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Lori Turk-Bicakci

Andrea Berger

Leaving STEM: STEM Ph.D. Holders in Non-STEM Careers

The United States is at a critical juncture in its ability to remain internationally competitive in science, technology, engineering, and mathematics (STEM). At present, too few people from diverse populations, including women, participate in the STEM academic and workforce communities. This series of issue briefs is produced by American Institutes for Research (AIR) to promote research, policy, and practice related to broadening the participation of traditionally underrepresented groups in STEM doctoral education and the workforce.

AIR supports the national effort to prepare more students for educational and career success in STEM by improving teaching and providing all students with the 21st century skills needed to thrive in the global economy; meeting the diverse needs of all students, especially those from underrepresented groups; and using technology, evidence, and innovative practice to support continuous improvement and accountability.

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Overview

A strong workforce in science, technology, engineering, and mathematics (STEM) sustains a robust U.S. economy and supports our national security (Cadwalader, 2013; Sonnert, Fox, & Adkins, 2007). A diverse STEM workforce provides for a variety of perspectives and approaches to scientific and technological innovation, better reflects the global and culturally diverse economies of the 21st century, and results in a wide array of role models for future engineers and scientists (Hira, 2010; National Research Council, 2007; Stine & Matthews, 2009). STEM education and the workforce must draw talent from a broad student population at every level if the nation is to sustain its preeminence in the global STEM community.

During the last few decades, national, state, and institutional-level initiatives have been implemented to build and expand the STEM workforce by recruiting and retaining groups of individuals that have been traditionally underrepresented in STEM in higher education. The underlying theory of action is that individuals who earn STEM degrees aspire to careers in STEM. But to what degree does this assumption hold true? This brief examines the extent to which those who have committed the most time and resources to a STEM education, STEM Ph.D. holders, do not work in STEM careers.

When any STEM Ph.D. holder leaves a STEM career, his or her potential contribution to scientific advancements and technological innovation may be lost to the STEM community. The consequences of leaving a STEM career may be particularly acute if those leaving are concentrated in groups already underrepresented in STEM, especially among individuals with the highest level of research and technological training.[1] Potential contributions in offering new perspectives and an expanded

[1] In 1992, women earned 30 percent of science and engineering doctorates, Blacks earned 4 percent, and Hispanics or Latinos earned 3 percent of degrees. Not yet closing the gap, in 2012 women earned 42 percent of science and engineering doctorates while Blacks earned 6 percent and Hispanics or Latinos earned 7 percent of degrees (National Science Foundation & National Center for Science and Engineering Statistics, 2012). As a comparison, the U.S. population in 2012 was made up of 51 percent women, 13 percent Blacks, and 17 percent Hispanics or Latinos (see http://www.census.gov/newsroom/releases/archives/race/cb13-tps103.html).

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DATA

The findings are based on data from the National Science Foundation's (NSF's) 2010 Survey of Doctorate Recipients (SDR) and the Survey of Earned Doctorates (SED) (National Science Foundation & National Center for Science and Engineering Statistics, 2010a; National Science Foundation, & National Center for Science and Engineering Statistics. 2010b). The SDR draws its sample from the SED, which surveys all Ph.D. holders upon graduation. The SDR includes a representative sample of all STEM Ph.D. recipients between 1959 and 2010 who earned their degree in engineering, mathematics, computer and information sciences, biological/biomedical sciences, physical sciences, or agricultural sciences/natural resources. Most of the Ph.D. holders in the sample were in the middle to end of their careers, though the sample includes doctorate holders who were in their first year of postdoctoral work. In this analysis sample, 78 percent received their degree prior to October 2000.

We restricted the sample to include only Ph.D. recipients with degrees in STEM who were employed in October 2010, who were not working in a postdoctoral research or an associateship position, and who were U.S. citizens or permanent residents living in the United States. The weighted sample size of STEM Ph.D. holders in STEM and non-STEM careers in this brief is 425,431. The unweighted sample size is 16,295.

All analyses were weighted to reflect the full population of Ph.D. holders in the United States. Chi-square tests of independence were used to test the association between pairs of variables. All variables reported in this brief were significantly related using an alpha level of .05. Estimates based on samples are subject to sampling variability, and apparent differences may not be statistically significant. All noted differences were statistically significant at the .05 level.

pool of role models are lost to the field. Consequently, this brief also examines whether underrepresented groups leave STEM at a higher rate than other groups and explores the work activities and careers that "STEM leavers" are pursuing.

In summary, this brief focuses on understanding who is leaving STEM and the type of work they were doing if not in a STEM field. It examines a representative sample of all STEM Ph.D. holders who worked in non-STEM careers and looks at differences by gender for Black, Hispanic, Asian, and White STEM Ph.D. holders.[2] We pose two main research questions:

1. To what extent did STEM Ph.D. holders work in non-STEM careers?
2. In what type of work were STEM Ph.D. holders in non-STEM careers engaging?

The key findings are as follows:

- About one of every six employed STEM Ph.D. holders reported working outside of STEM.
- Female Ph.D. holders were more likely to leave STEM compared with male Ph.D. holders; Black Ph.D. holders were more likely to leave STEM compared with other racial/ethnic groups.
- Among STEM Ph.D. holders who left STEM, Black females, Black males, and Hispanic and White females were more likely compared with other groups to be employed in the government sector; Asian females, Asian males, and Hispanic and White males were more likely employed in the private, for-profit sector.
- Female STEM Ph.D. holders who left STEM were less likely to be involved in research and development (R&D) compared with male STEM leavers within each racial/ethnic group.
- Female STEM Ph.D. holders who left STEM were less likely to be in management positions compared with male STEM leavers within each racial/ethnic group.

[2] Although some analyses included Ph.D. holders across all races/ethnicities, analyses that focused on gender and race/ethnicity included females and males who were "Black, non-Hispanic only," "Asian, non-Hispanic only," "Hispanic, any race," and "White, non-Hispanic only." Some gender and racial/ethnic groups were small but sufficient to make group comparisons. Black and Hispanic females each made up 1 percent, Asian females made up 5 percent, and White females made up 16 percent. Black and Hispanic males each made up 2 percent, Asian males made up 17 percent, and White males made up 56 percent. The smallest gender and racial/ethnic group was Black females, with a weighted sample size of 2,788 and an unweighted sample size of 256. The number of Native Americans earning STEM doctoral degrees was too few to include in the analyses for this brief.

Definitions

STEM leavers: STEM Ph.D. holders who reported working in a career in the social and related sciences and other nonscience and engineering fields in October 2010. Ph.D. holders who were in STEM or STEM-related careers were defined as staying in STEM.[3] Ph.D. holders who had a career that was not in their particular Ph.D. field but was in another STEM field were categorized as staying in STEM.

Employment sector: The sector in which respondents reported being employed.

- *Private, for-profit companies or organizations*
- *Private, nonprofit organizations*
- *Government*, including local, state, and federal government and the military
- *Self-employed or other employers*, including self-employed in a unincorporated or incorporated business or professional practice and other types of employment

Primary work activity: The activity in which respondents reported spending the most hours during a typical work week. Doctoral programs in STEM require students to engage in intensive research and also often mandate that students teach through fellowships or assistantships. With this in mind, we examined the extent to which STEM Ph.D. holders may be applying the R&D and teaching skills they acquired during their Ph.D. programs in non-STEM occupations.

- *R&D*, including basic research, applied research, and development. Basic research refers to gaining scientific knowledge primarily for its own sake; applied research refers to gaining scientific knowledge to meet a need; and development refers to gaining knowledge from research to produce materials or devices, design equipment or processes, or develop computer applications or systems.
- *Non-STEM teaching*, including postsecondary and precollege teaching in a non-STEM subject. Respondents in non-STEM careers reported teaching in the following fields: business, commerce, and marketing; education, foreign language, history, and other non-STEM postsecondary fields; psychology, economics, and other social sciences; elementary education; and other subjects.
- *Other work activity*, including managing, accounting, marketing, professional services, and other activities.

Non-STEM careers: A job category that best describes the principal job. See the Technical Appendix for a detailed list of non-STEM careers.

- *Top managers and academic administrators*, regardless of whether the organization being managed was STEM focused. These Ph.D. holders may, in fact, be leading science- or engineering-related organizations or educational institutions and applying their scientific training in management and administrative work. However, top managers and administrators are typically not engaged in R&D as would be expected of a STEM professional. Rather, they are moving away from core STEM work activities. Furthermore, categorizing top managers and administrators into non-STEM careers follows NSF's coding convention in SDR to identify them as in "non-science and engineering occupations."
- *Mid-level non-STEM managers and academic administrators*
- *Business professionals*
- *Other non-STEM professionals*, including arts and humanities professionals, social scientists, teachers, instructors, lawyers, counselors, farmers, and so on.

[3] STEM careers included jobs in computer and mathematical sciences; biological, agricultural, and other life sciences; physical and related sciences; engineering; and science and related occupations. Science and related occupations included health-related occupations, science and engineering managers, science and engineering precollege teachers, science and engineering technicians and technologists, and other science and engineering occupations.

Who Left STEM?

Overall, 16 percent of employed STEM Ph.D. holders were not working in a STEM profession in 2010 (see Figure 1).

TIME SINCE PH.D.

A smaller percentage of newer STEM Ph.D. holders reported working in a non-STEM career compared with Ph.D. holders who were 10 or more years out of their doctoral program (see Figure 2). Ten percent of those who had their Ph.D.s for less than 10 years did not work in STEM while 18 percent of those who had earned their degree 10 years ago or more did not work in STEM.

Figure 1: Percentage Distribution of Employed STEM Ph.D. Holders by Career Type, 2010

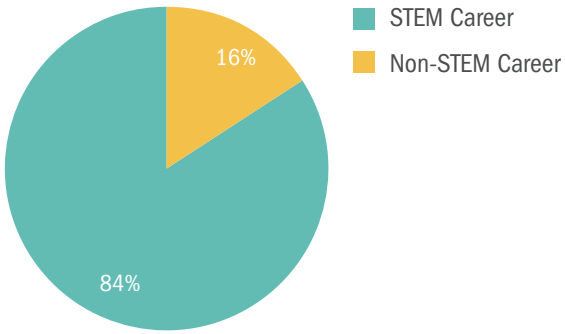
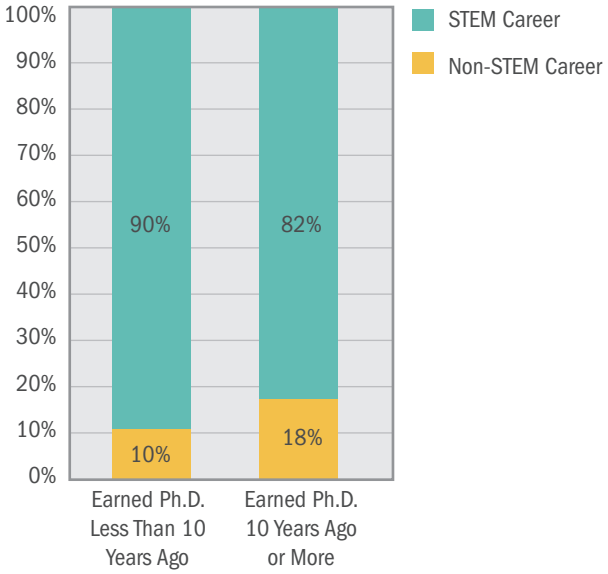


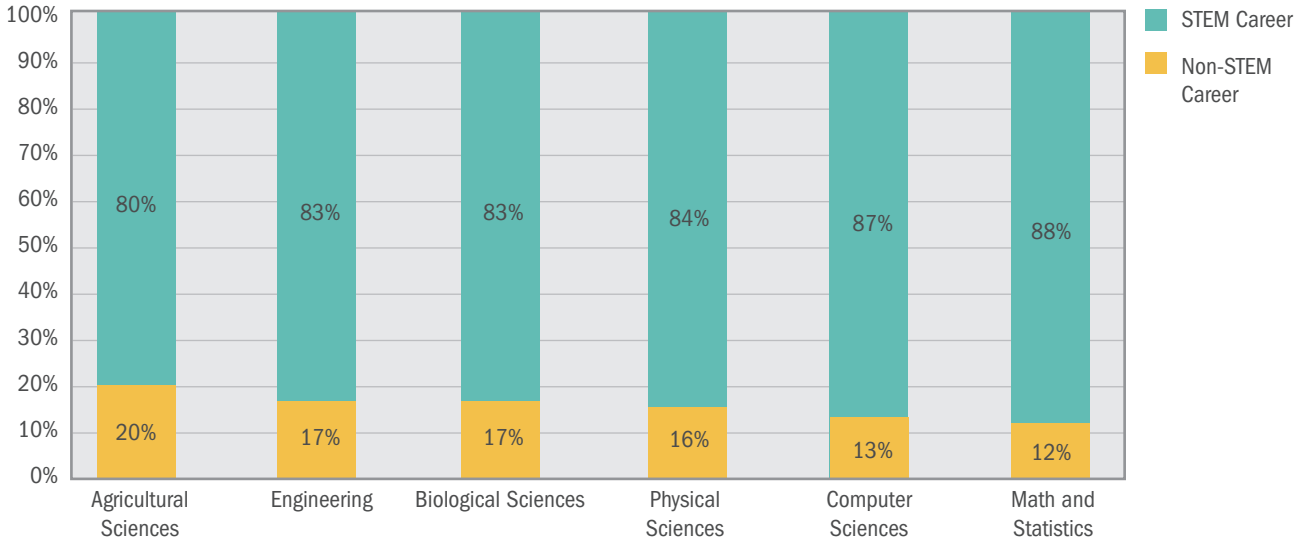
Figure 2: Percentage Distribution of Employed STEM Ph.D. Holders by Career Type and Years Since Ph.D., 2010



PH.D. FIELD

Across STEM disciplinary groups, the agricultural sciences had the highest percentage of STEM Ph.D. holders who were working in non-STEM careers in 2010, with 20 percent of degree holders working outside of STEM (see Figure 3). The percentages of Ph.D. holders with degrees in engineering, biological sciences,[4] and the physical sciences who reported not working in non-STEM careers were similar, however, ranging from 16 to 17 percent. The disciplinary groups of mathematics and statistics and the computer sciences[5] had the lowest percentages of Ph.D. holders working in non-STEM careers (12 percent and 13 percent, respectively).

Figure 3: Percentage Distribution of Employed STEM Ph.D. Holders by Career Type and Ph.D. Field, 2010



[4] The disciplinary category, biological sciences, includes the biomedical sciences.

[5] The disciplinary category, computer sciences, includes information sciences.

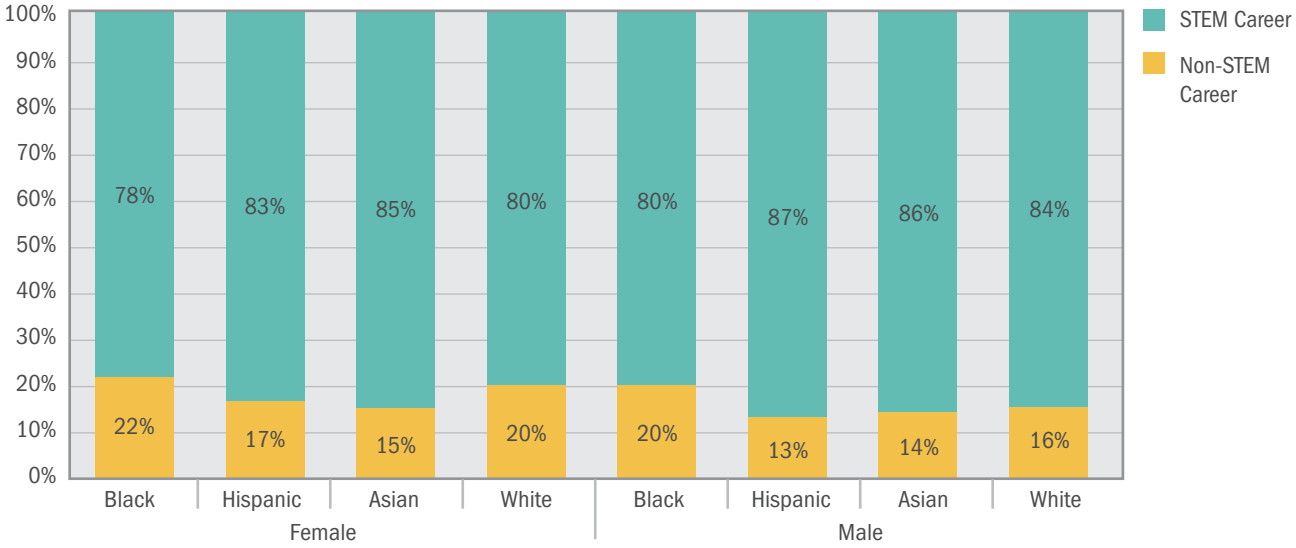
GENDER AND RACE/ETHNICITY

Leaving STEM by Gender

Overall, a larger percentage of female STEM Ph.D. holders were in a non-STEM career compared with their male peers: 19 percent of females worked outside of STEM compared with 16 percent of males.

At least one in five Black female, Black male, or White female STEM Ph.D. holders was working in a non-STEM career (20–22 percent; see Figure 4). In contrast, about one in eight Hispanic males worked in a non-STEM career (13 percent). Other groups fell in the middle, including Asian males and females (14 percent and 15 percent, respectively) and White males and Hispanic females (16 percent and 17 percent, respectively).

Figure 4. Percentage Distribution of Employed STEM Ph.D. Holders by Career Type and by Gender and Race/Ethnicity, 2010



Leaving STEM by Race/Ethnicity

Across racial/ethnic groups, Black Ph.D. holders had the highest percentage working in a non-STEM career: 21 percent compared with 17 percent of White Ph.D. holders, and 14 percent each of Hispanic and Asian Ph.D. holders.

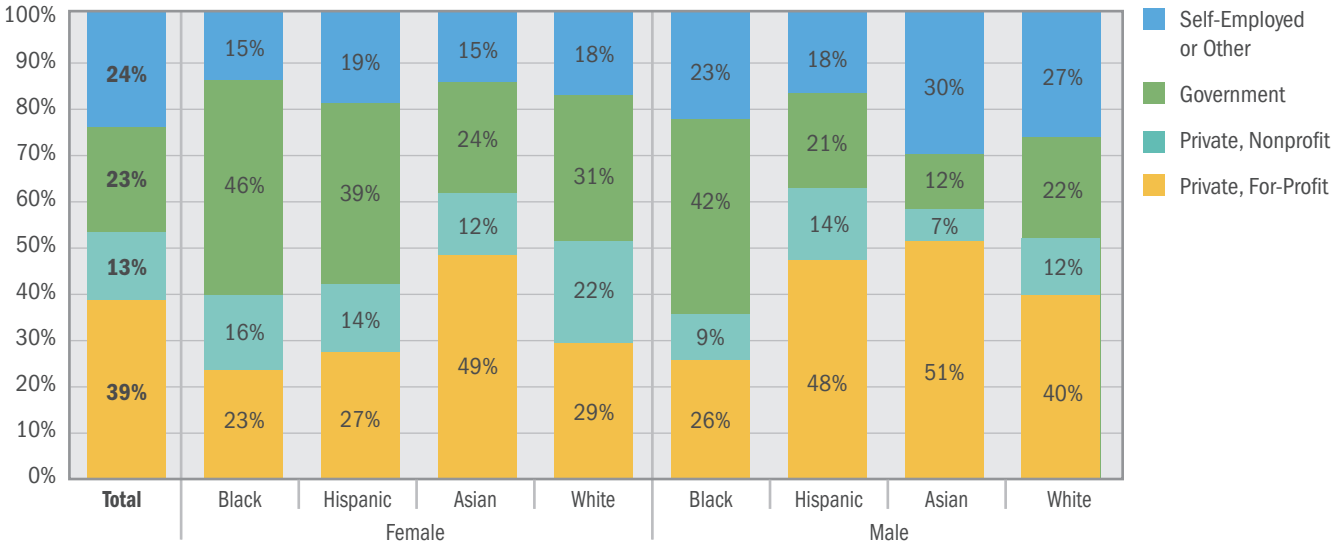
Where Do STEM Leavers Work?

The types of work activities and careers of STEM Ph.D. holders working in non-STEM careers provide insight into where the nation's STEM talent is employed, if not in STEM. Patterns of non-STEM employment and work activities by gender and race/ethnicity also raise important questions regarding why these patterns exist. Although our data do not allow for an investigation of the factors influencing STEM Ph.D. holders' movement into non-STEM careers, in this section of the brief we examine, by gender and race/ethnicity, the types of work STEM leavers were engaged in, including employment sector and type of primary work activity.

CAREER SECTORS

Nearly 40 percent of STEM leavers worked for private, for-profit companies (see Figure 5). About one quarter worked in government, about one quarter were self-employed, and 13 percent worked for private, nonprofit organizations. However, these overall patterns mask important gender and racial/ethnic differences in non-STEM employment. A smaller proportion of Black females and males and Hispanic and White females were employed in the private, for-profit sector compared with other groups (23–29 percent compared with 40–51 percent) and a larger proportion had positions in government (31–46 percent compared with 12–24 percent).

Figure 5: Percentage Distribution of Employed STEM Ph.D. Holders Working in Non-STEM Careers by Employment Sector and by Gender and Racial/Ethnic Group, 2010



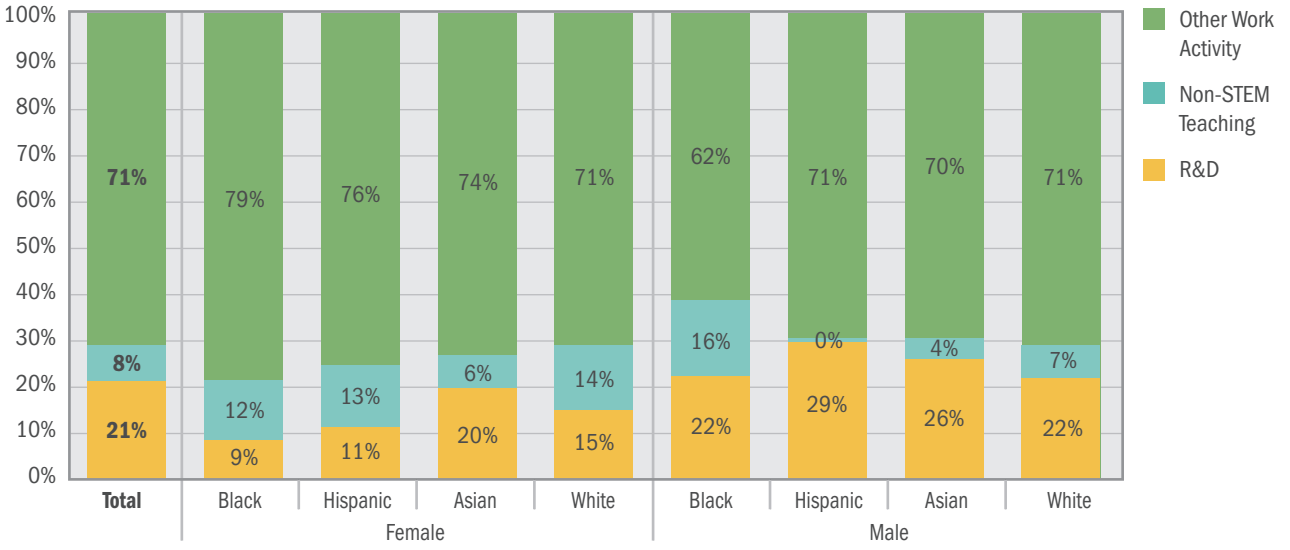
NOTE: Category totals are not always 100 percent due to rounding.

PRIMARY WORK ACTIVITY

A minority but sizable percentage of STEM leavers were in careers that involved R&D (21 percent; see Figure 6). Teaching was less common, with 8 percent of STEM leavers reporting that as their primary work activity. Instead, most STEM leavers reported that their careers primarily involved managing, marketing, providing professional services, or other activities (71 percent). Within each racial/ethnic group, a larger percentage of male STEM leavers reported being in careers that involved R&D compared with female STEM leavers. Among males, Hispanics most often reported engaging in R&D work in contrast to Blacks and Whites (29 percent compared with 22 percent each). Among females, Asians most often reported being in a career that required R&D work in contrast to Blacks (20 percent compared with 9 percent).

The proportion of STEM leavers who primarily taught in non-STEM fields showed a similar, though opposite, gender divide, with one exception. Within most racial/ethnic groups, a larger percentage of female STEM leavers reported being in careers that primarily involved teaching compared with male STEM leavers. However, a larger proportion of Black males reported teaching as a primary work activity compared with Black females (16 percent compared with 12 percent). Among females, Whites most often reported teaching as a primary activity while Asians reported teaching least often (14 percent compared with 6 percent). Among males, Blacks had the highest percentage who reported teaching; notably, no Hispanic STEM leavers reported teaching as a primary work activity.

Figure 6: Percentage Distribution of Employed STEM Ph.D. Holders Working in Non-STEM Careers by Primary Work Activity, 2010



NOTE: Category totals are not always 100 percent due to rounding.

CAREERS

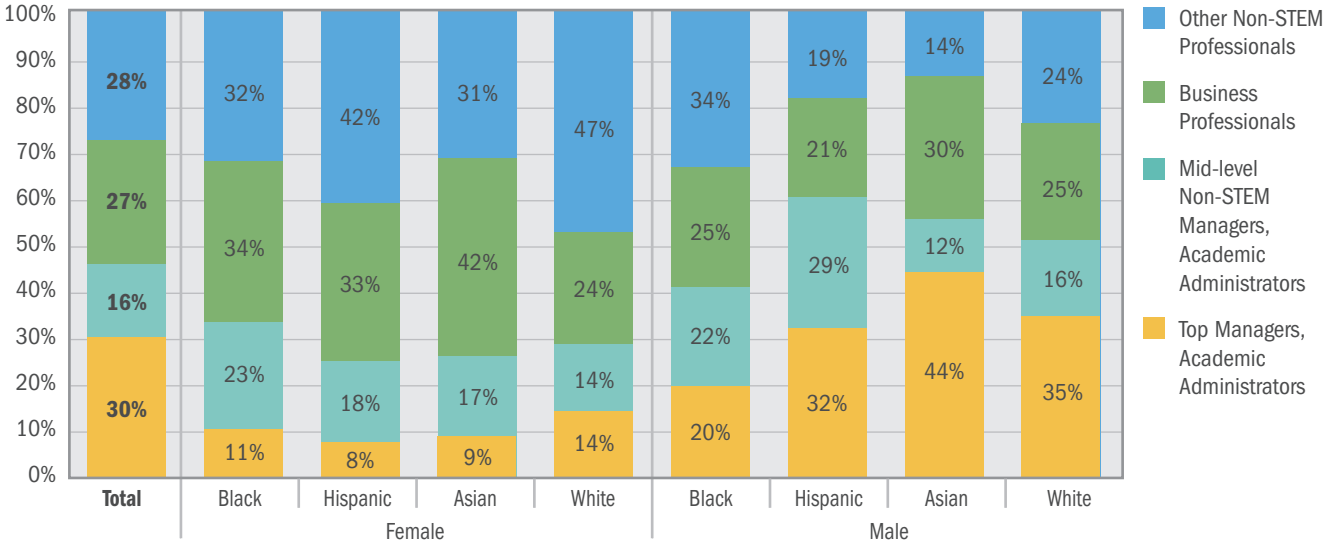
Overall, 30 percent of STEM leavers across the employment sectors were working as top managers or academic administrators; an additional 16 percent were working as midlevel managers (see Figure 7). Twenty-seven percent were employed as business professionals and 28 percent were in other non-STEM positions.

Overwhelmingly, a larger percentage of male STEM leavers reported working in top management or administrator positions within each race/ethnicity group compared with their female peers (20–44 percent compared with 8–14 percent). Even when midlevel management positions were considered, female STEM leavers were notably less represented in management positions than their male peers. More Black, Hispanic, Asian, and White males were mid- to top-level managers or administrators compared with their female peers (42–61 percent for males compared with 26–34 percent for females).

Business professionals formed a sizable group among STEM leavers of all genders and race/ethnicities. A larger percentage of Black, Hispanic, and Asian female leavers were business professionals compared with their male counterparts (33–42 percent compared with 21–30 percent), while about one quarter of both White females and males were in these positions (24 percent and 25 percent, respectively).

Twenty-eight percent of STEM Ph.D. holders working in non-STEM careers, regardless of gender and race/ethnicity, reported being other types of non-STEM professionals. These careers included, for example, arts and humanities professionals, social scientists, postsecondary instructors, precollege teachers, and lawyers. The highest proportion of STEM leavers in these positions were Hispanic and White females (42 percent and 47 percent, respectively) compared with other groups. About one third of Black females, Asian females, and Black males were in other non-STEM careers (31–34 percent). In contrast, less than one quarter of Hispanic, Asian, and White males were in these careers (14–24 percent). See the Technical Appendix for a detailed list of non-STEM careers and the percentage of STEM Ph.D. holders in each career.

Figure 7: Percentage Distribution of Employed STEM Ph.D. Holders Working in Non-STEM Careers by Principal Position, 2010



NOTE: Category totals are not always 100 percent due to rounding.

Discussion

About one in every six employed STEM Ph.D. holders did not work in a STEM career in 2010. Furthermore, Black, Hispanic, and White females and Black males were more likely to leave a STEM career than other groups. Because of this attrition, the STEM community potentially loses contributions to scientific and technological discovery, restricting potential advantages gained from diverse perspectives and the availability of role models for underrepresented groups.

A large portion of STEM leavers, especially males, were in management and academic administration positions. One potential explanation of this finding, not unique to STEM fields, is that men may tend to be "promoted" out of STEM careers, while women may be pushed or pulled out of STEM careers for non-STEM lines of work due to "glass-ceiling" effects or perceptions that opportunities for advancement in STEM careers are limited for women (Barreto, Ryan, & Schmitt, 2009). Additional research would be valuable to disentangle the factors that contribute to "leaving STEM" patterns related to STEM Ph.D. holders who have attained top management or academic administrative positions.

STEM Ph.D. holders who do not work in STEM careers undoubtedly contribute to the workforce and are likely using their talents to benefit the sectors in which they work. For example, almost one in three STEM leavers was involved in R&D or teaching, suggesting that they were using some of the skills they developed during their doctoral programs in new contexts, including scientific inquiry, research, and teaching. Perhaps the framing of a "STEM career" requires reconceptualizing to capture careers that apply STEM-based knowledge in non-STEM environments. The traditional notion of career pathways in STEM may be giving way to a new perspective on applying STEM knowledge in novel ways, and additional research could reshape our understanding of the definition of a "STEM career" (Lahey, 2014).

This brief, although revealing patterns in attrition from the STEM workforce, cannot answer why some STEM Ph.D. holders left STEM or the factors that may be influencing differences by gender and race/ethnicity in non-STEM career patterns. Other research, primarily focused on women, has reported that people who leave STEM may seek a career that is perceived to offer greater opportunity for career advancement, workplace flexibility, time management, or "work-life" balance (Glass, Sassler, Levitte, & Michelmore, 2013; Heilbronner, 2013; Williams & Ceci, 2012; Frome, Alfeld, Eccles, & Barber, 2006). Furthermore, STEM leavers may have lacked role models, struggled with confidence in their professional roles, or experienced stereotyping, compelling them to pursue non-STEM careers (Cech, Rubineau, Silbey, & Seron, 2011; Beede et al., 2011). Additional systematic research would lead to better understanding the factors contributing to STEM loss of talent and why some groups are more likely than others to pursue careers that do not directly draw on the advanced academic and research training they received in their doctoral studies.

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Technical Appendix.

Classification of Non-STEM Careers

Career Categories	Job Titles	Percentage
Top Managers, Academic Administrators	CEO, COO, CFO, president, district or general manager, and provost	30
Other Non-STEM Managers, Academic Administrators	Midlevel managers of non-STEM employees	6
	Education administrators (e.g. registrar, dean, principal)	10
Business Professionals	Accountants, auditors, and other financial specialists	3
	Insurance, securities, real estate, and business services	2
	Personnel, training, and labor relations specialists	1
	Sales—retail (e.g., furnishings, clothing, motor vehicles, cosmetics)	1
	Sales—commodities except retail (e.g., industrial/medical/dental equipment)	1
	Other marketing, sales, and management-related occupations	18
Other Non-STEM Professions	Postsecondary instructors	7
	Precollege teachers and instructors	2
	Arts and humanities professionals (e.g., writers, editors, public relations specialists, artists, entertainers, broadcasters)	6
	Social scientists (e.g., economists, psychologists, sociologists, other social scientists)	2
	Lawyers and judges	4
	Counselors, social workers, and clergy	1
	Farmers, foresters, and fishermen	1
	Librarians, archivists, and curators	1
	Other administrative personnel (e.g., record clerks, telephone operators)	1
	Precision/production occupations (e.g., metal/wood workers, butchers, bakers)	1
	Other non-STEM professionals	2

Notes: The percentage of employed STEM Ph.D. holders in non-STEM careers who reported each profession is shown in the third column. Respondents who were first-line managers were asked to select the job that describes the occupation of people they manage; therefore, first-line managers who managed employees working in non-STEM careers were included in nonmanagement careers. Due to rounding error, the column may not add to 100 percent.

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