U.S. DEPARTMENT OF ENERGY | Office of Science

Summary of Surveys of Workforce Development Needs in the Office of Science

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History – FY 2014 STEM Education Consolidation

OMB directed cuts to STEM education and workforce training programs in more than 10 Federal agencies, including DOE. Across the Federal agencies, OMB proposed terminating or reorganizing over 115 programs, including terminating 9 programs in DOE (6 in SC, 2 in EERE, 1 in NE).

DOE Programs Identified for consolidation:

- Computational Sciences Graduate Fellowship (SC-ASCR)
- Summer School in Nuclear Chemistry and Radiochemistry (SC-BES&NP)
- Global Change Education Program (SC-BER)
- QuarkNet (SC-HEP)
- National Undergraduate Fellowship Program in Plasma Physics and Fusion Energy Sciences (SC-FES)
- Plasma/Fusion Science Educator Programs (SC-FES)
- Graduate Automotive Technology Education (EERE)
- Wind for Schools (EERE)
- Nuclear Scholarships/Integrated University Partnerships (NE)

A primary motivation for OMB's decisions was to eliminate small programs in favor of aggregating them into larger programs at a fewer lead agencies.

SC's Assessment of Workforce Development Needs

- In February 2014, in response to OMB's requirement for an evidence based assessment of workforce needs, the Office of Science initiated a study to identify disciplines in which significantly greater emphasis in workforce training at the graduate student or postdoc levels is necessary to address gaps in current and future Office of Science mission needs.
- In this study, each of SC's six Federal Advisory Committees, seven SC Associate Directors, and 10 SC Laboratory Directors were asked for their expert assessment on the following:
    i. STEM disciplines not well represented in academic curricula;
    ii. STEM disciplines in high demand, nationally and/or internationally, resulting in difficulties in recruitment and retention at U.S. universities and at DOE laboratories;
    iii. STEM disciplines for which the DOE laboratories may play a role in providing needed workforce development; and
    iv. recommendations for programs at the graduate student or postdoc levels that can address discipline-specific workforce development needs.

Responses

We received responses from everyone who was polled. The input identified both program-specific workforce development needs and crosscutting workforce development needs:

- Over 50 SC program specific disciplines were recognized as needing greater emphasis for workforce training.

- Several crosscutting areas were identified:
  - Computational Sciences (all 6 SC program areas; 6 SC labs)
  - Accelerator and Detector R&D (BES, HEP, NP; 4 SC labs)
  - Instrumentation (BES, BER, HEP; 4 SC labs)
  - Nuclear chemistry/Radiochemistry (BES, NP; 3 SC labs)

- Interdisciplinary sciences was emphasized by several programs and labs.

The Computational Sciences Graduate Fellowship (CSGF)

- The single highest-cited program is the Computational Sciences Graduate Fellowship. By far!
- Not only was it mentioned by name, it was also used as a model for training in other disciplines.
- The next couple of charts give some testimonials.

Workforce Data Call – Recommendations for Computational Sciences Graduate Fellowship (CSGF) Program[1]

STAKEHOLDER GROUP *[Disciplines]*	**COMMENTS AND RECOMMENDATIONS**
ASCR –AD *[Applied Mathematics and Computer Science]*	*Comments:* • "While academic curricula are well established in applied mathematics and computer science, few academic institutions offer the interdisciplinary curricula needed to train the computational workforce needed to support DOE missions." *Recommendations:* • "Continue supporting a graduate immersion program (CSGF)" • "Expand CSGF to include applied mathematics and computer science as recommended by ASCAC in 2008." [and 2014]
ASCAC *[Computing Sciences and Engineering Disciplines*[2]*]*	*Comments:* • Insufficient educational opportunities are available for graduates in ASCR-related Computing Sciences that are most relevant to the DOE mission." • "The exemplary [CSGF] program, program deemed effective in every one of multiple reviews, is uniquely structured and positioned to help provide the future workforce with the interdisciplinary knowledge, motivation, and experienced necessary for contributing to the DOE mission." • "Graduate CS&E programs typically do not provide exposure to real-world applications and hence are not able to impart some of the complexities of the field." • "CSGF effectively lowers the barriers that separate the different scientific disciplines and exposes fellows to knowledge, experiences, and tools that alter their single-faceted view of science." • "Reviews of the CSGF program (Kerman 2006, Manteuffel 2011, McNeely 2012) indicate that it has been highly successful within its size and scope." *Recommendations:* • "Preserve and increase investment in the DOE CSGF program to increase opportunities for more high-quality students, particularly students from underrepresented populations and demographics. • Establish new fellowship programs, modeled after the CSGF program, for research opportunities in enabling technologies in the computing sciences, including computer science for HPC, large-scale data science, and computational mathematics."

[1] Several additional stakeholder groups called for lab practicum and/or thesis research/training at DOE labs for areas of computational sciences (BES-AD, BER-AD, FES-AD, HEP-AD, BERAC, ANL, ORNL, PPPL, TJNAF)

[2] Algorithms (both numerical and non-numerical); Applied Mathematics; Data Analysis, Management, and Visualization; Cybersecurity; Software Engineering and High Performance Software Environments; and High Performance Computing Systems.

STAKEHOLDER GROUP *[Disciplines]*	**COMMENTS AND RECOMMENDATIONS**
BESAC *[Computational Sciences and "Big Data" underpinning BES fundamental science]*	Recommendation: • "The DOE ASCR Computational Sciences Graduate Fellowship program has been particularly effective as one approach to address this national need."
NSAC *[High Performance Computing (HPC) and simulations for nuclear science and its applications.]*	*Comments:* • *"The Computational Sciences Graduate Research Fellowships have worked to identify the most talented U.S. students working in high-performance computing and the exciting science they want to address. These fellowships require the recipient to spend a practicum at a national laboratory, making these awards truly traineeships. However, this effort falls short of the needs for these highly talented individuals at DOE laboratories for fundamental and applied science, that is exacerbated by the highly competitive opportunities in the private sector."* *Recommendations:* • *"…increase the number of awards with full support and a practicum opportunity given directly to graduate students to enhance their training, targeted to areas with demonstrated needs. The awards could be modeled on the Computational Science Graduate Research Fellowships."*
LBNL *[Team science, multidisciplinary sciences, computational science and engineering]*	*Comments:* • "The DOE CSGF has proven to be a very successful model for filling the workforce pipeline with computational scientists and engineers who can thrive in a large group, multidisciplinary setting." *Recommendation:* • "Fellowships like CSGF and special named Lab Fellowships"
BNL *[Computational sciences]*	*Comments:* • "Computer science or disciplinary specific curricula is ready accessible through academic sources. However, the integration of scientific disciplines with computational sciences is not." *Recommendations:* • "Restore the Computational Sciences Graduate Fellowship program. The national laboratory system needs access to candidates with capabilities in a specific scientific discipline accompanied with skills in computational science. "

Other Recommendations for Programs Appropriate for SC

A number of STEM training programs were identified as appropriate for SC and that involve the DOE labs – DOE's unique asset. Some examples:

- Graduate Fellowships with a research practicum at a DOE laboratory, i.e., CSGF.
- Thesis parts research conducted at DOE labs, either as part of a Traineeship or as a stand alone program.
- Lab-based postdoctoral appointments, e.g., the postdoctoral appointments at NERSC and the LCFs described by ASCR.
- Intensive, topic-specific workshops, seminars, or "summer schools" in areas where discipline is not well represented in academic curricula.
- Outreach – develop recruiting and retention programs that increase DOE's visibility on university and college campuses.

Some Comments from Responders to the Surveys

- "The demand for graduates in Computational Sciences and Engineering far exceeds the supply from academic institutions." "There is a large industry demand for students with Master's level education, which drains the number of students pursuing advanced degrees." [computational science/ASCAC]
- "…the U.S. is not training sophisticated instrumental scientists at the level needed by the U.S. national laboratories and industry." [BESAC] "In Europe a HEP Ph.D. is often awarded for instrumentation research; this is very rare in the U.S." [HEPAP]
- "…accelerator science and technology is not yet broadly recognized as an essential, vital, and exciting frontier research field. In most universities it is not considered as an academic subject 'worthy of faculty lines'." [HEPAP]
- "The workforce of tomorrow must be interdisciplinary…It is also clear that the exciting challenges of the future involve the study of natural systems across spatial and temporal scales." [BERAC]
- "In particular, Ph.D.'s in nuclear and radiochemistry are at risk…Currently about 5 students per year receive a Ph.D. in nuclear chemistry…" [NSAC]
- "China has made a big push into this area with funding and equipment, drawing U.S.-based scientists to Chinese universities." [radiation effects in materials/BES-AD]

Overview of FESAC Survey Results

- "Community input was sought through a survey and general calls for whitepapers that were broadcast to the mailing lists of the American Physical Society, the U.S. Burning Plasma Organization, and the University Fusion Association, as well as to a list of Principal Investigators of research projects funded by Fusion Energy Sciences (FES). The survey targeted institutions rather than individuals in order to cover the majority of U.S. institutions participating in research funded by FES, including universities, national labs, and industry."

- "The survey covered three broad areas: Magnetic Fusion Energy (MFE) sciences, High-Energy-Density Laboratory Plasma/Inertial Fusion Energy (HEDLP/IFE), and Discovery Plasma Science. In addition, the survey also asked for input regarding growth or decline of each group, department, or institution over the past decade …"

- "The three core areas are reasonably represented in academia, but a possible crisis is developing in MFE due to the declining number of faculty, departments, and institutions. Emerging disciplines in Discovery Plasma Science represent a vibrant component of plasma science research and likely will remain so in the foreseeable future. In contrast, emerging disciplines in fusion engineering sciences (topics requiring integration of fundamental plasma physics and applied technologies) represent the largest potential gaps in workforce development."