Review of 1953-2003 ORAU Follow-Up Studies on Science Education Programs: Impacts on Participants' Education and Careers

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BACKGROUND

This retrospective study summarizes impacts of selected science education programs on undergraduate, graduate student, and postgraduate participants. The summary data presented here are from follow-up studies conducted from 1953 through 2003 by Oak Ridge Associated Universities (ORAU) and its predecessor, the Oak Ridge Institute for Nuclear Studies (ORINS).

Many of these science education programs, sponsored by various federal agencies, were national in scope. Most of the programs involved research participation in a national laboratory or federal research center. Research appointments ranged in length from 10 weeks in the summer for undergraduates to two or three years for postgraduates. Scholarship and fellowship programs supporting undergraduate and graduate education frequently had research components as well. Other science education programs included short-term events, such as the Lindau Graduate Student Awards, which were designed to stimulate interest in scientific careers.

The objectives of these federally sponsored science education programs were to encourage talented students to pursue graduate education and employment in science and engineering fields, specifically in careers involving research and development and work in fields related to agency missions, such as energy, national defense, environment, safety, and health. The report that follows summarizes program outcomes by participant level.

The follow-up studies reviewed for this report occurred at various intervals after program participation; some were short-term follow-up, one or two years after participation, and some were longer-term follow-up, occurring as many as 10 to 20 years after participation. The studies sought to examine impacts of program participation, focusing on the degree of influence of the program on participants, the educational and occupational attainment of former participants, and the field of work and employer as related to the program participation.

Typically, studies of science education programs involving research show that participants are more likely to go on to careers involving research than are similar non-participants. This is not surprising since many applied to the program in the first place because of a prior interest in conducting research. What is not so obvious is whether these students who participate in research with a focus on a certain area (for example, energy), or who are supported by a specific agency, will be motivated to continue with careers in this research area or in support of the agency's mission. Many of the follow-up studies conducted by ORAU do attempt to measure former participants' continued focus on research areas or missions of importance to the sponsor of their research experience. In specific, where data are available, we will look at whether the participants are working for the program sponsor or related contractors, or are doing research related to their program participation.

SUMMARY OF FINDINGS

Through sponsorship of programs for **undergraduates** such as the Science and Engineering Research Semester (SERS) and the Laboratory-University Cooperative Student Research Participation Program (SRP), the Department of Energy (DOE) encouraged the development of adequate numbers of qualified science and engineering (S&E) personnel to meet its current and future research and development (R&D) needs. Follow-up studies on these programs collected information that reflects the programs' impact on participants' education and careers, specifically in areas of interest to DOE. Highlights of findings include the following:

- Undergraduate respondents from both the SERS and SRP programs reported far larger proportions of degrees in the physical sciences as compared with all natural science and engineering (NS&E) degrees. The general pattern of fields of work and degree were in areas supportive of DOE science and engineering R&D activities.

- One-half to two-thirds of the undergraduate SRP respondents reported attaining graduate degrees, which far exceeds those of all S&E graduates in which only one-fourth receive a graduate degree.

- Three large follow-up studies of DOE-sponsored undergraduate programs showed far greater proportions of respondents engaged in research and development as their primary work activity, exceeding those of national comparison groups.

- The percentage of SERS and SRP respondents working in federal laboratories was also greater than for national comparison groups.

- Former SERS and SRP respondents reported that these programs had a large influence on area of specialization, whether to attend graduate school, and current or past research activities.

- Special studies on the effects of research participation programs on underrepresented minorities indicated even more positive results for this group of participants, with higher rankings of the influence of the programs, as compared with the overall group of respondents.

DOE and its predecessor, the Atomic Energy Commission (AEC), sponsored both fellowship and research appointment programs for **graduate students** beginning in 1948. Among the larger programs were the AEC predoctoral fellowships supporting more than 750 students from 1948-1953, as well as a group of special AEC fellowships, which ended in 1973 and supported more than 2000 fellows. The University-DOE Laboratory Cooperative Laboratory Graduate (Lab Grad) program began in the 1960's and sponsored about 200 appointments per year for graduate students in disciplines and specialty areas of interest to DOE. Follow-up studies for the AEC programs were conducted at the termination of each group of fellowships as well as at intervals during the period in which the programs were running. Several follow-up studies of the Lab Grad program have focused on the program's long-term impacts on the educational accomplishments and professional activities of former participants.

- Studies of the AEC predoctoral fellows and Lab Grads showed a high level of educational attainment. All of the early AEC fellows, 90 percent of pre-1971 Lab Grads, and 57 percent of 1979-1987 Lab Grads reported holding a Ph.D. or other professional degree.

- A 1985 study of Fellows and Lab Grads found their graduate degrees and areas of expertise to be concentrated in science and engineering disciplines that are needed to conduct energy research.

- Almost one-fourth of the 1979-1987 Lab Grad respondents were working in federal laboratories, as were almost 38 percent of the pre-1971 Lab-Grad respondents.

- Studies of the early AEC fellowships showed high proportions of the former fellows employed in the fields of their fellowships, ranging from 68 to 83 percent employed in health physics and nuclear fields.

- In comparison with 11 percent of all employed Ph.D. S&Es, many more of the Lab Grads and Fellows reported funding by DOE, from 50 to 75 percent.

- From 40 to more than 50 percent of the Fellows and Lab Grad respondents were engaged in basic or applied R&D, as compared with only 27 percent for a national comparison group of S&Es.

- Lab Grads and Fellows reported that the program in which they participated had a great influence on completion of graduate degree and employment opportunities following their appointment.

- A majority of early AEC fellows responding to follow-up studies said that they would not have been able to pursue a graduate degree without the fellowship, and many indicated they would have had no knowledge of the nuclear or health physics fields had it not been for the fellowship.

In addition to **postgraduate** programs in the physical and biological sciences sponsored by AEC during the early 1950's, DOE sponsored several research programs for postgrads during the 1980's, including the prestigious Alexander Hollaender Distinguished Postdoctoral Fellowship which ran from 1986-2002.

- The 2002 study of the Hollaender Program and a 1989 follow-up study of Lab Postgrads and Fossil Energy and Fusion Energy Fellows showed that 20 to 28 percent of the respondents were working for a federal lab, which is three to four times greater than a national comparison group of postdoctorates.

- From two-thirds to three-fourths of the postgrad respondents reported that they received federal funding; many indicated funds were from the Department of Energy.

- Two-thirds of postgrad respondents reported R&D to be their primary work activity.

- Nearly 70 percent of the Hollaender respondents reported they were currently working on the same research or on research that evolved from their fellowship appointment.

UNDERGRADUATES

From the late 1950's through the early 2000's, ORAU administered science education programs for federal agencies including undergraduate scholarship programs and programs that placed undergraduate students in laboratories to experience hands-on research. This report focuses on a group of undergraduate programs that began in the late 1970's. Among the main sponsors of these later undergraduate research participation programs were various offices of the U.S. Department of Energy (DOE), such as the Office of Nuclear Energy, Science and Technology; Office of Science (OUSE, USEP); Office of Human Resources and Administration. Various coordinating associations included AISES, HACU, and NAFEO. The National Oceanic and Atmospheric Administration (NOAA) also sponsored one of the programs reviewed in this report.

Undergraduate programs include the NOAA Student Research Participation Program and DOE's programs: Nuclear Energy Training (NET) Program for Minority-Serving Education Institutions, Science and Engineering Research Semester (SERS), Laboratory-University Cooperative Student Research Participation Program (SRP), and Diversity Partnership Program.

Measures of Program Impact

Career development research indicates that active participation in research projects at the undergraduate level is one of the most important factors in recruiting and retaining students in scientific careers (Garfield, 1987; Stanitski, Frankfurt, & Muir, 1986). Measures of program outcomes for undergraduate research programs, which may be investigated through follow-up studies, typically include: educational intentions and attainment, both in level and field of degree expected or obtained; type of work and employer; and ratings of program influence on educational and professional goals.

Follow-Up Studies and Response Rates

Two large and long-standing DOE research participation programs for undergraduates were the Science and Engineering Research Semester (SERS) and the Student Research Participation (SRP) program. A follow-up study of the first three years of the SERS program (1987-1990) encompassed more than 600 students at 6 laboratory sites. After discounting for undeliverable surveys, the response rate for the SERS follow-up was 64 percent, with 317 respondents.

Follow-up studies also examined the 1985 SRP program (a total of 782 participants at 35 DOE sites) and the 1979-1982 SRP Program (2,752 participants). The response rate for the 1985 study was 62 percent, a total of 279 respondents (which subtracts those for whom no permanent address was available, and any surveys returned as undeliverable). The 1979-1982 SRP study was based on a 15 percent random sample, and had a 64 percent response rate, with 208 surveys completed.

Degrees Attained or Expected

The SRP studies were long-term follow-ups conducted 6 to 9 years after program participation. Almost all of the 1985 SRP respondents reported undergraduate degrees in the natural sciences and engineering (NS&E), with the largest proportion in the physical sciences (31 percent), much higher than the percentage of physical science degrees (8 percent) earned in 1987 out of all NS&E degrees. (National Science Board, 1993). Two-thirds of the 1985 SRP respondents had attained graduate degrees with more than one-fourth holding a Ph.D.; almost 60 percent of the 1979-1982 SRP respondents had attained a graduate degree with almost two-thirds expecting a Ph.D. or other professional degree to be their highest degree. These expectations far exceed those of all S&E graduates in which more than three-fourths **never** receive a higher degree (National Science Foundation, Pipeline, 1987).

Similarly, in the 1990 shorter-term follow-up study of 1987-1990 SERS participants, 95 percent expected to obtain a graduate degree with more than 60 percent expecting a Ph.D. Current academic status of SERS respondents indicated 40 percent were in graduate school, as compared with only 24 percent of the national comparison group, the 1986-1987 S&E bachelor's graduates (1988 NSF New Entrants Survey).

Follow-up studies on smaller programs, such as the NOAA Student Research Participation Program (352 participants from 1993-2002), the DOE NET Program for Minority-Serving Education Institutions (90 former participants), and the DOE Diversity Partnership Program (which included 58 undergraduate and graduate students for the 1995 program), provided similar results. For all of these studies, the vast majority of the respondents (from two-thirds to almost all) indicated they held or were pursuing graduate degrees. Regarding expectations for a doctorate degree, 30 percent of the NOAA respondents and almost two-thirds of the DOE Diversity Partnership respondents expected to attain that degree or another professional degree.

Degree Field

Field of degree can be another indicator of program impact, to the extent that the fields are supportive of the agency's missions and activities. Among the 1979-1982 SRP respondents, the general pattern shows that the fields of work and degree were in areas supportive of DOE science and engineering research and development activities; 22 percent worked in engineering, 21 percent in physical sciences, and almost 20 percent in environmental and life sciences.

The SERS program provided research opportunities in biomedicine, chemistry, materials science, engineering, physics, environmental science, math and computer science, and energy systems and waste technology. Thus, it is not surprising that the follow-up study for the 1987-1990 SERS program found larger proportions of respondents choosing biological sciences, physics, and chemistry as the field of their expected highest degree, in comparison with a national group of 1986-1987 S&E bachelor's graduates (1988 NSF New Entrants Survey).

The results of the follow-up assessment on the 1985 SRP program were very positive, with large proportions reporting degrees in science and engineering. The largest proportions were in the physical sciences with 31 percent, followed by engineering with 29 percent. Ph.D. recipients from the 1985 SRP program also held a larger proportion of degrees in physical sciences (47 percent of the Ph.D.s) as compared with national statistics for Ph.D.s granted in NS&E in 1991, in which only 21 percent were in the physical sciences.

Employment

Encouraging undergraduates to be involved in research and development and to work in federal laboratories are important goals of many undergraduate research participation programs, especially those sponsored by the Department of Energy. In the three larger follow-up studies of DOE research participation programs (the SERS and the two SRP follow-ups), the proportions of respondents choosing research and development (R&D) as their primary work activity, which varied from 48 percent to 57 percent, exceeded percentages for national comparison groups (about twice that of NS&E bachelor's graduates, even exceeding the 33 percent of employed Ph.D. S&Es and the 41 percent of employed energy Ph.D. S&Es reporting R&D as their primary work activity).

Similarly, the percentage of respondents working in federal laboratories (ranging from 9 percent for both groups of former SRPs to 26 percent for SERS respondents' expectations for future work) was again greater than for national comparison groups (from 2.5 to 7.6 percent of employed Ph.D. S&Es).

When asked to report the area of national interest they expected to devote the most time to in their future careers, larger percentages of SERS respondents chose energy/fuel (almost 13

percent) and the environment (20 percent) as compared with percentages of 1986-1987 S&E bachelor's graduates (3 percent and 7.6 percent, respectively). The SRP follow-up studies did not find such large percentages as did the SERS study; only 5 to 8 percent of the SRP respondents chose energy.

Influence of Programs as Reported by Former Participants

Another means of determining if research participation programs influenced the undergraduate participants to continue on paths of interest to the sponsoring agency is to ask former participants to rate the amount of influence the program had, for example, on choice of career, attending graduate school, area of specialization, highest degree, choice of occupation and employer, and current or past research activities. On a scale of "not at all" to "to a large extent," former participants in the SRP and SERS programs were asked to rate the influence of the program on the above factors. Responses varied somewhat; however, consistently ranked high by the respondents to the three follow-up studies were: area of specialization, whether to attend graduate school, and current or past research activities. The programs tended to have less influence, according to both SRP and SERS respondents, on choice of graduate school and choice of employer.

Special studies on the effects of research participation on underrepresented minorities indicated similar results as the larger studies discussed previously. In 1995, a follow-up study was conducted with a subset of former participants from underrepresented minorities (89 students) whose names were provided by major DOE labs and facilities hosting SRP, SERS, and Laboratory Graduate programs. Of these, 65 returned responses. The influence of the programs on these respondents in general received higher rankings in comparison with other SRP respondents; however, the areas of more and less influence were quite similar. Current or past research activities, area of specialization, and whether to attend graduate school were most influenced by program participation for these underrepresented minorities. Choice of graduate school and current employer received ratings indicating they were less influenced by program participation.

In a 1998 follow-up study on the 1995 DOE Diversity Partnership Program (with 27 of 48 former participants returning the survey), 60 percent indicated the program had a "large" or "some influence" on their decision to go to graduate school.

GRADUATE STUDENTS

One of the larger DOE-sponsored programs for graduate students was the Laboratory-University Cooperative Laboratory Graduate (Lab Grad) Research Participation Program; from 1979-1987, more than 700 graduate students participated in thesis research appointments at 37 laboratory sites. Other smaller DOE programs for graduate students operating from 1976-1989 included the Nuclear Engineering and Health Physics Fellowship Program, the Magnetic Fusion Energy Technology Fellowship Program, and the Fossil Energy Program.

Early predecessors of these graduate student programs were AEC-sponsored predoctoral fellowship programs, which ran from 1948-1953 and supported more than 750 students; other special AEC fellowships ran until 1973 and included Health Physics Fellowships, Nuclear Science and Engineering Fellowships, Advanced Health Physics Fellowships, and Industrial Hygiene Fellowships.

Since 2000, DOE's Office of Science has sponsored the Graduate Student Awards for the Lindau Nobel Laureates Meeting, which supports graduate students to attend the Nobel Laureates meeting. From 2000-2002, 117 U.S. students participated in the meeting. While not a research participation program, per se, these graduate student awards seek to inspire students to continue their energy-related scientific pursuits by exposure to Nobel Prize scientists in their fields.

Measures of Program Impact

For graduate student research participation programs, measures of program outcomes can be more far-reaching—certainly educational attainment is an important measure, and because of their advanced level while participating, it is much more likely that these former graduate student participants have already attained advanced degrees by the time of the follow-up study. And for those that further expect a Ph.D., the intention seems more likely to occur than for an undergraduate. Type of employer, area of work, and participation in research and development (R&D) may also be more accurately assessed for these former participants. Direct questions about the influence of program participation are also more relevant, because of the level of attainment already achieved against which they can assess the impact of program participation.

Follow-Up Studies and Response Rates

A 1985 follow-up study of Lab Grad programs and two smaller DOE-sponsored fellowship programs (Nuclear Engineering and Health Physics Fellowship, and Magnetic Fusion Energy Technology Fellowship) found that past program participants were heavily involved in DOE-sponsored and other energy-related R&D activities. The study looked at former graduate students in these programs for the years 1976-1985. The survey contacted 65 Lab Grads, and received a 57 percent return; for the 32 fellowship recipients surveyed, 87.5 percent returned responses.

A larger-scale study followed up on the 1979-1987 Lab Grads, contacting 398 individuals and receiving 255 responses for a response rate of 64 percent. In addition, 101 participants from the Lab Grad program prior to 1971 (1960's through early 1970's) were mailed surveys, and responses were returned by 69 (for a 68 percent response rate).

The early AEC-sponsored programs included both graduate students and postdoctorates. The final report for those programs ending in 1953, prepared by Oak Ridge Institute for Nuclear Studies, examined each of the fellowships separately and included predoctoral fellowships in physical sciences (552 participants from 1948-1952) and biological sciences (213 participants over the same period). Of the predoctoral physical science fellows, degree data was not available on 160 of the fellows; for those in biological sciences, degree data was not available on 62 of them. However, occupation or further study was known for about 88 percent of both groups.

The AEC special fellowship programs (for graduate work in health physics, industrial hygiene, and nuclear science and engineering) continued through 1971. A 1973 report summarized data obtained by periodic surveys of these special fellows from 1954-1971. The last study in 1971 surveyed 882 former Health Physics Fellows and obtained responses from 823, a response rate of 93 percent. A 1971 follow-up on all 80 former Industrial Hygiene Fellows yielded 77 responses, or 96 percent. The Nuclear Science and Engineering Fellows were similarly surveyed from 1961-1971; the final survey in 1971 was sent to 1,330 former fellows, of whom 1,272 responded (96 percent).

In addition to the specific surveys by type of fellowship, a letter was sent by ORAU in 1972 to ALL former AEC fellows, taking note of the termination of all AEC special fellowship programs at the end of the 1973 fiscal year, asking them "what the program did for you." A total of 683 responses were received; of those, 504 respondents (85 percent) were still pursuing professional careers in the field for which they were trained under the fellowship.

In 2003, a short-term follow-up study of graduate students sponsored to attend the Lindau Nobel Laureates meeting was done to determine how the program impacted participants' educational plans, career aspirations, and research activities. Of the 117 students surveyed, 92 responded for a response rate of 79 percent.

Degrees Attained or Expected

All of the Fellows and Lab Grads responding to the 1985 study completed a graduate degree, with 57 percent holding a master's, and the remaining 43 percent with a Ph.D. By comparison, about 14 percent of all employed scientists and engineers hold Ph.D. degrees according to the NSF 1982 Postcensal Survey of S&Es. The 1979-1987 Lab Grad respondents had an even higher level of educational attainment, with almost 57 percent holding a Ph.D. or other professional degree and 38 percent holding a master's. Expectations for highest degree were higher yet, with almost 70 percent expecting ultimately to receive a Ph.D. or other professional degree. Ninety percent of the pre-1971 Lab Grads held a Ph.D. For the Lindau participants from the year 2000, almost half had earned a Ph.D.

For the studies of early AEC predoctoral fellows, all for whom data were available (391 in physical sciences and 151 in biological sciences) had received doctorates or completed all requirements while under the AEC fellowships.

Degree Field

For the Fellows in the 1985 study, because of the orientation of the fellowships, virtually all received their graduate degrees in 2 areas: engineering (70 percent) and health physics or related biological sciences (30 percent). Forty percent of the Lab Grads from this same study received graduate degrees in the biological sciences, with the remainder distributed among the physical sciences and engineering. Compared to a large sample of all S&Es surveyed by NSF, the DOE program participants are significantly more likely to have degrees in engineering or in the life sciences, including health physics.

The 1985 study of Fellows and Lab Grads found that the graduate degrees and areas of expertise are concentrated in the science and engineering disciplines needed to conduct energy research. The report concludes that appropriate fellowship and research support of graduate students can have a significant impact on career development of students.

For the 1979-1987 Lab Grads, the largest percentage reported their highest degree to be in biological sciences (22 percent), followed by physics and astronomy (19 percent). For the sample of pre-1971 Lab Grads, the largest percentage for field of highest degree was physics and astronomy (38 percent), followed by biological sciences (22 percent) and engineering (20 percent).

For the early AEC predoctoral fellows, the largest percent were studying physics (33 percent) followed by biology (28 percent).

Employment

For the longer-term follow-up studies, it is not surprising that almost all of the respondents were employed. More than one-fourth of the Fellows and almost 17 percent of the Lab Grads from the 1985 study were employed by federal laboratories, as compared with only 2.4 percent of all employed Ph.D. S&Es (NSF, 1984). Among the pre-1971 Lab Grads, an even greater percentage were working for federal labs, almost 38 percent. For the 1979-1987 Lab Grads who responded, almost one-fourth were working in federal labs.

For the AEC Fellows from 1948-1952, the largest percentage of Fellows (40 percent) were working in universities or colleges, followed by private industry, and AEC or other government agencies.

Of the AEC Health Physics Fellows surveyed during the course of the program, studies consistently showed that between 70 and 80 percent of former fellows were either employed in health physics or continuing their education. The 1971 study showed that the largest proportion of those employed were working for the government (39 percent), followed by university teaching (25 percent). The overall proportion working in health physics for this study was 82 percent. In addition, AEC-supported candidates for health physics certification had a large percentage certified (85 percent, as compared with the overall certification rate of 64 percent).

Similar success stories were reported for the AEC Industrial Hygiene Fellows, with 68 percent working in nuclear fields, 43 percent working in industry, and 36 percent working in government. An even higher percent of the Nuclear Science and Engineering fellows were involved in nuclear work at 83 percent; about 28 percent of those employed were working for the government, including AEC.

Funding Sources

The longer-term studies of graduate students consistently found large numbers of the 1976-1985 former participants receiving funding from the federal government. Of these, almost half of the Lab Grad respondents reported funding by DOE; among the Fellows in the study, the proportion was almost three-fourths. In comparison, of all employed Ph.D. S&Es, only 11 percent reported funding by DOE (NSF, 1985). More than three-fifths of the 1979-1987 Lab Grads reported being supported by federal agencies, with DOE by far the most commonly reported source of funds. Similarly among the pre-1971 Lab Grads, more than four-fifths of respondents reported support by federal agencies; of those, 73 percent named DOE as at least one source of their funding.

Even the shorter-term follow-up study of the Lindau attendees found 94 percent of those currently employed had federal funding, with more than half reporting funding from DOE; one-fourth indicated funding from Basic Energy Sciences, the DOE office that had sponsored the most students to attend the Lindau meetings.

Type of Work and Research

Some of the standard questions asked in these follow-up studies enable comparisons with national data on S&Es. Two such questions asked about primary professional work activity and area of national interest to which most work time is devoted. Since the Lab Grad and Fellowship programs seek to promote interest in research, the percentage of later involvement in R&D is of key interest. Almost 40 percent of the pre-1971 Lab Grad respondents were engaged in basic or applied research and development. Among the 1979-1987 Lab Grad respondents, almost one-half reported involvement in R&D, in comparison with 37 percent of all Ph.D. S&Es. Among the Fellows in the 1985 follow-up, almost 56 percent reported R&D as their primary work activity.

As for area of national interest, more than half of the Fellows reported energy and fuel. For the 1976-1985 Lab Grads, only 6 percent indicated energy and fuel, with more than one-third reporting environment and one-fifth reporting health—all of which are areas of interest to the Department of Energy. The 1979-1987 study of Lab Grads held similar results for the respondents—not surprising since there are several overlapping years of participation for these two studies. In comparison with all Ph.D. S&Es, the percentages for the 1979-1987 Lab Grads were higher in energy and fuel, much greater in the area of environment (almost five times greater), and not quite as high in the area of health.

However, for the pre-1971 Lab Grad respondents, 29 percent chose energy and fuel (a much larger percentage than the later Lab Grads), followed by the environment with 19 percent. This is not surprising because the pre-1971 participants were all in programs related to nuclear energy which involved very specific fields of study and work specialization.

Influence of Programs as Reported by Former Participants

For two of the studies, the 1990 Lab Grad study and the Lindau study, results are reported for a direct question about the degree of influence of the program. On a scale of 1 to 4, where 1 = "not at all" and 4 = "to a great extent," the 1979-1987 Lab Grads reported on the perceived effect of program participation on selected professional activities. The greatest influence was reported for completion of graduate degree, a mean rating of 3.3 on the 1-4 scale, followed by employment opportunities following appointment with a 2.7. The pre-1971 Lab Grads were asked the same question, and typically followed the same pattern in rankings as the later Lab Grads, although their rankings tended to be somewhat higher; for example, they ranked completion of graduate degree as highest with a 3.4 mean on the same scale.

The short-term follow-up of the Lindau participants asked to what extent their participation in the meeting helped them in various ways. The three areas upon which participation had the greatest influence were 1) acquiring a different perspective on science and technology, followed by 2) broadening knowledge of DOE and its research, and 3) encouraging completion of doctoral degree. For these areas, 60 percent, 58 percent, and 57 percent, respectively, said the program participation helped them "to a large extent," the highest ranking on this question's scale.

In response to the 1973 ORAU survey of all former AEC fellows, out of the 683 responses received, some general observations about the impacts of these fellowships can be gleaned. A number of respondents who had completed their fellowships 15 to 20 years prior described very rewarding and distinguished careers in the fields of their training. A majority of respondents indicated that, without the AEC fellowship, they would not have been able to pursue a graduate degree. Several reported that, at the time, they did not know what health physics was and would have never made it a career had it not been for the AEC fellowship.

POSTGRADUATES

Early AEC-sponsored postgraduate student programs included physical sciences, biological sciences, and medicine postdoctoral fellowship programs which ran from 1948-1953; these programs supported 155 participants over the period.

During the 1980's, DOE sponsored several postgraduate research programs: Fossil Energy Postgraduate Research Training Program, Fusion Energy Postdoctoral Research Program, and the Laboratory Postgraduate Research Program. A more recent program (1986-2002) was the Alexander Hollaender Distinguished Postdoctoral Fellowship Program, which was established by the U.S. Department of Energy's Office of Health and Environmental Research in fiscal year 1986 in memory of the late Dr. Hollaender, a radiation biologist who directed biomedical research at Oak Ridge National Laboratory.

Measures of Program Impact

For postgraduate student research participation programs, many of which are postdoctorates, measures of program outcomes can focus more on actual employment—for example, are these former participants working in federal labs, are they working in R&D, is their current research related to program participation, and are they funded by the same program sponsor? Direct questions about the influence of program participation are also more relevant, because of the career attainment already achieved against which these postgrads can assess the participation's impact.

Follow-Up Studies and Response Rates

The early AEC postdoctoral fellowships were summarized after the 1953 termination of some of the fellowships (155 postdoctoral fellows). For the biological, physical science, and medical fellowships terminating in 1953, data were available for all but the medical fellows, for a total of 98.

In 1989, 161 participants from the years 1981-1988 were surveyed from three DOE-sponsored postgraduate research programs: the Fossil Energy Postgraduate Research Training Program (103), the Fusion Energy Postdoctoral Research Program (3), and the Laboratory Postgraduate Research Program (55). All of the participants in the Fusion program, and almost all of the Lab Postgrads held doctorates; the Fossil Energy program supported a nondoctoral component (about one-half of the participants). The overall response rate for this study was 55 percent.

In 2002, a similar follow-up study was conducted for the Alexander Hollaender Distinguished Postdoctoral Fellowship Program, which had a total of 104 postdoctoral participants for the years 1986-2002. The response rate for this study was 88 percent, a relatively high response rate, indicating that the results can be interpreted to apply to the large majority of Hollaender Fellowship recipients.

Employment

For the early AEC fellows surveyed in 1953, the largest proportion of both the physical and biological fellows were working in universities or colleges (57 percent).

For both the 1989 and 2002 studies, almost all respondents reported they were employed. Both studies found similar percentages to be working for a federal laboratory, from 20 to 28 percent of respondents. These percentages are about three to four times greater than a national comparison group of postdoctorates (NSF, 1995 Survey of Doctorate Recipients).

Funding Sources

Current funding sources were similar for both groups of DOE program participants; from two-thirds to three-fourths reported that their work was, at least in part, supported by federal funds, in comparison with fewer than half in the NSF comparison group of postdoctorates. Of those DOE program participants supported by federal funds, 30 percent of the Hollaender respondents and more than 50 percent of the Fossil Energy, Fusion Energy, and Lab Postgrads reported funding from the Department of Energy.

Type of Work and Research

Primary work activity was reported to be research and development by two-thirds of respondents for the 1989 study and almost two-thirds for the Hollaender study (37 percent in basic research and 25 percent in applied).

Another key outcome important to measuring the success of a program's impact on career paths of participants is the extent to which they continue to work in areas important to the sponsor's missions. The Hollaender study found that nearly 70 percent reported they were currently working on the same research as their Hollaender appointment or on research that evolved from it.

Influence of Programs as Reported by Former Participants

The Hollaender study further inquired as to the extent of influence of the program on aspects of the participants' professional careers. By far, the biggest impact was the acquisition of new skills and knowledge (with 78 percent reporting influence to a "large extent"), followed by attainment of a desirable position after the postdoc (55 percent said to a "large extent") and developing valuable professional contacts (49 percent said to a "large extent").

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