TRANSITION POINT TWO:
EXPERIENCING CONTEMPORARY GRADUATE EDUCATION

The path to the Ph.D. is frequently a long and arduous journey, and many of those who begin that journey do not complete their degrees. In some disciplines, graduate study is primarily for the master's degree. Naturally, graduate school is experienced differently by every student because of individual differences in backgrounds, educational preparations, and temperaments. Additionally, as will be elaborated upon, that experience is shaped to a large extent by the norms and expectations of the particular disciplines and institutions to which the student belongs.

Nonetheless, key challenges and elements cut across these individual, disciplinary, and institutional differences. One of these is the need to secure adequate financial support and the nature and source of that support. Graduate students also must meet the demands and expectations associated with advanced study in a field, including coursework, research, teaching, and publishing or presenting work. They are expected to complete degrees within time limits imposed not only by the university but often also by the availability of financial support or external factors, including family obligations. They must gather information and decide about potential careers, procure a suitable position, and be able to demonstrate satisfactory progress and productivity within it. While experienced differently by every student, these elements and challenges are present for all graduate students, and thus comprise critical factors that influence the effect of the GRF Program.

In this section, we discuss critical factors as they are experienced by NSF fellows and their peers and highlight the similarities and differences between the groups. We discuss the direct and indirect impacts of the GRF on the graduate student experience, and where possible we compare the experiences of Disciplinary fellows, WENG fellows, and MGF fellows. To place these evaluation findings in proper context, however, we first look at institutional variation in GRF impact and then discuss the differences that often make the most difference, namely, those arising from the particular disciplinary contexts within which NSF fellows and peers pursue graduate study.

Institutional Variation

In 1998-1999, the GRF provided stipends to students ($15,000 per year) and Cost of Education (COE) allowance to institutions ($9,500 per year). NSF funds are given to the institution, which distributes the stipend to GRF fellows enrolled. The cost of graduate education varies considerably, and there is also variation in the impact of the COE allowance.

For some institutions, there is a surplus of COE funds that may be used to support students or for other institutional programs. Where the COE allowance does not cover the costs of tuition and fees, however, institutions and/or departments must make up the difference from other sources of funds. For high-cost institutions with large numbers of NSF fellows enrolled, this can be a considerable expense. For example, although Institution D received over $2 million in COE funds in 1997-1998, this only covers about half of the actual costs. Although the GRF COE allowance was increased to $10,500 per year in 1999-2000, for high tuition institutions, a substantial gap between the allowance and actual costs remains. Other graduate fellowship programs pay the actual costs of tuition and fees (Department of Defense Science and Engineering Graduate Fellowship), making them more desirable from the institution's point of view.

In order to compete for the top students, institutions and/or graduate programs may supplement the GRF stipend to encourage enrollment of NSF fellows or to offset the high cost of living.[11] While some NSF fellows received no supplement to the $15,000 stipend, programs that seek parity in stipends for graduate support will supplement the GRF. We found that norms for graduate student support varied by both institution and discipline. For example, for 1998-1999 at Institution A, all Biochemistry students received $17,000 per year and at Institution D in Mechanical Engineering, support ranged from $17,400 to $19,200 per year, depending on status in the program. Other graduate fellowships offer higher stipends and support for more than three years (Fannie and John Hertz Graduate Fellowship). Some also provide an additional payment directly to students for educational expenses (Howard Hughes Medical Institute Predoctoral Fellowship). While three years of NSF funding is highly desirable, it appears that the stipend level has not kept pace with prevailing costs.

Where Discipline Makes the Difference

Graduate education in the science, mathematics, engineering and technology (SMET) fields supported by the NSF GRF Program occurs within distinctive disciplinary cultures situated within complex institutional settings. In many cases these disciplinary factors color the effect of the GRF Program. Norms, expectations, and requirements vary substantially by discipline in terms of financial support, teaching requirements, organization of research, productivity measures, and career options. For each of these dimensions, we look at how disciplinary differences manifest themselves.

Amount and Type of Financial Support Available

In top graduate programs, most students receive financial support throughout their graduate programs, especially Ph.D. students. However, certain disciplines, such as Biochemistry and Engineering, tend to be more resource rich than others with respect to the financial support available for graduate students. Programs with substantial external funding for research, such as Biochemistry, may be able to offer all students support from a variety of sources, including training grants, research grants, teaching funds, and institutional funds. For other programs, such as Mathematics, for which external funding is less available, teaching assistantships become the primary source of support.

[11] As of March 2001, the annual GRF stipend increased to $18,000, and in 2002 it increased to $20,500.

> It is almost exclusively TA-ships with limited departmental fellowships and RA positions…. We must offer support to get quality students…. For [external] fellowships, NSF is the only game in town. (E-M)

The impact of the GRF on graduate programs with more student funding options is understandably less significant than it is for those where even a small amount of external support has a substantial impact on program support for graduate students. The impact of the GRF on fellows in disciplines with fewer sources of graduate student support (Mathematics and Economics) is greater, too, because having the fellowship may reduce teaching demands on NSF fellows. Where departmental or institutional resources enable a program to offer complete packages of financial support, the GRF and other external fellowships enable articulation of support so that more graduate students can be funded. In addition, resource rich institutions and programs can and do supplement the GRF stipend.

Program Teaching Requirements

There is variation among programs in the emphasis placed on developing graduate students' teaching abilities, and this results in differences in teaching expectations. For example, Biochemistry at Institution E requires all students to be teaching assistants for at least three quarters whether they have an external fellowship or not, and they are not paid extra to do so because it is considered part of their training. In such cases, the GRF may make little or no difference in teaching requirements.

> There are no differences in requirements for NSF fellows. They don't get out of the teaching requirement. We want them to have enough exposure to teaching to know whether they want to do it or not. (E-Bio)

Other disciplines require less teaching, such as Economics at Institution D that requires only one quarter of teaching and pays a stipend to all students whether they receive external funding or not. In Mathematics, the heavy demand for staffing undergraduate math courses contributes to the expectation that graduate students will teach, although GRF or other external fellowship support can greatly reduce this requirement.

Nature of Research

Disciplinary differences in the nature of research have a direct bearing on such things as the availability of external research support, the degree to which collaboration with faculty members and/or other students is feasible and desirable, and the scope and duration of research projects. Pure Mathematics research, which is largely an individual activity, is very different from the nature of research done in Mechanical Engineering, which is by its nature more applied, amenable to team effort, and requires laboratory facilities and equipment.

Disciplines like Economics and Mathematics rely more on identification and pursuit of a unique problem or topic whereas Mechanical Engineering and Biochemistry research is based on collaborative work that is usually tied to a larger research project that is based in a laboratory. GRF support plays a different role in such settings where the primary benefit of the fellowship may be to the laboratory and faculty member rather than to the individual student.

Opportunities to Publish and Present Work

Traditionally, a key measure of professional productivity is number of publications and presentations. Disciplines differ substantially with respect to what is expected of graduate students, when the process of publishing or presenting work begins, and whether individual or multiple authorship is the norm. When comparing graduate student productivity, it is critical to view findings through the different disciplinary lenses. In Mathematics, for example, the norm is not to have produced any publications until well into the dissertation stage of a graduate career, whereas, in Economics, Mechanical Engineering, and Biochemistry, it is customary to begin presenting work and publishing far earlier. Disciplinary differences such as these again point to the need to interpret findings of professional productivity appropriately.

Career Paths and Job Markets

We speak to this more fully under Transition Point Three, but disciplines differ with respect to the nature of job markets and the careers pursued by students. More than in other fields, students in Mechanical Engineering enter graduate programs intending to leave with master's degrees rather than doctoral degrees. Even in fields where initial aspirations are for doctoral completion, a variety of factors lead NSF fellows and peers to exit with master's degrees. Thus, assessments of GRF Program effectiveness that are based primarily on fellows' Ph.D. degree completion must be tempered with an acknowledgment of the fact that for some students, exiting programs prior to doctoral completion is a desirable outcome.

Having highlighted in general terms the extent to which disciplinary contexts affect the use and impact of the GRF, we turn next to a discussion of the perceived advantages and disadvantages of the GRF identified by survey respondents, faculty, administrators, staff, and current graduate students.

Perceived Advantages and Disadvantages of the GRF

In the survey, we asked Disciplinary fellows, WENG fellows, and MGF fellows to tell us some of the advantages and disadvantages of receiving NSF fellowship support while in graduate school. Approximately 86% of fellows in each group cited the obvious advantage of financial support (stipend). Other advantages reported by more than half of the NSF fellows responding in each sample were "Reputation among faculty as a good student," "Having it on my CV helped/will help in job search," and "Tuition assistance (cost of education allowance)." Also, 72% of WENG fellows and 61% of MGF fellows thought the fellowship made them an “asset to faculty to work on their projects,” while 36% of Disciplinary fellows marked this as an advantage of the fellowship (Table G7). Based on our site visit interviews, this continues to be an important advantage for many fellows, especially in Mechanical Engineering and Biochemistry, and particularly for junior faculty whose research is not well funded by research grants.

More than one-third (38%) of NSF fellows in each survey sample thought that the GRF shortened time to degree. In our site-visits, we found that although there is a perception that fellowship support may reduce time to degree, there is little or no data to support this belief. Many NSF fellows indicated that the fellowship relieved them of specific duties (e.g., teaching or working as a research assistant on projects not directly related to their own research). Some thought that being relieved of such responsibilities would make it possible for them to complete degrees faster or has allowed them to take more courses.

> No teaching means more time for research…. The freedom means time to take an extra class per semester to explore and work on research—to be a mathematical tourist. (A-M)

More than half of WENG and MGF fellows mentioned that the increased flexibility provided by the GRF afforded them to pursue additional coursework or research opportunities.

Although generally NSF fellows do not complete in less time, some faculty interviewed speculated that they might.

> Given that fellows would be freed up from having to TA or RA every quarter, one faculty member commented, "if students take advantage of it, they should finish faster." The chair was even more emphatic: "They spend on average one year less in the teaching rotation, and that translates to getting done 6 months faster." (A-EC)

> Since NSF fellows are among the top students, the vice chair noted that it makes sense that they might finish the program in less time, although they have no data to confirm this. (A-M)

> They tend to take more courses overall, rather than getting through more quickly. (C-ME)

Some NSF fellows indicated that having the fellowship expanded their options in terms of laboratory or research advisor assignments. This varied not only by discipline, but also by the specific graduate program.

> The biggest single advantage is being able to be more choosy in who I get to work with and what kind of work I do with them, because professors don’t have to pay the tuition. For me, it worked well because there was a professor who’d just arrived who didn’t have funding yet that I wanted to work with. (D-EC)

> NSF fellows in the Biochemistry Department clearly had more options available to them in terms of lab assignments and research topics. (E-BIO)

> It's wonderful, totally changed my life. My first semester here I was living off of loans and also working as a teaching assistant. Because of that-it is a huge time sink to be a TA-and juggling classes, I didn't have any time at all for research.... Once you have an NSF fellowship, it allows you to be very, very picky about what lab you join.... (A-ME)

> It let me pick what I wanted to do.... I took the extra time that the fellowship bought me and I did more research. As a result, I have 7 or 8 papers, 5 of which have been accepted for publication. Most students come out with maybe 1 or 2 papers. (D-EC)

There are also significant advantages for graduate programs to having NSF fellows enrolled. In fact, in some disciplines, GRF impact may be more pronounced for the department than for the fellow.

> The main effect of an NSF fellowship, then, is not on the student who receives it, but rather on the department, which is able to stretch its resources (and maintain the high level of support). (Disciplinary fellow)

> Even when the number of NSF fellows admitted to these programs is relatively few (1-3 per year), the impact was described by faculty as being very significant in terms of both freeing up resources to support other students and contributing to the positive reputation/ranking of the department. (A)

> Furthermore, the faculty member gets a "free" student, a student who does not need to be supported by that faculty member's research funds. (B-ME)

> From the point of view of the department, it does help a lot that we've got these people here who are funded because the funding situation is extremely tight.... At any given time we would have maybe three or more NSF fellows. Simply they would be three people who we couldn't otherwise afford to have in the program without that funding. (D-M)

Turning to the perceived disadvantages of holding an NSF fellowship, it is striking how few NSF fellows responding to the survey (11) noted lack of office space, isolation, less opportunity to work with faculty, or less opportunity for collaborative work as disadvantages (Table G7). These items might be expected to be related to individual fellowship funding (National Science Board, 1998). The most commonly listed disadvantage was “Support only lasted 3 years,” mentioned by less that half of the NSF fellows in each sample. About 23% of fellows listed “Less opportunity to teach (TA)” as a disadvantage. This would be perhaps the strongest “academic” disadvantage for NSF fellows in disciplines where teaching experience is viewed as especially critical.

Other respondents commented on the constraining impact of eliminating from eligibility those who hold master’s degrees. One WENG fellow described her experience of trying to get a GRF for a doctoral program when she had worked after her master’s degree. Eventually, she was accepted by NSF, but she commented:

> I hope the exclusion on people with MSs is gone now, since a break/work between MSs and *Ph.D.s is very, very good for many people.* (WENG)

Finally, while most institutions provided continued funding to NSF fellows once the GRF ended, 9% NSF fellows did not receive such financial aid (Table G7). This was particularly difficult for a fellow contributed to a laboratory while on GRF funding who was not supported by that laboratory when the fellowship ended.

Graduate Student Activities and Preparation for the Real World

We asked a set of questions concerning the kinds of academic preparation received in graduate school (Table 5). Our intent was to investigate whether NSF fellows received more or different preparation by virtue of their external funding. We found no significant differences between Disciplinary fellows and program peers. Nor were the responses from WENG fellows and MGF fellows different, except with regard to funding to attend professional meetings, where Disciplinary fellows appear to receive less support than WENG fellows and MGF fellows. Graduate students in all four sample groups were most likely to report having opportunities to present research and least likely to have opportunities to learn about proposal writing (Table 5).

Table 5
Support Received while in Graduate Program

	Disc. Peers	Disc. Fellows	WENG Fellows	MGF Fellows
Opportunities to learn proposal writing	27%	33%	35%	46%
Help in publishing work	51%	55%	61%	61%
Opportunities to present research	76%	76%	67%	75%
Funds to attend professional meetings	53%	45%	56%	58%

We also included in the survey two questions about the acquisition of professional skills as a follow up to the report, *Reshaping Graduate Education in Science and Engineering* (COSEPUP, 1995) and to questions included in the Ph.D.'s Ten Years Later study (Cerny & Nerad, In Press). Table 6 shows the percentage of respondents whose graduate studies involved them in particular activities and their opinions about which skills should be developed in graduate school for subsequent professional success.

Table 6
Activities in Graduate School and Relevance for Professional Success

	Work on Team		Collaboration		Interdisciplinary research		Learning organizational or managerial skills		Interact with professionals in the field
	Had in Graduate School	Needed for Professional Success	Had in Graduate School	Needed for Professional Success	Had in Graduate School	Needed for Professional Success	Had in Graduate School	Needed for Professional Success	Had in Graduate School
Disciplinary Peers	56%	54%	65%	67%	28%	47%	28%	56%	28%
Mech. Engineering	71%	69%	71%	69%	60%	64%	50%	76%	55%
Mathematics	34%	44%	56%	64%	12%	36%	16%	34%	12%
Biochemistry	67%	58%	79%	71%	33%	56%	44%	77%	31%
Economics	55%	47%	55%	66%	9%	32%	9%	40%	19%
Disciplinary Fellows	44%	56%	62%	69%	35%	41%	27%	60%	26%
Mech. Engineering	62%	72%	66%	68%	54%	52%	48%	88%	50%
Mathematics	33%	57%	55%	74%	25%	39%	14%	37%	8%
Biochemistry	53%	68%	73%	65%	48%	55%	32%	84%	19%
Economics	29%	31%	59%	68%	20%	22%	14%	42%	20%
WENG Fellows	55%	76%	66%	61%	52%	51%	40%	73%	43%
MGF Fellows	64%	53%	76%	63%	48%	59%	40%	72%	40%
MGF Engineering	71%	71%	85%	71%	59%	74%	50%	85%	65%

We found no significant differences between Disciplinary fellows and program peers in their graduate school experiences or in their assessments of skills needed for professional success. However, responses do highlight some interesting discrepancies between the skills developed in graduate school and those respondents consider important for subsequent professional success in different disciplines.

We see a large discrepancy in the "learning organizational or managerial skills" responses. Almost one in three (27%) respondents overall reported that their graduate activities involved such an activity, while more than half (58%), and up to 73% for WENG fellows, reported that these were important skills for subsequent professional success. Breaking down these responses again by discipline, we see a sharp distinction among fields. More than three-quarters of respondents in the fields of Engineering (76%) and Biochemistry (77%) said that these skills were important, compared to 35% of those in Mathematics and 41% in Economics. Engineering and Biochemistry students were also more likely to have had some opportunity to learn these skills in graduate school, 44% and 37% respectively.

There is a better match between having collaborative experiences in graduate school and their relevance for professional success. One-half to three-quarters of NSF fellows in the three samples report having this experience. Disciplinary fellows and peers highly related collaborative experiences to subsequent professional success. Only about one-third of graduate students in Mathematics experienced teamwork in graduate school, but 44% of peers and 56% of fellows thought it was important for professional success. Interdisciplinary research obtained the lowest overall experience and interest. Again we see the disciplinary differences, with few Economics and Mathematics respondents having interdisciplinary experience in graduate school, and only a somewhat higher percentage rating that it was of professional importance.

Results reported in *NSF Fellows and their Doctoral Peers in the Ph.D.'s Ten Years Later Study* (Cerny & Nerad, 1999) are generally similar to the findings reported here. Given the small number of NSF fellows (107) and the different set of academic fields included in the Berkeley study, comparisons should be interpreted cautiously. However, what stands out is the larger percentage of respondents to our survey, a 1989-1993 cohort, who report having learned organizational or managerial skills as part of their graduate study than those NSF fellows of a decade earlier, especially as reported by biochemists and engineers. Despite the continuing gap between expressed professional need and graduate experience, the current situation appeared to be better in this category.

NSF fellows and Disciplinary peers responding to the open-ended survey item frequently expressed dissatisfaction with their graduate training, indicating a mismatch between their preparation and the "real world":

> Career development is a vital function in pursuing doctoral studies…to prepare them for the politics and realities of the real world. Doctoral education in the sciences is still too narrowly focused, even at the most prestigious institutions like [Institution C]. (Disciplinary fellow)

> My graduate training was technical and detached from the real world. When it was time to decide whether to go into academia or the private sector, the choice seemed obvious, private sector. I felt it was about time that I started to understand the economy and financial markets in an applied way. Although I had always wanted to become an academic, to research and to teach, I felt that this was not a viable option due to my lack of real world experience. Many of my colleagues felt the same way and ended up in the private sector as well. (Disciplinary peer)

> The main source of malaise or anxiety among graduate students in the biological sciences is that they have little contact with the world in which they will ultimately find employment. (Disciplinary peer)

Consistent with COSEPUP report findings, survey respondents expressed dissatisfaction at what they perceived to be inadequate mentoring and career guidance from faculty members.

> Very poor mentoring. There was no one to whom students could speak frankly about their career choices. (Disciplinary fellow)

> We mistakenly view graduate school and the Ph.D. as an end in itself and not as career training. Too little emphasis is placed on preparation for future careers. (WENG)

> I had absolutely no assistance from faculty in my department in job hunting or job counseling. (MGF)

Women also commented on gender-based barriers still present in the graduate school environment and SMET careers.

> My professional experience and career choices (at a National Lab) are very limited because I am a woman. NSF and the fellowship program are one of the few bright spots in a field that is still very hostile for women and minorities. (WENG)

Clearly, then, even though the majority of respondents indicated general overall satisfaction with their graduate school experiences, there were a number of common concerns that speak to the need for improvement in the degree of support, real-world preparation, and career guidance graduate students receive while in their programs.

Measures of Success for Graduate Education

In evaluating the effectiveness of programs designed to support graduate education, measures have historically been used that we also employed in this study. These traditional measures included time to degree completion and percentage of fellows who complete the doctoral degree. We added a new set of measures gathered through the survey related to productivity while in graduate school as evidenced by publications, presentations, patents, honors, and institutional service.

Productivity during Graduate School

We asked respondents to tell us about accomplishments while in graduate school. Very few respondents report more than one item in any particular category, and many report none. Therefore, we show below only the percentage of respondents who reported one or more accomplishment per category (Table 7).

Table 7
Accomplishments while in Graduate School: Disciplinary Fellows and Peers

Percentage with at least one of the following:	Disciplinary Fellows	Disciplinary Peers
Presentation at professional meeting	65%	57%
Publications	67%	65%
Refereed article	61%	59%
Book/chapter/edited	22%	16%
Patents	6%	9%
Academic honor	18%	17%
Institutional service	6%	4%

A slightly larger percentage of Disciplinary fellows than peers reported having achieved these accomplishments during graduate school. Most notably, 65% of fellows reported having presented at professional conferences, compared to 57% of peers. Overall more than half of respondents reported having presented and/or published work while in graduate school.
We also asked WENG fellows and MGF fellows to report on their accomplishments while in graduate school. More than three-quarters of each group reported having published or presented work while in graduate school (Table 8).

Table 8
Accomplishments while in Graduate School: WENG and MGF Fellows

Percentage with at least one of the following:	WENG Fellows	MGF Fellows
Presentation at professional meeting	76%	73%
Publications	77%	75%
Refereed articles	71%	71%
Book/chapter/edited	15%	21%
Patents	13%	9%
Academic honor	17%	18%
Institutional service	6%	8%

These findings are certainly positive, but they must be compared with care to responses from Disciplinary fellows and their peers because the disciplinary composition of the sample groups are different.

Differences in graduate school productivity emerged between Disciplinary fellows and peers within disciplines (Table 9).

Table 9
Accomplishments while in Graduate School: Disciplinary Analysis

Percentage with at least one of the following:	Mechanical Engineering		Mathematics		Biochemistry		Economics	
	Peers	Fellows	Peers	Fellows	Peers	Fellows	Peers	Fellows
Presentation at professional meeting	59%	71%	50%	59%	71%	74%	46%	60%
Publication	63%	70%	59%	72%	88%	81%	49%	49%
Refereed articles	55%	61%	54%	70%	88%	81%	35%	40%
Book/chapter/edited	6%	16%	10%	27%	29%	24%	19%	24%
Patents	17%	19%	4%	2%	13%	0%	0%	0%
Academic honors	14%	6%	20%	22%	10%	19%	23%	27%
Institutional service	5%	8%	8%	4%	2%	7%	0%	3%

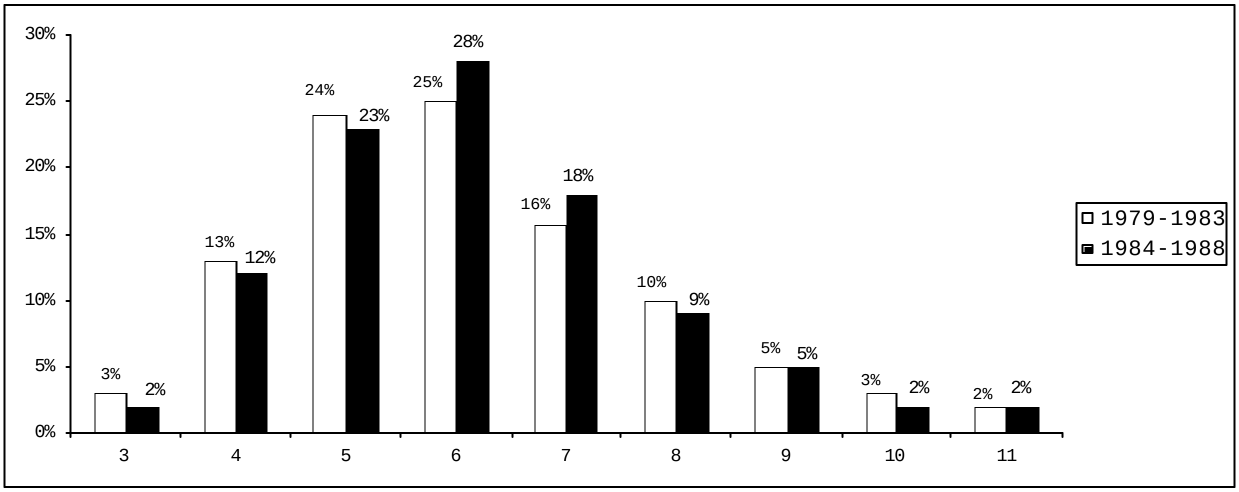
Respondents in Biochemistry reported the most presentation and publication productivity. Economics fellows are more likely to have made presentations at professional meetings than their program peers. Disciplinary fellows in the fields of Mechanical Engineering and Mathematics also reported more presentation and publication productivity, respectively, than their program peers.

Time to Degree

The length of time it takes for doctoral students to complete their programs, time-to-degree (TTD), is a commonly accepted and long-standing measure of graduate student success. It is of limited value when looking at trends, however, because it measures elapsed time from first enrollment in graduate school to receipt of the doctoral degree, rather than number of years enrolled. Many graduate students do not proceed directly to completion but may stop out temporarily or otherwise curtail their studies for a period of time before returning to finish. This persistence over time will affect the patterns of years to completion, and greater completion rates will likely also result in increases in TTD.

Using SED and CI data, we looked at the number of NSF fellows who had completed their doctorates within an eleven-year period from the time they enrolled in graduate school. We compared two cohorts of NSF fellows (those who initially enrolled between 1979-1983 and those who first enrolled between 1984-1988) in order to determine differences in TTD between earlier and more recent NSF fellows (Figure 1).

Figure 1
Years to Doctorate (TTD) for NSF Fellows Completing in Eleven Years



From this figure, we see that the distribution of TTD is similar for both cohorts of NSF fellows with the 1984-1988 cohort taking slightly longer to complete (37% versus 40% completing in five years or less). In both cohorts, about two-thirds of the NSF fellows who completed doctorates within 11 years did so within six years, and the average TTD remains fairly constant at about 5.5 years. The modal number of years to completion is six for both cohorts. Fellows in the 1984-1988 cohort taking more than six years were also more likely to finish by year seven than were 1979-1983 fellows. While the modal number of years to completion for the third cohort is also six, that is also the maximum possible time for the 1993 entrants using 1999 SED data.

For comparison purposes, we looked at TTD for QG2 non-awardees, and we found that fewer complete within six years than NSF fellows (60 % for the 1979-1983 cohort and 62% for the 1984-1988 cohort). In addition to looking at TTD for NSF fellows as a whole, we also examined differences between GF fellows and MGF fellows. TTD within six years is quite steady for GF and MGF fellows alike for the 1984-1988 fellows (GF fellows: 63% increasing to 65%; MGF fellows: 57% decreasing to 56%). The modal TTD, however, shifted from fairly equal percentages completing in five and six years, to a peak at six years for both groups.

TTD also varies by discipline. For the 1984-1988 cohort of NSF fellows completing doctorates in 11 years, those in Engineering/Mathematics/Physical Science finished fastest (71% in six years or fewer), followed by Behavioral/Social Sciences (58%), and the Biological/Life Sciences (58%). Shifts in TTD are related to the increase in the overall percentage of NSF fellows completing doctorates. We found that about one-third of NSF fellows who complete are still taking more than six elapsed years to earn doctorates. For the programs we visited during the site visits, faculty and student estimates of TTD ranged from five to six years, with only one program indicating an average of six years for completion (Institution C-EC).

Ph.D. Degree Completion

Although relying on Ph.D. completion as the primary measure of success for graduate students is problematic, especially for disciplines like Engineering, it remains an accepted measure of academic success. Therefore, we looked at Ph.D. completion rates for NSF fellows in the aggregate and for comparison purposes, using 5-year cohorts to avoid year-to-year fluctuations in completions. We calculated 11-year completion rates for the first two cohorts of fellows (1979-1983; 1984-1988) because these maximize our ability to compare groups over time using the most recent SED data available (1999). In order to include the most recent cohort (1989-1993), we also compared 6-year completion rates for all three cohorts (Table 10).

With the exception of Engineering fields, Ph.D. completion rates are high for all comparison groups – at or approaching three-quarters within 11 years and close to half within six years. The 11-year completion rates for NSF fellows in the first two cohorts (68.3% and 73%) are somewhat less that the eight to 12-year completion rates reported for earlier cohorts (1962 through 1981) in previous studies of NSF fellows conducted by the NRC (1977 at 78.7%; 1988 at 74.5%; 1994 at 75.8%). More recent cohorts have higher proportions of fellows in Engineering, which may account for these lower completion rates. A recent model projects overall Ph.D. attainment in science and engineering at only 24% for U.S. students and 27% for U.S. students at the most elite, research intensive, private graduate programs (Goldman & Massy, 2001) and concludes: "Three-quarters of science and engineering graduate students never receive a Ph.D." (p. 74). Placed in this context, the completion rates for NSF fellows are exceptional.

Table 10
Doctoral Completion Rates for NSF Fellows

Five-Year Cohort	Percentage completing Ph.D. in 6 years or less	Percentage completing Ph.D. in 11 years or less
1979-1983	44.5%	68.3%
1984-1988	47.3%	73.0%
1989-1993	41.0%	NA

While the 6-year and 11-year completion rates show increases from the first to the second cohort, the most recent cohort shows a decline in completions within six years. It remains to be seen whether the third cohort is taking longer to complete or completion rates are declining; however, the increase numbers of fellows in Engineering in this cohort may be related to Ph.D. completion rates in this cohort.

As in past NRC studies (Snyder, 1988; Baker, 1994, 1995) we used Quality Group 2 (QG2) non-awardees for comparison because in the application process they were assigned to the same group as QG2 awardees, although awards are not made randomly within the QG2 group. We used the Survey of Earned Doctorates (SED) through the most recent year available (1999) to compare completion rates. We made several comparisons using CI and SED data between NSF fellows and QG2 non-awardees. We compared the following Ph.D. completion rates and discuss each below:

- NSF fellows and QG2 non-awardees over time
- Gender differences over time
- WENG fellows and other engineering fellows
- Disciplinary differences by quality grouping
- MGF fellows and GF fellows
- MGF fellows and QG2 MGF non-awardees

Completion Rates of NSF Fellows and QG2 Non-Awardees over Time

Several important findings can be observed in Figures 2 and 3. First, more QG1 fellows than QG2 fellows complete doctorates, and this has not changed over time. Second, more QG2 fellows complete doctorates than QG2 non-awardees after 11 years, but at the 6-year mark, completion rates are somewhat higher for QG2 non-awardees in the most recent cohort (1989-1993). Finally, for the most recent cohort, early completion rates are very similar for fellows and non-awardees, but with additional time, more fellows complete the doctorate.

Figure 2
Six-Year Doctoral Completion Rates: NSF Fellows and Non-Awardees

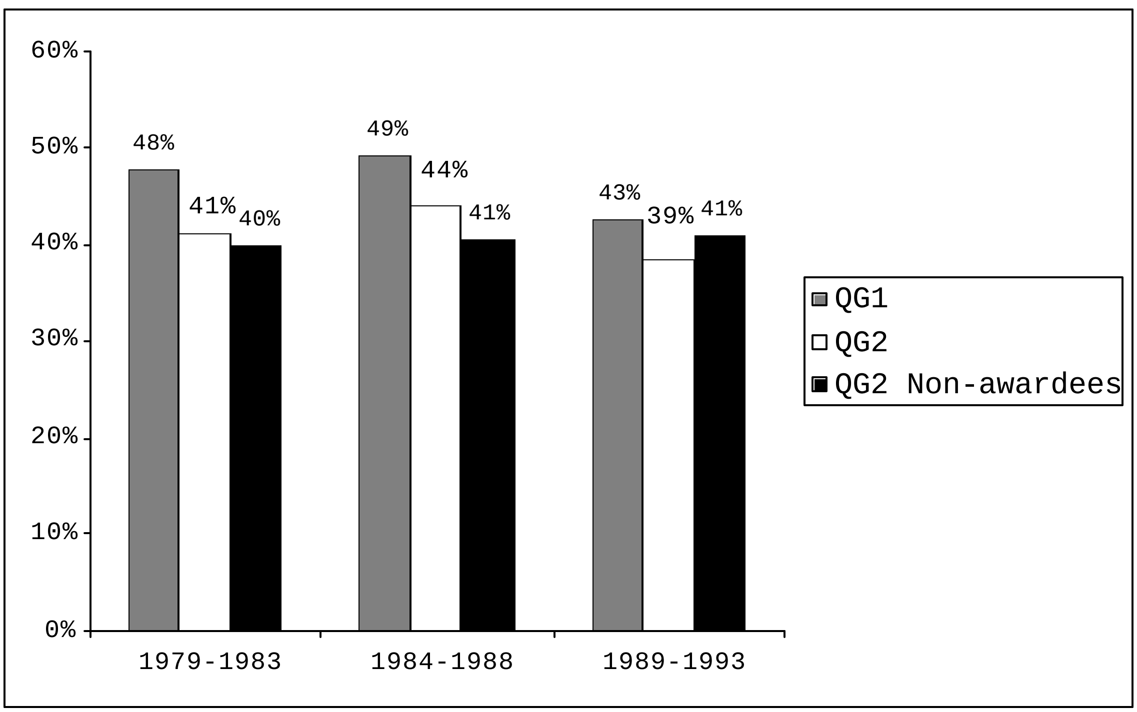
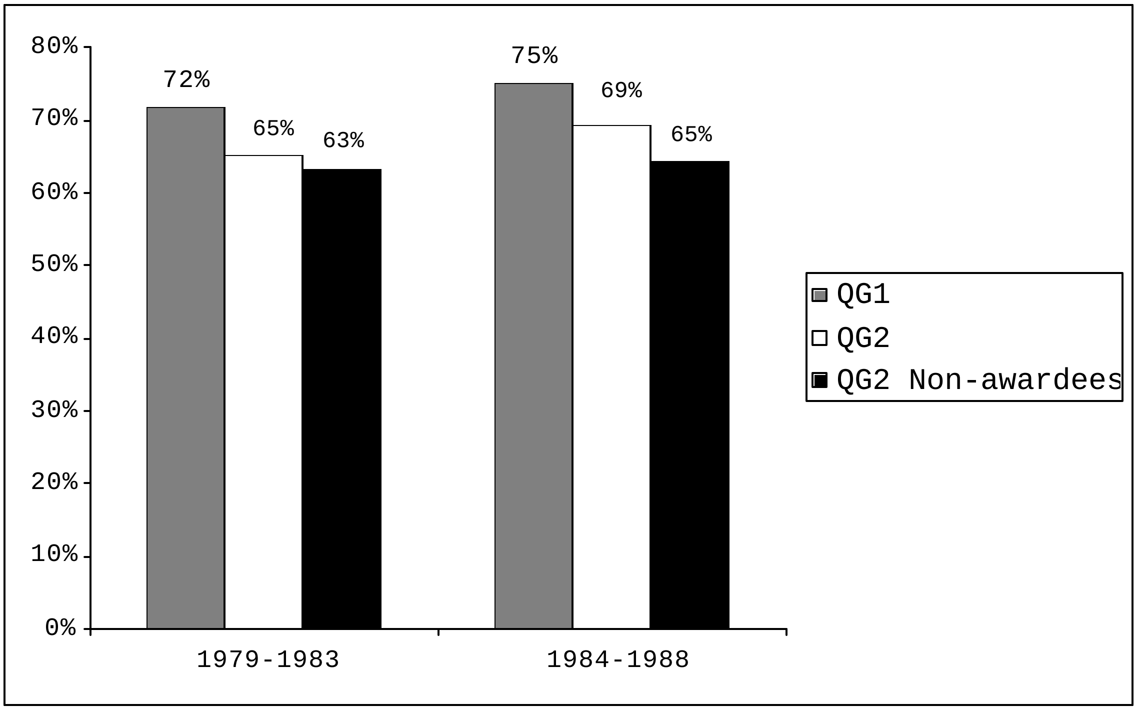


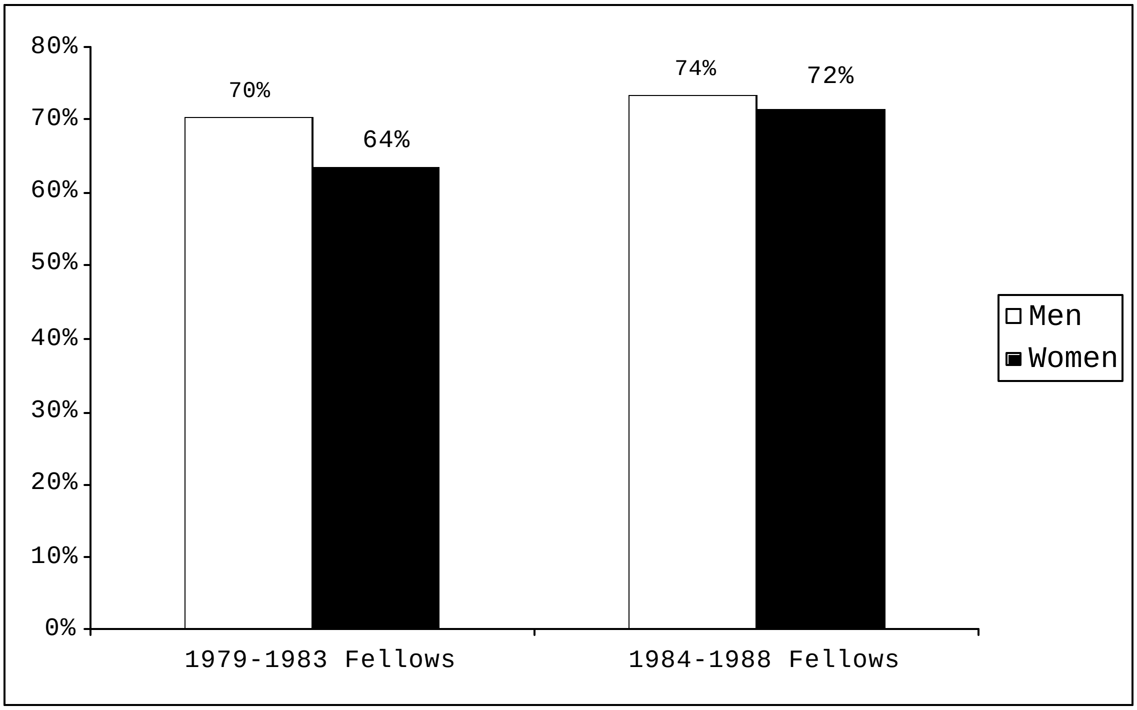
Figure 3
Eleven-Year Doctoral Completion Rate: NSF Fellows and Non-Awardees



Completion Rates by Gender over Time

Doctoral completion rates for women fellows were only slightly lower than for men within 11 years for the first two cohorts, and the difference is getting smaller (Figure 4).

Figure 4
Eleven-Year Doctoral Completion Rates by Gender



Completion rates for 1984-1988 women fellows in most discipline areas are within ±6 percentage points of those for men (Table G8). For the both cohorts, the largest discrepancies are in Social Science fields, where 57% of women, compared to 65% of men completed, and Computer Science/Math, where 37% of women and 66% of men completed within 11 years. Women fellows' doctoral completion rates are also lower in these disciplines than they are in other discipline areas. Importantly, the differences between NSF fellows and QG2 non-awardees is about four times greater for women than it is for men, with 73% of QG1 and 68% of QG2 women fellows completing, compared to 59% of QG2 non-awardees (Table G9). Thus, the GRF award seems to provide an advantage to women fellows in moving to doctoral completion.

Completion Rates of WENG Fellows Compared to Other Engineering Fellows

In 1990, NSF initiated additional GRF awards for Women in Engineering (WENG) to encourage more women to undertake graduate education in that area. Since the program had not been in place long enough to look at 11-year completion rates using 1999 SED data, we looked at 6-year completion rates for WENG fellows and other Engineering fellows (including non-WENG women fellows). We found that 40% of 1990-1993 WENG fellows had completed doctorates in six years, compared to 45% of other Engineering fellows, both men and women, in the 1989-1993 cohort. This difference is relatively small when you consider that most WENG fellows were selected from the Quality Group 3 (QG3) of applicants. QG3 is those who receive Honorable Mentions but are not considered to be as highly qualified as QG1 and QG2 applicants. It would be useful to follow the progress of the WENG fellows for a longer period to assess whether the gap narrows or grows as TTD increases.

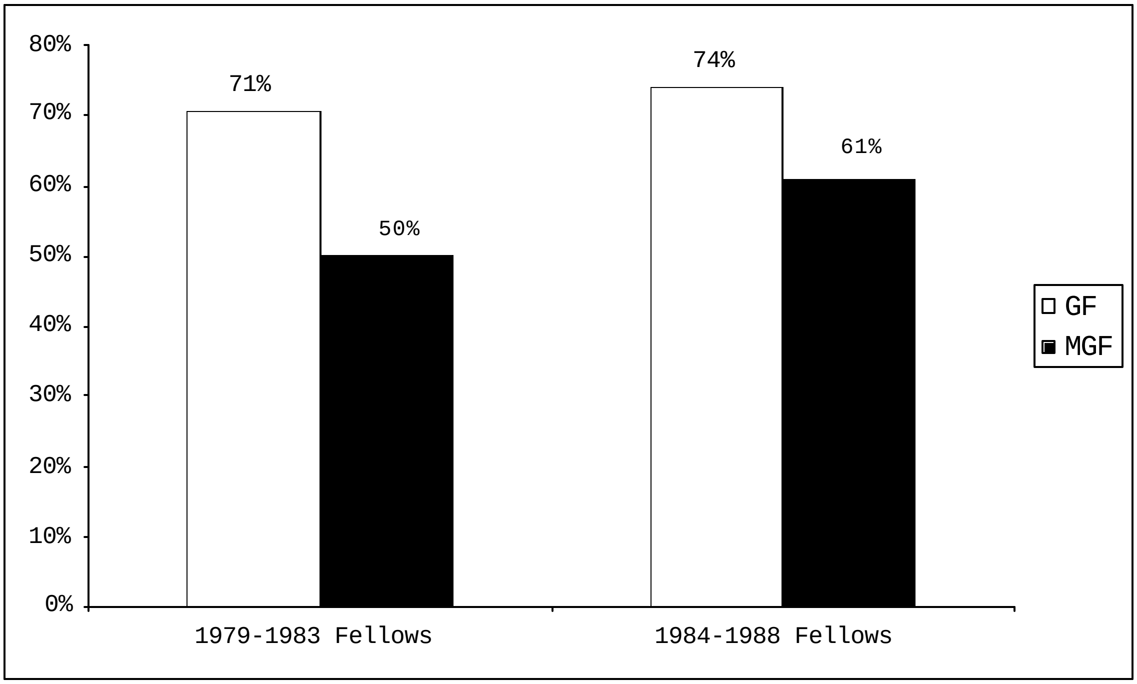
Disciplinary Differences in Completion Rates by Quality Grouping

For GRF QG1 fellows, 11-year doctoral completion rates have increased in all discipline areas except for Engineering/Math/Physical Sciences, where the completion rate declined slightly (less than one point) between the 1979-1983 and 1984-1988 cohorts (Table G10). Eleven-year completion rates for QG1 fellows in the Biological and Life Sciences rose from 72% to 79% between the 1979-1983 and 1984-1988 cohorts. For Behavioral and Social Sciences, the percentage of QG1 fellows completing within 11 years increased from 63% to 70%. For QG2 fellows, completion rates have risen in all three discipline areas. For QG2 non-awardees, on the other hand, completion rates in 11 years declined for those in Engineering/Math/Physical Sciences but increased in the other areas. Across all disciplines, 11-year completion rates have risen for both QG1 fellows and QG2 fellows while the 11-year completion rates for QG2 non-awardees have increased but to a less extent. QG2 fellows completed at somewhat higher rates (five percentage points) than QG2 non-awardees, and this difference was greater for the 1984-1988 cohort.

Completion Rates of MGF Fellows Compared to GF Fellows

In this comparison, we looked at doctoral completion rates for both Graduate Fellowship recipients and Minority Graduate Fellowship recipients. Completion rates for MGF fellows (+11) increased more than 11-year completion rates for GF fellows (+3) (Figure 5).

Figure 5
Eleven-Year Doctoral Completion Rates: GF and MGF Fellows



Analysis of SED and CI data shows that the gap between GF and MGF doctoral completion rates declined across all disciplinary areas except Social Sciences, where the gap between GF and MGF completion rates widened by 6% and Computer Science/Math where it widened by 2% (Table G11). For other disciplinary areas, the gap between GF and MGF doctoral completion rates has been narrowed dramatically. The difference decreased from 28% to 14% in Engineering, from 18% to 7% in the Physical Sciences, from 22% to 4% in the Biological Sciences, and from 15% to 14% in the Behavioral Sciences. However, for the 1984-1988 cohort, an overall 7% difference in 11-year completion rates persisted (Table G12).

Completion Rates of MGF Fellows Compared to QG2 MGF Non-awardees

To assess whether MGF fellows graduate more often, and more quickly, than do QG2 non-awardees in the same competition, we compared completion rates of QG1 and QG2 MGF fellows to a comparison group of QG2 non-awardees (Table G13). Completion rates have increased for both MGF fellows and QG2 non-awardees. For 1984-1988 MGF QG1 fellows, 11-year completion rates was 68%, exceeding in just 11 years the rate of completion after 16 years for the 1979-1983 group (61%). For QG2 MGF fellows, the increase to the 11-year mark is smaller- from 46% to 51%. Furthermore, the completion rate of QG2 non-awardees is approaching that of QG2 fellows, from 34% to 50%. In all categories of the MGF competition, completion rates increased, but the biggest differences were for the QG1 (12.6%) and QG2 non-awardee (15.7%) groups.

There were dramatic increases in completion rates in some discipline areas. For example, the percentage of QG1 MGF fellows who had completed doctorates within 11 years increased in the Engineering/Math/Physical Sciences disciplines from 50% for the 1979-1983 cohort to 67% for the 1984-1988 cohort. In the Biological and Life Sciences, the percentage increased from 57% to 79% for QG1 MGF fellows and from 47% to 69% for QG2 MGF fellows. By contrast, 11-year completion rates remained fairly constant for the same two MGF cohorts in the Behavioral and Social Sciences (Table G13). Completion rates declined in Engineering/Math/Physical Sciences for QG2 MGF fellows, and more QG2 MGF non-awardees earned doctorates within 11 years than QG2 MGF fellows did. Other changes in completion rates were similar to those of QG1 MGF fellows.

For all 1979-1988 fellows combined, 76% of QG1 GF fellows and 65% of QG1 MGF fellows had received doctorates by 1999 (Table G14). For QG2 fellows, these percentages were 72% and 52% respectively for GF fellows and MGF fellows. The distinction between the completion rates of fellows and non-awardees is especially striking for the MGF competition, where only 45% of QG2 non-awardees in all disciplines completed within 11 years.

Decisions to Leave Graduate Programs

Because not all graduate students complete their programs, we asked Graduate Student Follow-up Survey respondents to tell us if they left their first graduate program without completing the degree sought when they entered. The percentages of respondents in all samples reporting that they did so are small, ranging from 12% for Disciplinary fellows to 18% for Disciplinary peers. The most important reasons given for leaving programs were changing graduate programs, problems meeting academic requirements, family and other personal reasons, and accepting employment in the field of study. We found that very few NSF fellows changed graduate programs, which indicates that the portability benefit is not often used.

One problem with focusing too much attention on doctoral completion rates is the implication that those who do not complete doctoral programs have failed. Survey respondents offered many reasons for leaving graduate programs, and not all of them suggest that leaving meant either failure or leaving graduate study forever. Survey respondents also mentioned a lack of preparation for graduate school or inadequate guidance by faculty members as reasons for leaving.

> I entered graduate school because I was supposed to, based on what I had been told all my life. Once in graduate school, I found out that I was not ready for it. I really wanted it to be more like "real life." I wanted to get out of academia and apply what I had learned thus far, which is what I am doing now. I am still being encouraged, by my husband and also by my academic advisor, to complete a master's program. I am still not quite ready, but I will keep the option open. (MGF)

> As you can tell from my responses, I left [Institution E] in my first semester and therefore forfeited my NSF award. There were multiple factors in this decision. I had received inadequate career guidance as an undergraduate and graduate student so I was misguided

> in my desire for a Ph.D. in mathematics. The isolation and disconnectedness, combined with a lack of opportunity to participate in research and/or teaching, was also a significant factor. I will begin a Biostats ScD program at [University X's] School of Public Health in the fall. (Disciplinary fellow)

However, other survey responses emphasized that graduate students also leave programs with the intent to shift career focus or fulfill other obligations.

> Overall, I enjoyed my graduate school experience. I had to leave earlier than I wanted because my family was experiencing a financial rough spot, but I'm hoping to go back and do things, like publish and go to conferences, that I did not do. I am also planning to do research in a field like computer science or computational biology, where I see the research opportunities after school as greater. This was also another important thing I didn't spend too much time thinking about: What field or industry was I going to work in after finishing school and what are the research opportunities? (Disciplinary fellow and MGF)

> Having an NSF fellowship allowed me to transfer schools when I realized the 1st grad school I chose did not have a research project that seemed to be right for me. I did not complete my Ph.D., only my master's in engineering, but I also got a master's degree in physical therapy and am trying to combine both fields. I am currently getting ready to go back for my Ph.D. after having six years of clinical experience to guide my future research efforts. (WENG)

> A significant influence in my decision to leave my Ph.D. program in Political Science was that several friends in my program made a similar decision to go to law school. (MGF)

> I enjoyed my time at graduate school, but decided I wanted to do something different after completing my oral and comprehensive exams. I went back home to law school. (Disciplinary peer)

> I am an atypical respondent in that I worked for three years after completing my master's. I am currently in an MBA program. Even though I did not go into research, the NSF fellowship gave me an opportunity to explore a career in research and academia. (WENG)

Implications for Defining and Measuring GRF Program Success

As discussed earlier, assessments of graduate student success (and of the programs designed to support them) have relied on measures of time to degree and doctoral degree completion. We added measures of productivity during graduate school. Our findings suggest that these indicators provide at best an incomplete picture of GRF Program success. The GRF Program is providing support that is highly valued by fellows themselves and the graduate programs in which they are enrolled. Additionally, the productivity and completion rate data suggest that the GRF Program supports highly qualified students who demonstrate impressive accomplishments while still in graduate school.

It is important to keep in mind the contextual differences associated with graduate study in different disciplines and/or at different institutions, as well as those that stem from rapidly changing fields and job markets. Also important is the extent to which NSF fellows value the opportunity to have more time and flexibility to pursue additional coursework or research interests, particularly in relation to TTD. Faster does not necessarily mean better, in other words, and the benefits of the GRF freeing up discretionary time should not be underestimated.