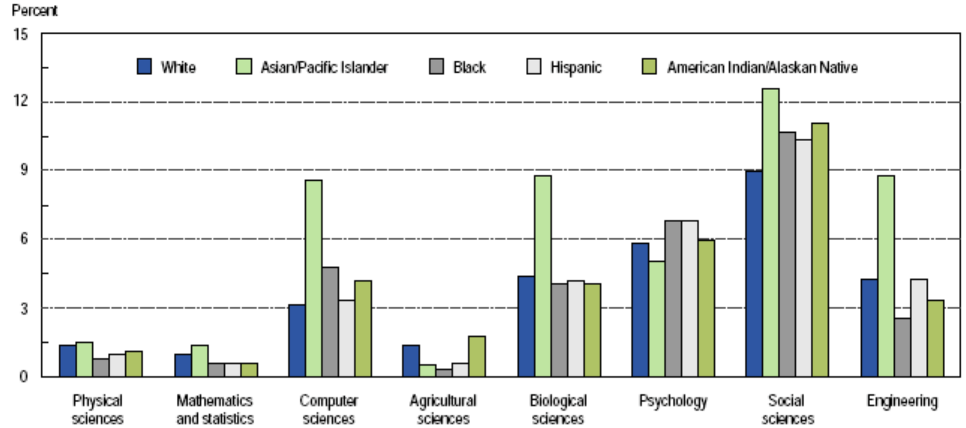
MORE LOSING OUR TECHNOLOGICAL EDGE: THE UNDERPRESENTATION OF PERSONS OF COLOR IN PHYSICS CREATES RACIAL IMBALANCES

The figure and description at right show current bachelor's degree production by race and discipline (NSF, 2007).

An earlier NSF (1996) report Women, Minorities, and Person with Disabilities in Science and engineering reveals progress as well as signs of persistent underrepresentation by non-white racial groups:

- Blacks, Hispanics and American Indians are taking more high school science classes than in the past. The percentage of blacks and Hispanics taking chemistry and physics doubled between 1982 and 1992.
- Minorities (except Asians) remain a small proportion of U.S. scientists and engineers. Blacks, Hispanics and American Indians as a group were 23 percent of the U.S. population, but 6 percent of the S&E labor force in 1993."
- However, Blacks are making significant gains in their math and science NAEP scores from age 9, age 13, and age 17 (see next slide):

FIGURE C-3. Bachelor's degrees awarded to racial/ethnic groups in S&E fields: 2004



NOTE: Percents refer to percentage of each racial/ethnic group earning degrees in a given field. Physical sciences include earth, atmospheric, and ocean sciences.

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

White, Black, Hispanic, and American Indian/Alaskan Native S&E bachelor's degree recipients are similarly distributed across most broad S&E fields.

- With the exception of Asians/Pacific Islanders, for whom almost half (48 percent) of all bachelor's degrees received are in S&E, about 31 percent of bachelor's degrees earned by each racial/ethnic group are in S&E.
- A higher percentage of Asians/Pacific Islanders than of other racial/ethnic groups earned their bachelor's degrees in computer sciences, biological sciences, and engineering.

More on Losing Our Technological Edge—Racial Imbalances

- Though gaps still persist, Black students improved their math understanding--more so than their science understanding—as assessed on the NAEP tests (NSF, 1996).
- These gains need to be capitalized upon in the sciences.

Figure 2-3.
A. NAEP mathematics scores at age 9, by race/ethnicity: 1978–1992, selected years. B. NAEP mathematics scores at age 13, by race/ethnicity: 1978–1992, selected years. C. NAEP mathematics scores at age 17, by race/ethnicity: 1978–1992, selected years.

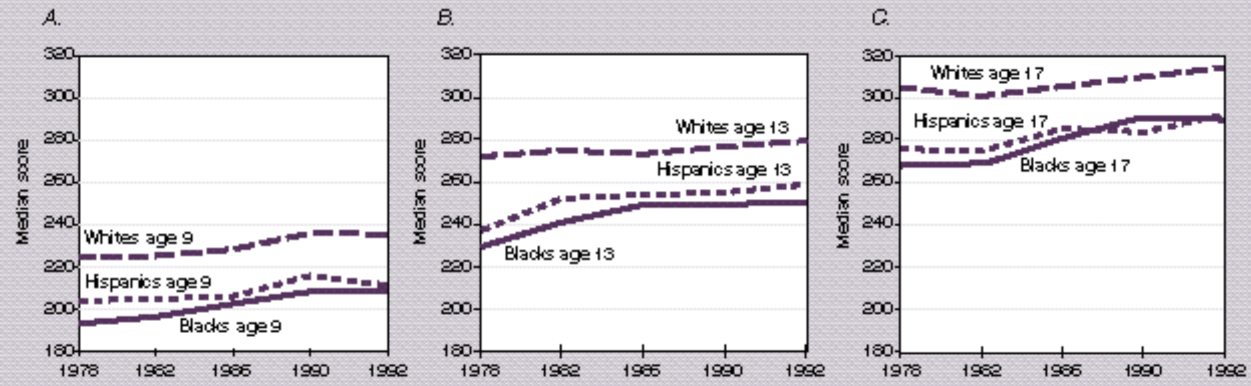
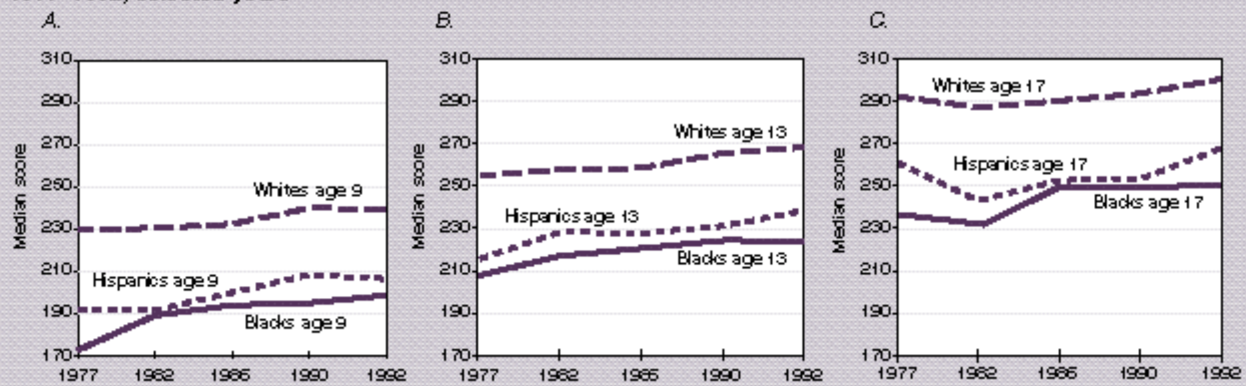


Figure 2-4.
A. NAEP science scores at age 9, by race/ethnicity: 1977–1992, selected years. B. NAEP science scores at age 13, by race/ethnicity: 1977–1992, selected years. C. NAEP science scores by age 17, by race/ethnicity: 1977–1992, selected years



AND, DON'T FORGET, THAT WE'RE ALL WORKING WITH A DIFFERENT TYPE OF STUDENT—THE MILLENNIALS:

- **Some insights about the Millennials:*** according to Taylor (2007), many Millennials have a reduced "self-efficacy" (the level of belief in their talents and skills); see also Albert Bandura, a leading researcher in self-efficacy (www.des.emory.edu/mfp/self-efficacy.html)
- Pintrich & Schunk (1996) studied the concept of "expectancy": which means that students won't try "a task when they expect to fail."*
- ISU's First Year Experience resource guide (2007) points out that Millennials have "not much experience being active agents in their own lives." (p. 12)*
- ISU's First Year Experience resource guide (2007) has as a "Guiding Principle" that students "benefit from being challenged and supported while making the transition to college by academic advisors…" (p. 3)

What this means to us as educators working with Millennials in general:

- * we need to recognize that a student's hesitancy or self doubt about their abilities might not be rooted in fact
- * we need to provide students with the data (math/science placement scores, HS Qtl, etc.) that tell us that the student will succeed in the math or science placement
- * we need to encourage students wanting "non-traditional" majors to follow their dream

What can we do as educators? We can make a difference and why it is important:

- Ma & Willms (1999) identified "critical junctures" where intervention is needed—8th and 11th grade. These are critical times when students are *selecting high school courses* to take as well as final preparations for college such as achievement tests and *taking the all important 4th year of math and science.*

- At no time previous has intervention been needed than with the *millennial students*. The millennials (Chronicle of Higher Education, 2007) don't have "much experience [in] being active agents in their own lives" and they "benefit from being challenged and supported while making the transition to college" (ISU's First Year Experience Resource Guide (2007).

- Previously marginalized student groups need to make up for lost time and do so with guidance and support networking from their teachers and role models (Lee, 2002).

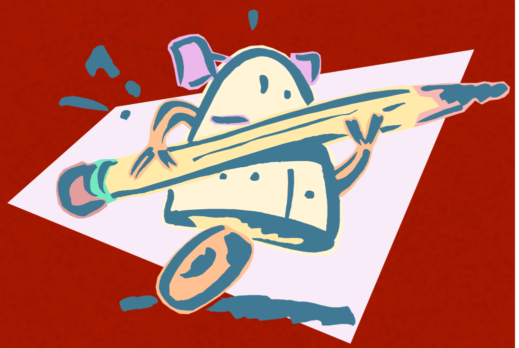
- Who benefits? We all do by having developed more young minds

  Who will contribute to society as their groundbreaking counterparts have before them—Dr. Percy Julian and Dr. Jewel Plummer Cobb (African American biologist and chemist, respectively); and

  Dr. Rosalyn Franklin, Dr. Neil DeGrasse Tyson, and Dr. Shirley Jackson (Physicists), etc.

Final Thoughts on Mentoring the Next Generation of Scientists:

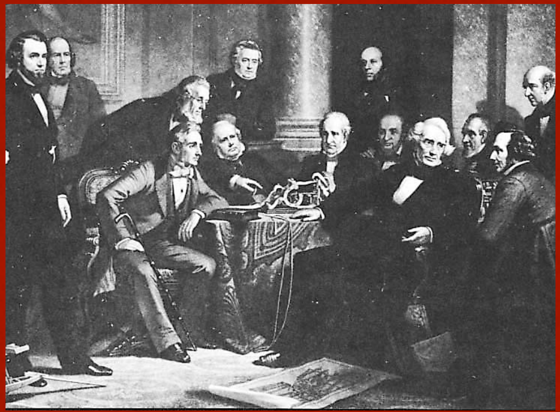
- In general, as educators:
  - We need to seek out high school students who are behind in the number of math and science classes they have taken and encourage them to pursue more of those college prep type classes.
  - We need to recognize that a student's hesitancy or self doubt about taking math and science classes might not be rooted in fact about their skills or abilities.
  - We can provide role models for students who are women and/or persons of color by seeking out professionals who reflect those groups—as well as being role models ourselves.

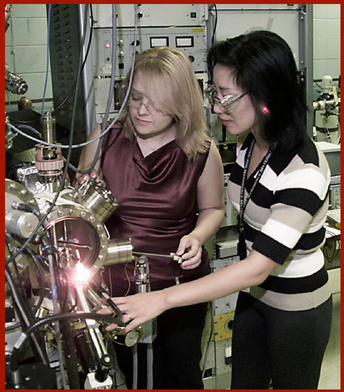


•In summary, mentoring is teaching (Ramsden, 2003) by creating learning environments where all students can grow (Furman, 2003). By providing pathways for change, mentors demonstrate moral leadership and caring as they seek to create accessible, safe, and nurturing learning environments for all individuals (Furman, 2003; Fisher, 2001; Noblit, 1993; Strathe, 2006; Heifetz, 1994).

Our “Traditional” picture of STEM scientists and inventors (right):

Our “New” pictures of today’s STEM scientists and inventors sampled from ISU and AWIS-HOI websites (everything else):





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