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 HEPAP Survey Results

- The subcommittee was charged to identify disciplines in which lack of workforce development threatens the HEP mission and to consider strategies for addressing the shortfalls.

- For one field in particular, the training shortage is severe: this is in the field of accelerator physics, where training falls far short of need.

- Two other fields suffer from workforce shortages: in instrumentation, graduate education is declining, threatening US capabilities in the long term, and in large-scale computing, intense demand by industry frustrates the retention of experts at the national labs.

BERAC, BER, & Lab Inputs for BER

BER	Multidisciplinary science and technology training [spanning BER] with strong emphasis in computation.	BERAC
	Physiology of Whole Plants	BERAC
	Multiscale Modeling of Biological and Environmental Systems[1]	BERAC
	Instrument Development and Application [3]	BERAC
	Public Communications Skills	BERAC
	Multidisciplinary science and technology training	BER-AD
	Quantitative molecular plant breeding for bioenergy crops	BER-AD
	Multiscale Modeling and interdisciplinary computational science[1]	BER-AD
	Electron Microscopy/Biological Spectroscopy[3]	Labs: Ames
	Systems Biology and Synthetic Biology	Labs: BNL
	Multidisciplinary and Team Science	Labs: LBNL
	Computational Biology, Informatics, Comparative Genomics[1]	Labs: ORNL
	Magnetic Fusion Energy (MFE) Sciences	FESAC

SC Program Office	Priority Topic Areas	Stakeholder Source
ASCR	Computing Science: Algorithms (both numerical and non-numerical)[1]	ASCAC
	Computing Science: Applied Mathematics [1]	ASCAC
	Computing Science: Data Analysis, Management and Visualization	ASCAC
	Computing Science: Cybersecurity	ASCAC
	Computing Science: Software Engineering and High Performance Software Environments[1]	ASCAC
	Computing Sciences: High-performance Computing Systems	ASCAC
	Computational Science[1]	ASCR-AD
	High Performance Computer Science	ASCR-AD
	Data Analysis and Visualization	ASCR-AD
	Computational Sciences[1]	Labs: ANL, BNL, FNAL, LBNL, PNNL, PPPL
	Software and Chip Design	Labs: LBNL
	High Performance Computing	Labs: ORNL, PNNL
BES	Fundamental Electrochemistry	BESAC
	Nuclear/radiochemistry (Actinide/Lanthanide Science)[4]	BESAC
	Crystal Growth/Fundamental Studies of Crystal Growth	BESAC
	Computational Sciences and "Big Data" underpinning BES fundamental science[1]	BESAC
	Lab-based Instrumentation invention/development [3]	BESAC
	Detector Science	BESAC
	Accelerator Science[2]	BESAC
	Predictive Materials and Chemical Sciences (computational science)[1]	BES-AD
	Heavy Element Chemistry[4]	BES-AD
	Neutron Scattering Research and Instrumentation	BES-AD
	Radiation Effects in Materials	BES-AD
	Synthesis Science	BES-AD
	Accelerator and Detector R&D[2]	BES-AD
	Multidisciplinary Sciences - physics-chemistry-materials	Labs: Ames
	Beamline Physics and Engineering[3]	Labs: BNL
	Nano-fluidics and Biotechnology	Labs: BNL
	Multidisciplinary and Team Science	Labs: LBNL
	Optical Engineering (x-ray optics and metrology)	Labs: LBNL
	Neutron & X-ray Scattering and Diffraction	Labs: ORNL
	Computational Materials Modeling and Simulation[1]	Labs: ORNL
	Nuclear Chemistry and Radiochemistry[4]	Labs: ORNL, PNNL
	FEL Laser Science	Labs: SLAC
	X-ray Optics	Labs: SLAC
	Accelerator Science: Superconducting RF Physics[2]	Labs: SLAC
	X-ray Chemical Science	Labs: SLAC
	Engineering - Accelerator Technology (Digital/Analog)[2]	Labs: SLAC
	Engineering - Facility Instrumentation[3]	LBNL
BER	Multidisciplinary science and technology training [spanning BER] with strong emphasis in computation.	BERAC
	Physiology of Whole Plants	BERAC
	Multiscale Modeling of Biological and Environmental Systems[1]	BERAC
	Instrument Development and Application [3]	BERAC
	Public Communications Skills	BERAC
	Multidisciplinary science and technology training	BER-AD
	Quantitative molecular plant breeding for bioenergy crops	BER-AD
	Multiscale Modeling and interdisciplinary computational science[1]	BER-AD
	Electron Microscopy/Biological Spectroscopy[3]	Labs: Ames
	Systems Biology and Synthetic Biology	Labs: BNL
	Multidisciplinary and Team Science	Labs: LBNL
	Computational Biology, Informatics, Comparative Genomics[1]	Labs: ORNL
FES	Magnetic Fusion Energy (MFE) Sciences	FESAC
	Fusion Engineering Sciences: Plasma material interaction/Divertor	FESAC
	Fusion Engineering Sciences: Magnets	FESAC
	Fusion Engineering Sciences: Tritium Handling	FESAC
	Fusion Engineering Sciences: System Safety and Design	FESAC
	Fusion Engineering Sciences: high/pulse power electrical engineering	FESAC
	Burning Plasma Physics	FES-AD
	Fusion Material Science	FES-AD
	Plasma-Materials Interface	FES-AD
	High-Energy-Density Plasma Science	FES-AD
	Computer Science: Managing and Processing "Big Data"[1]	FES-AD
	Multiscale Physics Modeling[1]	FES-AD
	Magnetic Fusion Energy (MFE) Sciences	Labs: PPPL
	Fusion Engineering Sciences (via FESAC)	Labs: PPPL
	RF Physics and Engineering	Labs: PPPL
	Neutral Beam Physics and Engineering	Labs: PPPL
	Fusion Facility Design	Labs: PPPL
	MHD Theory and Computation[1]	Labs: PPPL
	X-ray Imaging Science	Labs: PPPL
HEP	Accelerator Science[2]	HEPAP
	Instrumentation for HEP[3]	HEPAP
	Large-scale computing and "Big Data"[1]	HEPAP
	Accelerator Science[2]	HEP-AD
	Detector Instrumentation[2]	HEP-AD
	Computational Science	HEP-AD
	Theoretical Particle Physics	HEP-AD
	Accelerator and Detector R&D[2]	Labs: BNL
	Accelerator Science[2]	Labs: FNAL, LBNL
	Large-scale computing and "Big Data" [1]	Labs: FNAL
	Instrumentation for HEP[3]	Labs: FNAL
	Accelerator R&D: Cryogenic Engineering[2]	Labs: FNAL, LBNL
	Accelerator R&D: RF Engineering[2]	Labs: FNAL, LBNL
	Accelerator R&D: Superconducting Magnet Engineering[2]	Labs: FNAL
NP	Fundamental Nuclear Science and Technology	NSAC
	Nuclear Chemistry and Radiochemistry[4]	NSAC
	Accelerator Science and Associated Technologies[2]	NSAC
	High Performance Computing and simulations for nuclear science and its applications[1]	NSAC
	Applied studies in nuclear science and related fields	NSAC
	Radiochemistry and nuclear chemistry, and nuclear physics relevant to isotope production[4]	NP-AD
	Science and Technology Management	NP-AD
	Nuclear Science[4]	Labs: ANL
	Nuclear Chemistry and Radiation Chemistry[4]	Labs: BNL
OPA	Risk and Uncertainty Management	OPA-OD
	Risk Management	Labs: LBNL
	Project Management	Labs: LBNL
DOE Applied/NNSA	Decision Sciences	Labs: ANL
	Applied Energy Sciences	Labs: ANL
	Nuclear Energy and Nuclear Non-Proliferation	Labs: BNL
	Sustainable Energy	Labs: BNL
	Applied Physics	Labs: PNNL
	Nuclear Engineering	Labs: PNNL
Other STEM Fields and non-STEM Skills	Technical Procurement Specialists	Labs: FNAL
	Facility-related S&T	Labs: LBNL
	Engineering in targeted areas: high power electronics, systems, cryogenics, power RF	Labs: LBNL
	Engineering: Reliability	Labs: LBNL
	Engineering: Fire protection	Labs: LBNL
	Engineering: Building	Labs: LBNL
	Health Physics	Labs: LBNL
	Skilled Craft Workers (electricians, plumbers, HVAC, carpenters)	Labs: LBNL
	Quality Assurance	Labs: LBNL
	Safety -radiological, chemical, electrical, biological	Labs: LBNL

[1] Disciplines within Computational Sciences and Engineering
[2] Disciplines within Accelerator and Detector R&D/ Accelerator Science
[3] Instrumentation relevant to different disciplines
[4] Discplines within Nuclear Chemistry and Radiochemistry

From FY 2015 Interactions with OMB re STEM

This discussion was the basis for the call to the FACs, the ADs, and the Labs

Passback supported the Administration's STEM education consolidation strategy, and provided no funds for activities consolidated in FY 2014. However, OMB recognized that DOE has mission-specific workforce needs in STEM fields and that the DOE laboratories are a unique resource for training workers in STEM research and development. OMB requested that STEM workforce development activities in the Office of Science include:

- an evidence-based statement of the workforce need, including other options considered;
- a clear statement of program goals;
- documented best practices that will be followed to ensure a diverse applicant pool and an unbiased selection procedure;
- and a mechanism for tracking program outcomes and evaluating success.