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Will the Scientific and Technology Workforce Meet the Requirements of the Federal Government?

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Summary

The federal government relies on technically trained personnel to carry out a variety of critical functions in several mission areas, including national defense, homeland security, health, space, transportation, and agriculture. Recently, the size and adequacy of the federal workforce for carrying out scientific, technical, engineering, and mathematics (STEM) activities have become areas of concern in many policy circles. Knowledgeable sources both inside and outside of government have voiced fears that this workforce is aging and may soon face a dwindling labor pool, a problem that could be compounded by skill shortages in key areas and a growing proportion of non-U.S. citizens obtaining STEM degrees in the United States.

This report assesses the condition of the federal STEM workforce,[1] based on the best data available, and also discusses the data that would be required for a more comprehensive analysis. The report examines three issues:

[1] This research does not address the specific composition or diversity of the federal STEM workforce with the one exception of a brief look at the need for citizen versus non-citizen workers. It was developed based on available data and interviews with representatives from nine federal departments, agencies, or offices: the Departments of Homeland Security, Energy, Transportation, Health and Human Services (to include representatives from the Centers for Disease Control and Prevention and the Agency for Toxic Substances and Disease Registry), and Agriculture, the National Aeronautics and Space Administration, the National Science Foundation, the Office of Personnel Management, and the Office of Management and Budget.

- Broader trends in the U.S. STEM workforce that might affect the federal STEM workforce
- Trends and workforce-shaping activities in the federal STEM workforce
- Legislative and programmatic mechanisms for influencing the federal STEM workforce.

To address these issues, a RAND Corporation team reviewed the relevant literature and data on STEM education, labor force, and labor markets. The team also collected data and interviewed STEM managers at selected federal agencies, including the National Aeronautics and Space Administration (NASA), the National Institutes of Health (NIH), and the Departments of Agriculture, Energy, Defense, Homeland Security, and Transportation, the Office of Management and Budget, and the Office of Personnel Management.

Background: Are There Looming Shortages in the U.S. STEM Workforce?

If there are looming personnel shortages in or skill mismatches for the federal STEM workforce, these problems might be reflected in broader U.S. STEM workforce data and trends.[2] Therefore, the first phase of our analysis is an examination of the broader U.S. STEM workforce. We focused on whether economic indicators point to shortages of U.S. STEM workers in the recent past, at present, or in the near future.

Data Sources and Limitations

At the time of this research, which was conducted in 2003, much of the available data on STEM personnel in the U.S. workforce were

[2] Different concepts of "shortage"—what it is and how to measure it—underlie much past discussion of the topic of this report, even though authors and commentators have often neglected to define their particular concepts. This report attempts to be clear about particular concepts, following the alternative concepts defined and analyzed in Butz et al. (2003).

available only up to the year 2000. Hence, the effects of both the collapse of the Internet "bubble" and the recession of 2002 are not reflected here. These events presumably slowed or reduced the demand for STEM personnel compared with expectations derived from this analysis.

Findings

Despite recurring concerns about potential shortages of STEM personnel in the U.S. workforce, particularly in engineering and information technology, we did not find evidence that such shortages have existed at least since 1990, nor that they are on the horizon.

If there were shortages of STEM workers, we would expect these shortages to be reflected in certain economic indicators, most notably low levels of unemployment and rising wages for STEM workers. However, in examining earning patterns and employment patterns for STEM workers, we found no patterns that were consistent with a shortage of STEM workers. The statistics do not portray the kinds of vigorous earnings and employment prospects that would be expected to draw increasing numbers of workers into STEM fields.

Likewise, "underemployment patterns"—indications of STEM workers involuntarily working out of their fields—suggest that underemployment of STEM workers is relatively high compared with non-STEM workers. Engineering is an exception—its underemployment rate has been lower than that for non-STEM workers.

There are also concerns about the high proportion of non-citizens earning STEM degrees in the United States. These concerns typically center on potential shortages of U.S. citizens to fill security-related STEM jobs that require STEM degrees, or broader concerns that the United States could become too dependent on foreign STEM expertise. The non-citizen trend was up at least between 1970 and the mid-1990s. More recently in the half decade before 2000, the proportion leveled off. Overall, this growth was proportionally less than the growth of non-STEM Ph.D.s acquired by non-citizens. On the demand side, we do not foresee sufficient growth in the numbers of STEM workers who must have security clearances (and hence U.S. citizenship) to strain the numbers available.

Based on all of these indicators, we find neither an inadequate supply of STEM workers to supply the nation's current needs, nor indications of shortages in the foreseeable future. While it may be argued that any possibility of shortages must be met by accelerating the supply, the cost to young people of completing years of training only to emerge into labor markets with surplus STEM workers should also be considered. Over the past half century, the latter problem has occurred much more frequently than the former.[3]

The Federal STEM Workforce

With this context in mind, we collected data from federal agencies about their STEM workforces and solicited their perceptions of major problems and concerns.

Data Sources and Limitations

The federal Office of Personnel Management (OPM) keeps accurate data on the current federal STEM civil service workforce. However, federal agencies' forecasts of future needs are inadequate to inform current decisionmaking. An important trend in the federal STEM workforce is the increasing use of contract workers, rather than civil service employees, to perform federal STEM functions. Few agencies, NASA being the only exception that we found, keep adequate data on this workforce. Given these limitations, our analysis focused on the federal civil service STEM workforce.

Our interviews, along with data from the Office of Personnel Management, permit a more-timely portrait, however incomplete, of the federal STEM workforce than is available for the U.S. STEM workforce. In particular, initial effects of the collapse of the Internet bubble, the 2002 recession, and the terrorist attacks of September 11,

[3] Note that this statement does not claim that labor market conditions have not been generally good for STEM workers. Rather, it points out that the data indicate periodic surpluses and a softening of the market for important elements of the STEM workforce (see Chapter Two for details).

2001, are presumably incorporated in these data and in the expectations of federal STEM managers.

Findings

- There is evidence that the federal STEM workforce is aging. Department of Defense (DoD) data show that the percentage of its STEM workforce that is eligible to retire will more than double by 2012. Both NASA and NIH anticipate similar trends.
- However, older federal STEM workers tend to stay on for a longer period past retirement age than many other groups of workers. Hence, retirement eligibility is an unreliable harbinger of workforce shortages.
- Notwithstanding agency concerns about potential losses to retirement or a dwindling STEM workforce, the actual turnover rate for federal STEM workers is lower than that for the equivalent workforce in industry.
- STEM workers who do leave federal employment tend to be younger workers—in their 30s—who are headed for the "greener pastures" of industry rather than older workers entering retirement.
- The federal government tends to hire relatively older workers. For example, 70 percent of government hires in 2002 were over the age of 30. A substantial number of older STEM workers were hired by the federal government between 1997 and 2002.
- Workforce incentives are becoming more prominent as a way of attracting and retaining high-quality STEM workers. Some agencies have had success with these techniques and others anticipate using them more aggressively. NASA and the Centers for Disease Control and Prevention (CDC), for example, have obtained special authority from OPM to offer salaries above typical federal rates.
- A significant proportion of STEM workers employed on federal projects work in fact for private-sector contractors. This mechanism allows the government to reach flexibly into the private sector for more or fewer STEM workers as the requirements change. Accordingly, the workforce constraints become the size

and characteristics of the entire national STEM workforce, not just those who choose to be government employees.
- Although the proportion of STEM workers who require security clearances (and hence citizenship) may increase due to national defense and homeland security concerns, the actual numbers of such jobs are very small compared with the federal STEM workforce and with the number of STEM workers in the national workforce who are citizens. We do not foresee a shortage of STEM-trained citizens eligible for security clearance.

Legislative and Programmatic Mechanisms for Influencing the Federal STEM Workforce

We examined the policy mechanisms—including legislative initiatives, agency programs, and other means—by which the federal government influences both the national and the federal STEM workforce. We found virtually no measures that have specifically focused on the entire federal STEM workforce. Instead, most mechanisms have addressed aspects of the workforce (such as information technology workers) or specific agency needs.

We divided these mechanisms into two basic categories, "filling the pipeline"—mechanisms for attracting students into STEM fields and supporting their education and training, and "shaping the workforce"—mechanisms for recruiting, retaining, and developing the skills of STEM workers.

Filling the Pipeline

The goals of the pipeline-filling mechanisms are to attract students into STEM fields. These mechanisms are also used to address diversity issues by targeting underrepresented demographic groups, including ethnic minorities and women. These mechanisms include:

- General interest building: kindergarten through grade 12 (K–12) programs, summer institutes for teachers, university-

school partnership programs, and other means for increasing interest and awareness in STEM careers.
- Counseling and guidance: programs that direct students into STEM careers. These include internships and apprenticeships.
- Resources for universities: the broad range of federal programs for supporting higher education, including grants, loans, assistantships, most of which are funded by the three federal agencies with a science education mission—the National Science Foundation (NSF), the NIH, and NASA.

Shaping the Workforce

The goals of the workforce-shaping mechanisms are to recruit, retain, and promote a quality STEM workforce. These mechanisms include:

- Adjusting the labor pool: This mechanism focuses on immigration measures that adjust the pool of foreign STEM workers (H-1B visa holders) allowed to work in the United States.
- Adjusting the workforce: this includes mechanisms (like those noted above in use by NASA and CDC) to recruit, retain, and promote STEM workers.

Historically, the most sweeping attempt to address STEM needs was the National Defense Education Act of 1958, passed in response to concerns about U.S. science education prompted by the Soviet Sputnik launches.

Conclusions

The data and observations discussed in this report suggest the following conclusions.

No Compelling Evidence of Current or Imminent Federal STEM Shortages

Our analysis found no compelling evidence of current or imminent shortages of STEM personnel in the federal workforce. Certain fields may develop shortages (e.g., rapidly growing sub-fields within information technology [IT]) and should be closely monitored. However, the downturn in the fortunes of the IT field after the Internet bubble burst makes such shortages less likely. In addition, STEM workers are not immune to employment variations over business cycles, although they tend to be less affected than other college graduates. In any case, for the general population, almost any shortfall in workers in any STEM field can be made up by changing H-1B Visa quotas and immigration policies.[4]

Likewise, we found no clear evidence of shortages in the federal STEM workforce. However, existing data are weak and do not support a comprehensive analysis. Some federal agencies believe there will be a problem in the near future as the number of STEM employees who are eligible for retirement increases, but indicators suggest that shortages, if any, will be less serious than many assert. This is principally because retirement eligibility does not translate automatically into retirement and because many federal workforce needs can be flexibly met through outsourcing to the private sector, thereby attaining access to the entire national labor market, and even the international labor market.

Our understanding of future federal STEM workforce requirements is limited by inadequate forecasts based on rough projections of current needs. The difficulty is further complicated by the federal government's growing propensity to contract out STEM work, which may decrease the in-house, civil service requirement. No adequate forecasts exist for this process, either.

We have found no comprehensive assessments of legislation or programs aimed at influencing the U.S. or federal STEM workforce. With respect to the two major types of federal mechanisms—(1) those aimed at filling the pipeline in educational and training facilities and (2) those aimed at shaping the workforce—we can conclude that the federal government mechanisms have focused primarily

[4] This point assumes that there is a supply of skilled workers elsewhere in the world. As economies outside the U.S. grow and become more developed, this assumption may no longer hold true.

on filling the pipeline, using mature institutions and programs that have been focused on this effort for decades. These pipeline-filling measures are now embedded in a mature institutional framework with implementing mechanisms refined by decades of experience. At the aggregate level, these measures have had some success addressing supply issues, including those affecting minorities and women. Federal agencies appear to have the statutory authority they need to conduct whatever innovative pipeline-filling programs are needed to address particular needs.

With respect to workforce-shaping mechanisms, the federal government has only recently begun to use these for STEM positions, and their use has varied widely by agency. Because most civil service STEM staffing is done at the agency level, there is not a great deal of precedence or experience using workforce management mechanisms across the entire federal STEM workforce. Cross-agency STEM workforce management initiatives require significant coordination that has proven difficult to engineer. However, there is no clear, widespread need for such programs. For example, retaining STEM workers does not seem to be a major problem for the federal government, implying that special retention mechanisms are probably needed sparingly and only in high demand sub-fields. However, there appear to be opportunities for workforce-shaping mechanisms in other areas, such as recruiting.

Given that many STEM graduates leave universities with sizable loan debt, some form of loan forgiveness or repayment as a recruiting mechanism could affect significant numbers of entering STEM workers. Whether such programs are widely needed is not clear, however.

A Clearer Picture of Federal STEM Workforce Requirements and Personnel Will Require Better Data

Agency perceptions of the federal STEM workforce suggest that it is an area of concern and that the federal government should monitor it. Doing so usefully in a timely way will require improved data. We identified deficiencies in the data that should be corrected to facilitate this process. Such improvements involve counting and describing both "spaces"—the requirements for workers with specific sets of skills, and "faces"—qualified persons actually filling the spaces.

Data on Spaces.[5] As commonly used in federal circles, the term "spaces" refers to requirements for STEM workers. The federal government needs to forecast the number of spaces it will require for all STEM specialties. Making such a forecast requires understanding evolving technology and changes in government roles. Data on future spaces should be consolidated within, or be accessible from, a central location. Relevant agencies might be required to develop and maintain forecasts for some years into the future, but not so many as to be beyond what could reasonably be anticipated. The federal government should develop a methodology for doing this forecasting and provide it to all departments and agencies. Additionally, attention should be paid to changes in the civil service/contractor mix in the federal STEM workforce, particularly if the current trend toward outsourcing continues.

Data on Faces. The data needed to adequately determine the ability of the national STEM workforce to supply the faces for filling the forecasted federal spaces are outlined in part in Chapter Three. Projection models for the national workforce are maintained by the Bureau of Labor Statistics. Other methods for filling STEM spaces (e.g., retraining workers into STEM specialties) should be considered in these models, as well as foreign workers and the output of standard education programs.

The broad patterns of STEM workforce requirements and availability reported here have emerged despite data that are not well suited to this purpose. Without better data, it will be difficult to undertake more-targeted investigations for particular STEM specialties,

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[5] Our use of the "spaces" and "faces" terminology is not meant to assume that employers have fixed requirements for workers or that the definition of a qualified person is not subject to change. We presume that forecasts and data on requirements will want to take market and personnel flexibility into account to the maximum extent possible. So, for example, in the face of shortages, employers may redefine work and outsource some of it globally. Conversely, when there is an oversupply of highly skilled workers, employers may raise requirements for positions. We also note that forecasting STEM requirements is notoriously difficult, and to be useful, forecasts must be regularly updated and based on competent models.

particular agency employers, or particular geographic regions or demographic groups.

Next, we note the major data deficiencies that hamper a more firmly grounded and finely grained analysis than ours. The first set of deficiencies pertains to the broader U.S. STEM workforce, while the second pertains to the narrower federal STEM workforce. We include both because an understanding of the overall U.S. picture is important to the federal STEM workforce as well.

The U.S. STEM Workforce

The federal STEM workforce is a component of the U.S. STEM workforce, and in some ways is entirely reliant upon it. A look at U.S. STEM workforce data deficiencies is, therefore, necessary if one is to understand the federal STEM workforce.

Lack of Timeliness

- Publication of consistent data on major characteristics of the national STEM workforce often occurs more than two years after the fact.

Lack of Comparability

- Characterization of workers by area of formal education ("face" in our nomenclature) or job classification ("space") is inconsistent in the data.

Inconsistent Definitions

- Data from different sources feature varying definitions, time domains, and levels of disaggregation. This inconsistency also makes comparability more difficult to establish.
- Important data series have experienced changing definitions without reported crosswalks or even documentation.

Lack of Data

- Data on years to Ph.D. degree are not consistently available by discipline.

- Earnings, unemployment, underemployment, and other economic indicators of a shortage or surplus are not available consistently for the STEM workforce and its components.
- Data are unavailable on numbers of STEM workers in other than STEM spaces.
- There are no "flash" indicators[6] (available with, say, a one-quarter lag) of numbers of STEM students, proportion of foreign students, and numbers of STEM "spaces" in the federal government and private sector by major discipline and by selected critical sub-disciplines.

Federal STEM Workforce

Relevant data issues for the federal workforce are similar but not identical to those for the broader U.S. STEM workforce. As we have noted, OPM data on the federal workforce are much more timely than those available on the national workforce. They are also reasonably consistent across agencies. However, there are inconsistencies and gaps at the agency level and very little information on projections of future needs.

Inconsistent and Incomplete Data

- Consistent data are lacking on workforce retraining to meet STEM requirements.
- Current and historical demographic data on age, qualification level, and average age at retirement of STEM workers are incomplete.

[6] That is, there are no short turnaround indicators of pending shortages or surpluses that can quickly direct policymakers' attention to potential problem areas. These so-called flash indicators could provide early warning as quickly as three months after the fact. Additional in-depth data would then be gathered on these particular problem areas to decide whether the potential problems are serious or not. In the meantime, policy solutions would be at the ready. Such flash indicators might be developed for numbers of STEM students, proportions of foreign students, and numbers of STEM "spaces" in the federal government and private sector in selected critical subdisciplines.

- Few agencies maintain data on numbers and characteristics of the STEM workforce indirectly engaged through the A-76 mechanism or other outsourcing processes.
- Few agencies maintain forecasts of STEM worker requirements.

Lack of Data

- The data on STEM workers maintained by many agencies are no more detailed or complete than the data kept by the OPM.
- Data are unavailable on interagency mobility of STEM workers.
- There are no "flash" indicators of numbers of STEM students, proportion of foreign students, and numbers of STEM "spaces" in the federal government and private sector, by major discipline and selected critical sub-disciplines.
- There are no data available on the time interval between the government's decision to fill a STEM vacancy and its time of hiring a STEM worker to fill that vacancy. These data would shed light on the frequent claim that the federal government's long hiring time lags put it at a disadvantage relative to the private sector.

Some of these deficiencies are more damaging than others, depending on the particular focus of monitoring or analysis. Some are more easily corrected than others, depending on whether the cause of difficulty is at the source of the data or in the aggregation and reporting of the data. Processes for improving federal data statistics have been implemented in several areas in recent years. Establishing priorities, assigning responsibility, providing resources, and coordinating efforts could lead to similar improvements in the federal STEM workforce data.

These improvements that would result from these recommendations—when embodied in specific data with specified sources and methods—would permit statistical models to forecast STEM workforce trends in a comprehensive and timely manner and also permit comparisons of requirements (space forecasts) with personnel (face forecasts). Scientifically supportable policy decisions on STEM workforce mechanisms would be facilitated, as would informed training and career decisions by students and their advisors. Both personnel shortages and their attendant risks for the nation and personnel surpluses and their costs and disruptions for trained workers can thereby be reduced.