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Executive Summary

The Department of Defense's (DoD) Science, Mathematics, and Research for Transformation (SMART) Scholarship for Service (SFS) program provides scholarships for scientists and engineers at the undergraduate and graduate levels across 19 different science, technology, engineering, and mathematics (STEM) disciplines. After a pilot year in 2005, the program was made permanent in the 2006 National Defense Authorization Act (NDAA) with the goal "to provide financial assistance for education in science, mathematics, engineering, and technology skills and disciplines that, as determined by the Secretary, are critical to the national security functions of the Department of Defense and are needed in the Department of Defense workforce" (SMART Defense Education Program 2006).

The program supports two types of individuals: recruitment and retention scholars. Recruitment scholars are students who are pursuing a degree and are not DoD civilian employees. Retention scholars are current DoD civilian science and engineering (S&E) employees who have received the scholarship in support of an additional degree. To prepare them to enter the DoD S&E workforce, scholars intern at DoD sponsoring facilities within the Army, Navy, Air Force, or within another DoD agency while pursuing their degree. Upon degree completion, scholars fulfill their scholarship service commitment at a DoD sponsoring facility. For every year of scholarship, scholars commit to work one year in the DoD civilian workforce. Between 2006 and 2016, the SMART program awarded 2,021 scholarships to students earning degrees at 305 unique higher education institutions who have served or who are serving out their commitments at 169 unique DoD sponsoring facilities.

In June 2015, the SMART program office tasked the Institute for Defense Analyses (IDA) to conduct an evaluation to understand whether the program's practices have been effective (process evaluation) and whether the program has been impactful (outcome evaluation) from inception in 2006 through the 2015–2016 academic year.

This report focuses on the results of the outcome evaluation, which is guided by a set of research questions:

- To what extent did the SMART program improve the quality of the civilian S&E workforce?
- To what extent did the SMART program attract scientists and engineers who would not have normally worked at DoD?

- To what extent did the SMART program attract a more diverse set of S&E workers to the DoD as compared to the broader DoD S&E workforce?
- To what extent does the SMART program contribute to the retention of SMART scholars at the facilities post-service commitment?
- To what extent do SMART scholars who leave DoD employment join organizations that serve DoD interests (DoD contractors, Federally Funded Research and Development Centers (FFRDCs), etc.)?

Three process evaluation questions provide context for the outcome evaluation findings and recommendations:

- What are the goals of the SMART program?
- How does SMART scholar hiring fit into the larger hiring strategy at DoD facilities?
- What is the level of satisfaction of the SMART scholars with the SMART program?

To answer these research questions, the IDA research team relied on program documentation, over 150 interviews with SMART program stakeholders including S&E managers and scholars, a scholar survey, programmatic data, longitudinal defense personnel data from the Defense Manpower Data Center (DMDC) for both the SMART scholars and a comparison group of DoD S&E employees, and bibliometric data for PhD SMART scholars and their comparison group of PhD S&E employees.

Findings

There are six overarching findings. The first four findings are specific to the outcome evaluation, and two additional findings are process evaluation findings that are important and inform the outcome evaluation:

Overarching Finding 1: SMART scholars improve the quality of the DoD workforce

We considered several aspects of SMART scholar quality given that there is no single measure of worker quality. Our overall assessment is that on average, the SMART scholar group is higher performing than those DoD civilian S&E workers hired through other mechanisms. Table 1 provides a summary of the quality findings. Based on DoD S&E civilian personnel data from the DMDC, SMART recruitment scholars are promoted more rapidly and have faster salary increases than their counterparts. S&E managers that directly oversee the work of SMART scholars at their sponsoring facilities stated in structured interviews that SMART scholars, when compared to traditional workers, usually perform better across several aspects of quality including technical capability and caliber of work produced.

We also investigated background metrics related to SMART scholars and the comparison group of DoD civilian S&E workers. There is evidence that the SMART program draws from a candidate pool that is higher quality than the one from which the DoD hires S&E workers. Analyses of the type of research institutions by Carnegie Classification and research and development (R&D) spending at doctoral institutions suggest that SMART doctoral scholars come from higher quality institutions than the DoD civilian S&E workers comparison group. Yet we found SMART recruitment scholars are, in part, hired into the civil service at lower salaries than their counterparts. One possible reason for the difference in starting salary is that SMART scholars have a scholarship service commitment and are limited in their consideration of other competing offers as compared to non-SMART scholars who contemplate accepting a civil service job (i.e., DoD civilian S&E comparison group). SMART program staff have been working since 2014 to fix this issue, but because these analyses extend until only 2016, it is too early to see the effects of any changes implemented.

Table 1. Summary of Quality Metrics

Quality Findings: Job Performance	
Change in Salary—recruitment scholars only	On average, recruitment scholars received an increase of $2,110 (bachelor's), $980 (master's), and $616 (doctoral) more in salary every two years than their comparison group.[#]
Promotion—recruitment scholars	Recruitment scholars are twice as likely to be promoted every year relative to their comparison group.[#]
Promotion—retention scholars	No difference in promotion rate with comparison group.
S&E Manager Perspectives	50 percent indicated SMART scholars perform better than comparison group; 50 percent indicated SMART scholar performance is equal to comparison group.
Quality Findings: Background	
Carnegie Classification of PhD Institutions—recruitment scholars only	83 percent of SMART scholars at Highest Research Activity institutions versus 70 percent of their comparison group.[#]
Average PhD Institution R&D Expenditures—recruitment scholars only	Average total R&D expenditures for SMART scholars' PhD institutions is $536,000 versus $457,000 for their comparison group.[#]
Bibliometrics—recruitment scholars only	No difference in field weighted citation index and number of highly cited papers with comparison group.
Starting Salary—recruitment scholars only	SMART scholars earn $4,756 less on average than their comparison group to start.[#]

Note: [#] Indicates difference is statistically significant

Overarching Finding 2: The SMART program attracted students who had not considered the DoD as an S&E employer

Thirty percent of recruitment scholars surveyed were not aware of S&E workforce opportunities at DoD prior to applying for the SMART scholarship, indicating that a number of scholars who join the DoD workforce through the SMART program would not have otherwise come. The two types of scholars apply for the program for different reasons—retention scholars have already chosen to serve the DoD mission and want to gain more skills through receiving another degree, viewing the SMART scholarship program as a professional development opportunity. In contrast, the recruitment scholars are new to the DoD and tend to be early in their career. They learn about their program through word of mouth, not necessarily through their universities or advisors. The SMART program office has implemented activities such as site visits and the SMART scholar symposium to help scholars better understand the work at the facilities and engage in activities that build their careers.

Overarching Finding 3: The SMART program has greater gender diversity, but less racial diversity, than the DoD S&E workforce

The SMART program has more women, or greater gender diversity (26 percent of scholars hired into DoD), than the DoD S&E workforce (21 percent). The gender diversity of SMART scholars has increased since the start of the program. In contrast, SMART scholars are less racially diverse than both the pool of S&E applicants receiving STEM degrees and the overall DoD S&E workforce. Furthermore, racial diversity decreases at every step in the application process.

Overarching Finding 4: The SMART program appears not to contribute to the retention of SMART scholars at DoD sponsoring facilities post-service commitment

SMART scholars are leaving DoD employment faster than their DoD S&E civilian comparison group. For example, the percentage of recruitment scholars retained at 3 years, and 5 years is 73 percent, and 55 percent respectively, and the percentage of their comparison group retained 3 years, and 5 years is 86 percent, and 78 percent. SMART scholars are leaving at statistically significantly faster rates because of low salaries (i.e., starting salaries compared to their S&E counterparts and in comparison to the private sector), frustration with the work culture and work experience, and the burden of working in locations far from their homes. These findings are generally in line with other studies on retention of incentive or scholarship recipients in DoD.

About 12 percent of DoD scholars that leave the workforce transition to jobs that serve the DoD mission—either in the DoD contracting workforce or with defense-related FFRDCs. The majority of scholars depart for non-DoD private sector employment (45 percent) or go into academia to teach or to further education (16 percent). Scholars reported leaving mostly for career growth and for more interesting jobs.

Overarching Finding 5: While the legislative goal of the SMART program is to provide S&E talent to meet the needs of the DoD mission, the actual execution of the program indicates that there are multiple goals in operation

Through interviews, we understood that initially the program was created, in part, to address the needs of the aging S&E workforce, indicating that DoD was interested in recruiting more S&E workers. Many stakeholders noted in discussions, however, that the SMART program provided facilities access to higher quality talent. Some SMART S&E managers stated that increasing diversity was important, though not listed as an explicit goal under the legislative authority of the program. The program goals are implemented in multiple ways given that there are retention scholars who are already DoD civilian S&E workers and seeking to further their education, and recruitment scholars who have never worked for the DoD and are in school at the time of application.

Having many stakeholders approaching the goals in multiple ways makes managing the SMART program more challenging. To that end, the SMART program office has implemented processes that address the legislative mandate of providing talent that have "STEM skills…as determined by the Secretary…needed in the DoD workforce." This is done by allowing the services to prioritize degree fields and degree levels that meet the service's critical mission area workforce needs each year. The services are then given the opportunity to determine the sponsoring facilities eligible to receive a SMART scholar. Each service approaches this opportunity differently, with Navy and Air Force taking a top-down approach and Army a bottom-up approach. This process uses degree fields and degree levels as a proxy for "skills" and could be refined to identify demand more effectively. The S&E talent hired through the SMART program is very broad, across many disciplines and degree levels. Scholars are placed at sponsoring facilities across the laboratory and facility enterprise, with slightly more than 50 percent of scholars being placed at laboratories within the Defense Laboratory Enterprise structure, which focuses more on basic and applied R&D. Some sponsoring facilities appear to be relying on the program because it recruits top talent and it offers non-competitive conversion hiring authority, which is an attractive hiring tool.

Overarching Finding 6: Many SMART scholars are satisfied with the program

Eighty-seven percent of scholars surveyed stated that the SMART program was a benefit to their career, and 84 percent indicated they would recommend the program to others. Scholars who are more satisfied with the program are more likely to be retained. Furthermore, scholars that are more satisfied are more interested in serving the DoD mission. Scholars noted that satisfaction with their work and the topics they are working on are very important as well. Matching the scholars to the facility that best suits their interests and meets the DoD workforce needs is challenging. Not surprisingly, those who were less satisfied with the program were more likely to leave DoD civilian employment than those who were more satisfied with the SMART program.

Overall, retention scholars had a higher approval of the SMART program and generally higher retention rates than recruitment scholars.

Recommendations

The SMART program office asked IDA to identify a set of recommendations to improve the outcomes of the SMART program.

Recommendation 1: The SMART program office could focus on continuing to recruit high quality scholars and improve the applicant pool

If the goal is to increase quality of the underlying people, then the focus should be on improving the pool of candidates, both recruitment and retention scholars at the recruitment and application stages.

Recruitment of High Quality Scholars

Recommendation 1.1. Build a SMART brand within DoD and outside of DoD that attracts high quality students through using SMART alumni from facilities to recruit new SMART scholars.

Recommendation 1.2. Educate faculty and university career offices to better understand the SMART scholarship program.

Recommendation 1.3. Create a pilot program with top higher education institutions to provide the academic advisors of SMART scholars with research support to conduct research of critical importance to the DoD mission, while also training SMART scholars. This approach could lead to stronger ties between academia and DoD research priorities.

*Recommendatio*n *1.4.* Create programming to help bring SMART scholars together to build networks of scholars at facilities and rely on these networks for recruitment.

Recommendation 2: The SMART program office could also focus on improving retention of scholars

If the goal is to train SMART scholars to be better DoD S&E employees who are interested in staying employed at the DoD, then the focus should be on influencing the internship experience to prepare scholars more effectively.

Retention of Scholars

Recommendation 2.1. Ensure that sponsoring facilities meet a standard of excellence regarding providing scholars effective mentorship and training, and provide scholars work experiences commensurate with their skills and interests.

Recommendation 2.2. Consider revising the scholarship application to more effectively test scholars' interest in serving the DoD mission.

Recommendation 2.3. Create a pilot program to build more flexibility regarding scholar placement between scholar and facility, perhaps allowing scholars to rotate between commands or services.

Recommendation 2.4. Implement more experiences like the SMART scholars symposium to recognize SMART scholars and highlight their accomplishments while they are working at their sponsoring facilities.

Recommendation 2.5. Reconsider relying on percentage of scholars retained as a metric by which to evaluate the SMART scholarship program.

Recommendation 3: Investigate differences in starting salaries and work with DoD facilities to understand the salary disparities

Starting salaries for SMART scholars are statistically significantly lower than their comparison group: DoD civilian S&E workers. Over the past 4 years, the SMART program office has worked to address this issue, but the timeframe of this evaluation analysis would not capture any SMART scholar policy changes that occurred after 2014.

Recommendation 3.1. Investigate hiring processes to ensure equity in the SMART scholar hiring process.

Recommendation 3.2. Monitor starting salaries and ensure SMART scholars are paid commensurate with their peers at all facilities.

Recommendation 4: To increase diversity, continue to recruit female scholars while expanding efforts to increase representation of underrepresented minority (URM)

Recommendation 4.1. Investigate why so many URMs drop out during the application process and if the process is losing top talent. Consider piloting a mentoring effort during the application process to a group of URMs to see if efforts will increase application success.

Recommendation 4.2. Explore focusing more recruiting on scholars from Hispanic Serving Institutions and large academic institutions with a large number of URMs.

Recommendation 5: Conduct a workforce demand analysis for components and facilities to determine and prioritize the sponsoring facility/laboratory need for SMART scholars including degree field, degree level, and skill level

Recommendation 5.1. Target certain disciplines and skill levels each year to meet the DoD S&E workforce demand. Given the changing landscape of S&T priorities within the services, such as artificial intelligence or quantum computing, the SMART program could be more targeted in recruitment, particularly in areas of science and technology where the Department is challenged in finding qualified workers. Furthermore, a workforce demand analysis could determine that certain degree field and degree levels may not be necessary to include in the SMART program because the Department is able to find these S&E workers through other hiring mechanisms.

Recommendation 5.2. Consider relying on a workforce demand analysis to determine the degree to which the SMART program should expand, if at all. This would ensure that any changes to the SMART program are driven by demand and need for the skills offered by scholars in the program.

Contents

1. Introduction

The Department of Defense (DoD) Science, Mathematics, and Research for Transformation (SMART) Scholarship for Service Program was initiated in 2005 as a pilot program in response to the Fiscal Year (FY) 2005 National Defense Authorization Act (NDAA) (National Defense Authorization Act 2005). It became a permanent program in 2006. The goal of the program is

> "to provide financial assistance for education in science, mathematics, engineering, and technology skills and disciplines that, as determined by the Secretary, are critical to the national security functions of the Department of Defense and are needed in the Department of Defense workforce" (SMART Defense Education Program 2006).

The program has been implemented to support the DoD's science and engineering (S&E) workforce at their laboratories and facilities (hereafter referred to as sponsoring facility).

The DoD provides scholarships for current and future scientists and engineers at the undergraduate and graduate levels across 19 different science, technology, engineering, and mathematics (STEM) disciplines. As part of the program, scholars intern at DoD sponsoring facilities and, upon degree completion, serve out their scholarship service commitment at a DoD sponsoring facility. For every year of scholarship, scholars commit to work one year in the DoD civilian workforce.

From 2006 to 2016, the SMART program awarded 2,021 scholarships to bachelor's, master's, and doctoral students. Approximately 65 percent of those students were or are studying engineering, 21 percent were or are studying mathematics/computer science, and the remaining 14 percent were or are studying physical and life sciences. A total of 169 DoD sponsoring facilities have sponsored a scholar in the SMART program. Thirty-one of those sponsoring facilities have employed 20 or more scholars over the life of the program. Most sponsoring facilities (108) have had fewer than 10 scholars.

A. Purpose of Evaluation

In May 2015, the SMART program office within the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) tasked the Institute for Defense Analyses (IDA) to conduct a process evaluation and an outcome evaluation for the SMART program. The SMART process evaluation report was published in May 2018, and sought to understand and assess the effectiveness of the program's processes. In contrast, the outcome evaluation, the focus of this report, aims to assess the overall impact of the SMART scholarship on the scholars and the DoD S&E workforce, and evaluates the extent to which the program has met its intended goals.

The program supports recruitment and retention scholars. Recruitment scholars are students who are pursuing a degree and are not DoD civilian employees. Retention scholars are those who were already DoD civilian S&E employees and have received the scholarship in support of another degree. The program also considers scholar experience in three distinct phases. In Phase I, scholars are enrolled in an academic degree program and receive the scholarship funding. For scholars who have multiple-year awards during the summers in between semesters. In Phase II, scholars repay their commitment by working as a government employee at a DoD sponsoring facility. In Phase III, scholars have fulfilled their commitment and may continue to work at the DoD sponsoring facility or may leave.

B. Study Questions

The evaluation study questions based the stated or explicit goals of the SMART program and through conversations with program stakeholders regarding the unstated or implicit goals of the program. Appendix A provides a more detailed list of study questions, and Appendix B provides the detailed logic model we developed for the SMART program.

1. Quality of Scholars

- To what extent did the SMART program **improve the quality** of the civilian S&E workforce?

2. Retaining Scholars

- To what extent does the SMART program contribute to the **retention** of SMART scholars at the facilities post-service commitment?
- To what extent do SMART scholars who **leave** DoD facilities join organizations that **serve DoD interests such as** DoD contractors or FFRDCs?

3. Recruiting Scholars

- To what extent did the SMART program **attract** S&Es who would **not have normally worked** at DoD?
- To what extent did the SMART program attract a more **diverse** set of S&E workers to the DoD as compared to the broader DoD S&E workforce?

4. Spillover Benefits

- To what extent did the SMART program create or strengthen ties between Principal Investigators (PIs) at academic departments and DoD facilities?

C. Methodology

The IDA research team relied on several methods to conduct this evaluation. We reviewed SMART program documentation such as applications, annual reports, and budget requests. We conducted more than 240 interviews with SMART program staff, SMART program contractors, SMART sponsoring facility points of contact, SMART sponsoring facility S&T mentors and supervisors, SMART scholars, and academic advisors to SMART scholars. A scholar survey was administered to 1,762 SMART scholars resulting in a 63 percent response rate. The survey covered both questions related to SMART program processes as well as questions related to scholars' satisfaction and perspectives questions. We also acquired and analyzed S&E workforce data from the Defense Manpower Data Center (DMDC) through which SMART scholars and S&E workers were longitudinally tracked through their careers in the DoD workforce to capture employment retention, salary, promotion trends. We identified a comparison group to SMART scholars using propensity score matching, and built statistical models of retention trends, salary trends and promotion trends and combined DMDC data with administrative data and survey data. We used publications as a metric for quality of scientific contribution between the SMART scholars and their comparison group. Appendix C provides a more detailed discussion of the methodology. The IDA research team conducted a substudy looking at academic ties formed between academic departments and sponsoring facilities, which is outlined in Appendix D. Finally, Appendix E dives deeply into the statistical analyses used to determine the evaluation findings and conclusions.

D. Report Organization

The report structure is aligned with the study questions. Chapter 2 provides an overview of the SMART program. Chapter 3 discusses findings related to SMART program recruitment including diversity, and Chapter 4 details quality metrics developed to assess the SMART program. Retention is discussed in Chapter 5, and Academic Ties in Chapter 6. Chapter 7 provides a findings related to the SMART program goal and workforce planning, and Chapter 8 describes additional stakeholder perspectives regarding satisfaction of the program. Finally, Chapter 9 outlines the summary findings and recommendations for this SMART program evaluation.

2. SMART Program Overview

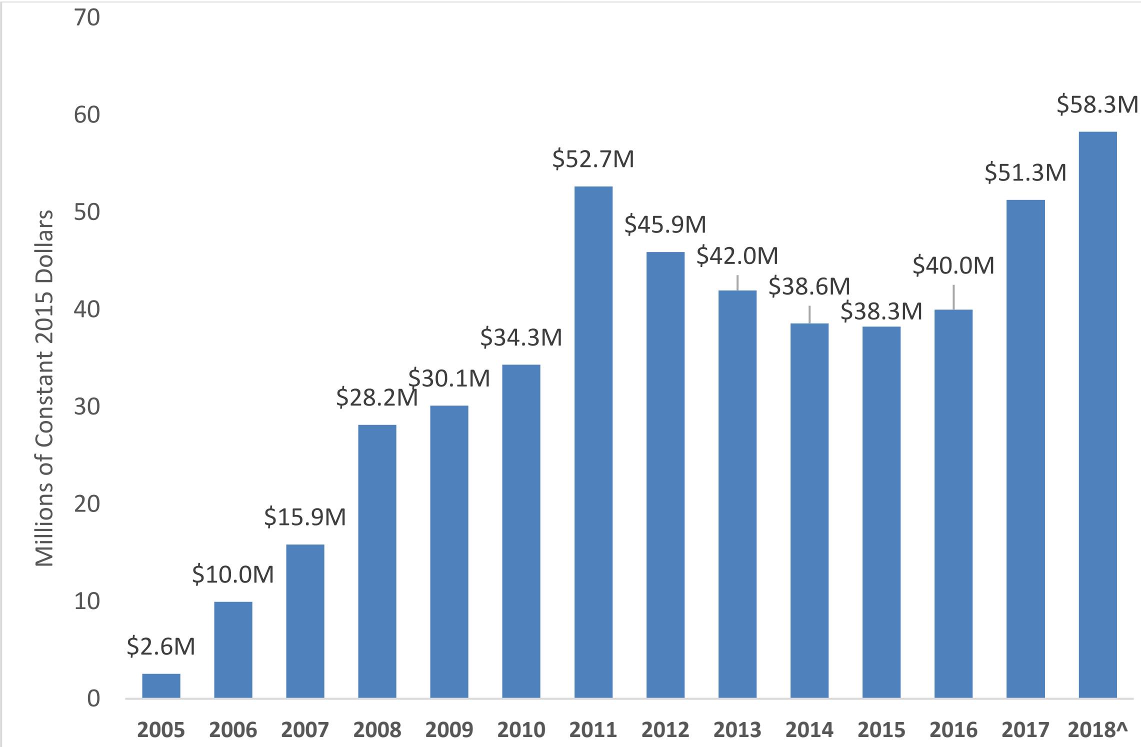
A. Legislative History

Congress established the SMART scholarship pilot program in the National Health Services Corps for FY 2005. The motivation for the program appears to stem from the Senate Armed Services Committee's concern "with the aging technical workforce and statistics which point to a growing deficiency in the right mix of scientists and engineers to support our national security workforce needs" (National Defense Authorization Act 2005). The committee indicated that the DoD had "not been … successful in recruiting and retaining scientists and engineers for positions in its laboratories, service components, and defense agencies" (National Defense Authorization Act 2005). It authorized funds for a pilot SMART program "as a means of increasing the number of U.S. citizens trained in disciplines of science and engineering of military importance" (National Defense Authorization Act 2005).

The permanent program was authorized the following year by the NDAA for FY 2006. In subsequent years, the SMART authorizing legislation was amended four times, in the NDAAs for FY 2010 and 2014–2016. These amendments altered the hiring mechanisms and class of eligible students, among other aspects of the program.

B. SMART Budget Requests: FY 2006–2017

Funding for the SMART program has varied since it started in 2005. Figure 1 shows a steady funding increase between the pilot year (2005) and 2010. In 2011, there was a sharp increase in funding, followed by a decline until 2014, where it leveled off through 2016. From 2013 to 2016, funding levels were around $40 million per year. FY 2017 increased sharply (over 25 percent) over FY 2016 funding levels and continued to increase in FY 2018.



Source: DoD Budget Requests and Program Office

^ 2018 is enacted funding.

Figure 1. SMART Appropriations 2005–2018

Funding authorized through the NDAA is 2-year money (Budget Activity 6 funding for research, development, test, and evaluation functions), so the program has the ability to adjust spending based on requirements and funding each year. In any single year, the funding is used for continuing the payment of tuition and stipends for progressing scholars in Phase I, and also for new awards. As expected, the funding mainly goes to supporting SMART scholars through tuition and stipend payments.

Between 2006 and 2016, the SMART program funded a total of 2,021 scholarships. Of those 2,021 scholarship, 1,763 (87 percent) are recruitment scholars and 258 (13 percent) are retention scholars. The number of SMART scholarships awarded increased rapidly between 2006 (31 new scholars) and 2010 (297 new scholars). Due to reduced SMART funding for FY 2012, the number of new scholars was lowered dramatically (see Figure 2). Because the program funds scholars for multiple years, a moderate drop in funding across years causes a more drastic drop in new awards possible, because the commitment to fund current/continuing scholars takes precedence to funding new scholars. Since 2012, there has been a small increase in the number of new scholar awards year after year.

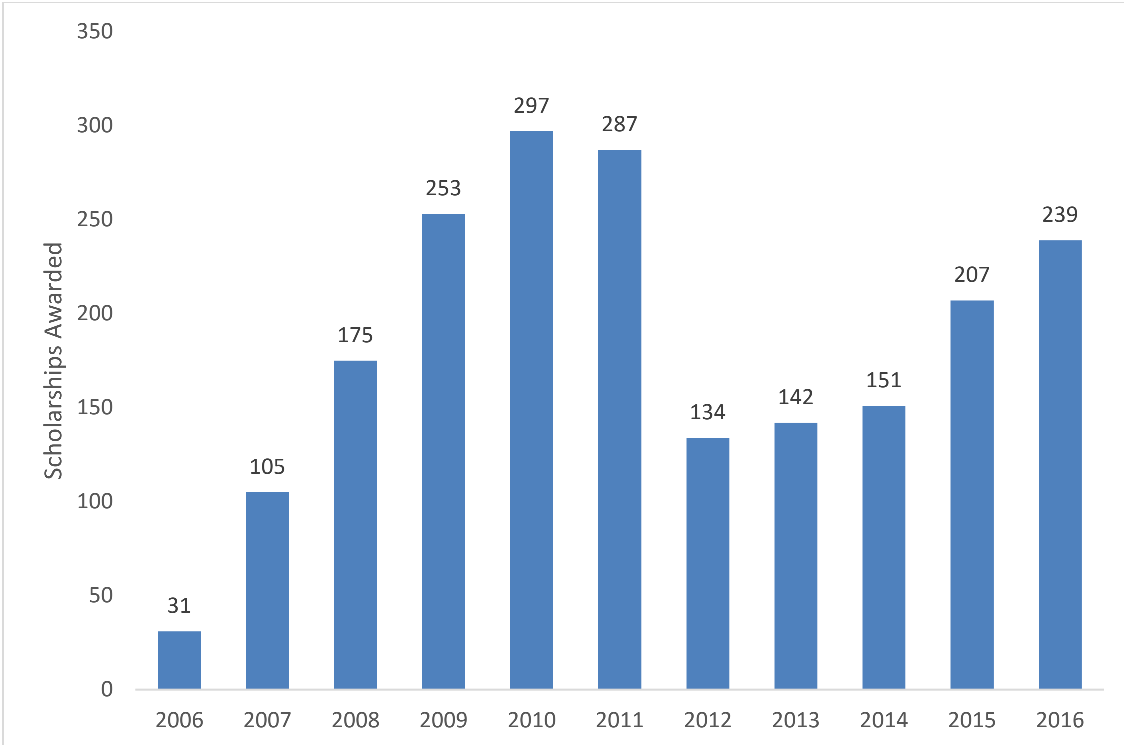


Figure 2. Number of New SMART Scholarships Awarded Per Year (2006–2016)

The 2,021 SMART scholarships are distributed across the three phases of the program. As of July 2016, 612 (30 percent) scholars were in Phase I or degree pursuit, 412 (20 percent) scholars were in Phase II or completing their service commitment, and 997 (49 percent) scholars were in Phase III or post-service commitment.

C. SMART Program Stakeholders

The SMART program process is complex and runs from the time of scholar recruitment to the point at which a scholar completes the service commitment and may be retained in the DoD S&E civilian workforce several years later. The process of collating the priorities of individual Components and sponsoring facilities that leads to identifying and allocating slots to applicants makes the SMART program process complex. As a result, several stakeholders are involved in the process:

- **Applicants.** The SMART program recruits scholar applicants from a number of academic institutions, through professional societies and through word of mouth.
- **Scholars.** The SMART program scholars are the recipients of the scholarship and are eventually hired by their assigned DoD sponsoring facility as part of the S&E workforce.

- **SMART Program Office.** This office is the central location for all activities surrounding the SMART program. It administers and implements the program policies and procedures and manages the contractors.
- **Assistant Secretary of Defense for Research and Engineering (ASD(R&E)).** The SMART program office is part of the STEM Development Office, which is within the Defense Laboratories Office, one of the offices under the purview of ASD(R&E).
- **Component Administrating Office (CAO) or Execution Leads and Component Heads.** The CAOs or Execution Leads and Component Heads are assigned for each military Service and for the other DoD agencies. Typically, the Execution Lead reports to the Component Head. These individuals represent the Components, particularly the position of the Component regarding S&E workforce planning and strategy. They also represent the leadership of the Components and sponsoring facilities to the Office of the Secretary of Defense, which manages the SMART program. Often the Execution Lead is more directly involved with the SMART program while the Component Head is a higher level, oversight position.
- **Sponsoring Facility Point of Contact (POC).** The facility POCs are the designated interface between the SMART program and the sponsoring facility and are usually within the Human Resources (HR) department of the facility. They communicate regularly with the SMART service liaisons and the SMART program managers, particularly in the sponsoring facility requirements phase and the scholar selection phase. At some sponsoring facilities, they are also S&E managers.
- **Sponsoring Facility S&E manager.** Most S&E managers represent the cadre of direct supervisors for SMART scholars. A few of the S&E managers are also SMART sponsoring facility POCs or have additional responsibility for sponsoring facility S&E leadership, such as branch chief or division chief positions. All S&E managers are civilian S&E professionals, some of whom were SMART scholars in the past.
- **SMART program support.** The SMART program office retains outside contractors to conduct much of the program administration work, including administering the application process, paying scholar stipend and tuition, providing helpdesk-like support to SMART scholars, and maintaining a database on past and present SMART scholars.
- **SMART service liaisons.** There are four SMART service liaisons: one for each of the three Services and one for the other DoD agencies. They are employees of the contractor and have critical roles in program management. These individuals fill a crucial role between the SMART program office, the sponsoring facility POCs, the CAOs, and the SMART program support team.

Figure 3 shows the interactions between these various stakeholders, their organizations, and their roles. Participating sponsoring facilities have discretion over how to administer the SMART program, which creates slight but significant variations in the process.

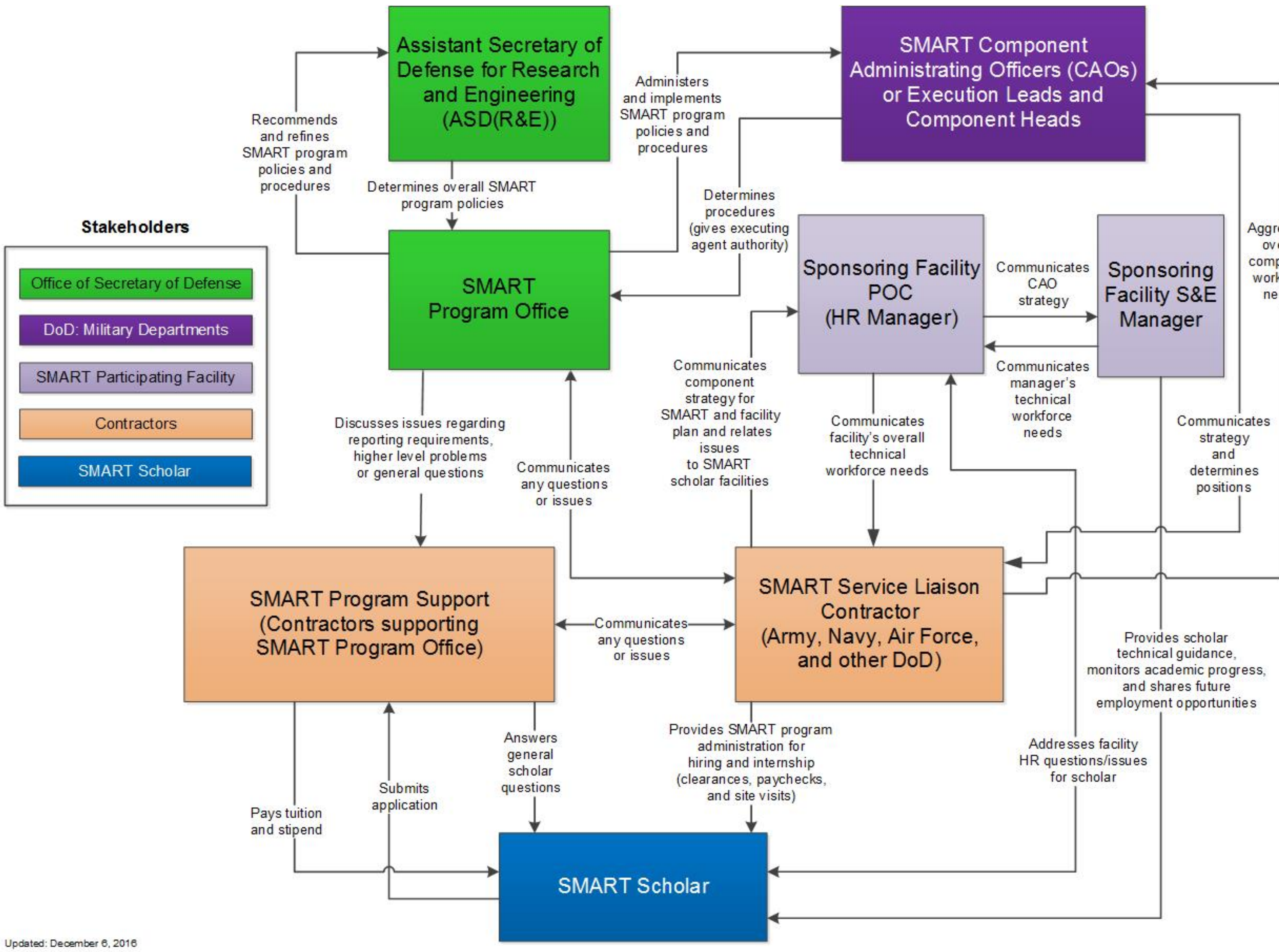


Figure 3. SMART Program Interactions

D. SMART Program Data by Degree Level and Discipline

The SMART program provides scholarships for students studying 1 of 19 STEM disciplines that DoD has identified as critical. The majority of awards have been given to engineers (65 percent) across all degree fields. The breakdown between students seeking bachelor's degrees and graduate degrees is about 45 percent and 55 percent, respectively, (see Table 2). During the time of this evaluation, SMART scholars could request funding for 1 to 5 years.[1] The median number of years for students seeking bachelor's or master's degrees is 2 years, and the median number of years for those seeking doctoral degrees is 3 years.

Table 2. Breakdown of Scholarships by Candidate Degree Type and Field 2006–2016

Disciplines	Bachelor's Degree Candidates	Master's Degree Candidates	Doctoral Degree Candidates	Total
Engineering	626	332	354	**1,312**
Electrical Engineering	235	125	127	**487**
Mechanical Engineering	183	84	73	**340**
Aeronautical and Astronautical Engineering	57	45	57	**159**
Civil Engineering	64	38	18	**120**
Industrial and Systems Engineering	34	16	17	**67**
Materials Science and Engineering	16	8	38	**62**
Naval Architecture and Ocean Engineering	16	12	13	**41**
Chemical Engineering	17	3	6	**26**
Nuclear Engineering	4	1	5	**10**
Computer Science	147	75	76	**298**
Computer and Computational Sciences and Computer Engineering	134	73	72	**279**
Information Sciences	13	2	4	**19**
Mathematical Science	66	34	26	**126**
Mathematics	58	14	21	**93**
Operations Research	8	20	5	**33**
Physical Science	47	13	62	**122**
Physics	36	7	30	**73**
Chemistry	11	6	32	**49**

[1] As of the 2017 cohort, SMART scholars can request funding from 1.5 to 5 years.

Disciplines	Bachelor's Degree Candidates	Master's Degree Candidates	Doctoral Degree Candidates	Total
Earth Science	19	18	20	**57**
Geosciences	15	13	10	**38**
Oceanography	4	5	10	**19**
Biological Science	12	14	31	**57**
Biosciences	12	14	31	**57**
Psychology	8	4	37	**49**
Cognitive, Neural, and Behavioral Sciences	8	4	37	**49**
Total	**925**	**490**	**606**	**2,021**

Note: 120 scholars sought joint Bachelor's/Master's degrees and are reflected in the master's degree category, and 63 scholars sought joint Master's/PhD degrees and are reflected in the doctoral degree category.

Scholars have different statuses depending on whether they are in Phase I, II, or III. Although 2,021 SMART scholarships have been awarded, 183 (9 percent) of these scholars have either withdrawn of their own volition during Phase I or Phase II or have been dismissed for being noncompliant. Noncompliance can include situations such as failing to meet grade point average (GPA) requirements, engaging in misconduct, or not being able to obtain a clearance during Phase I or Phase II.[2] Once the service commitment has been completed (Phase III), scholars have the option to either remain in the DoD S&E workforce or separate from the DoD without penalty.

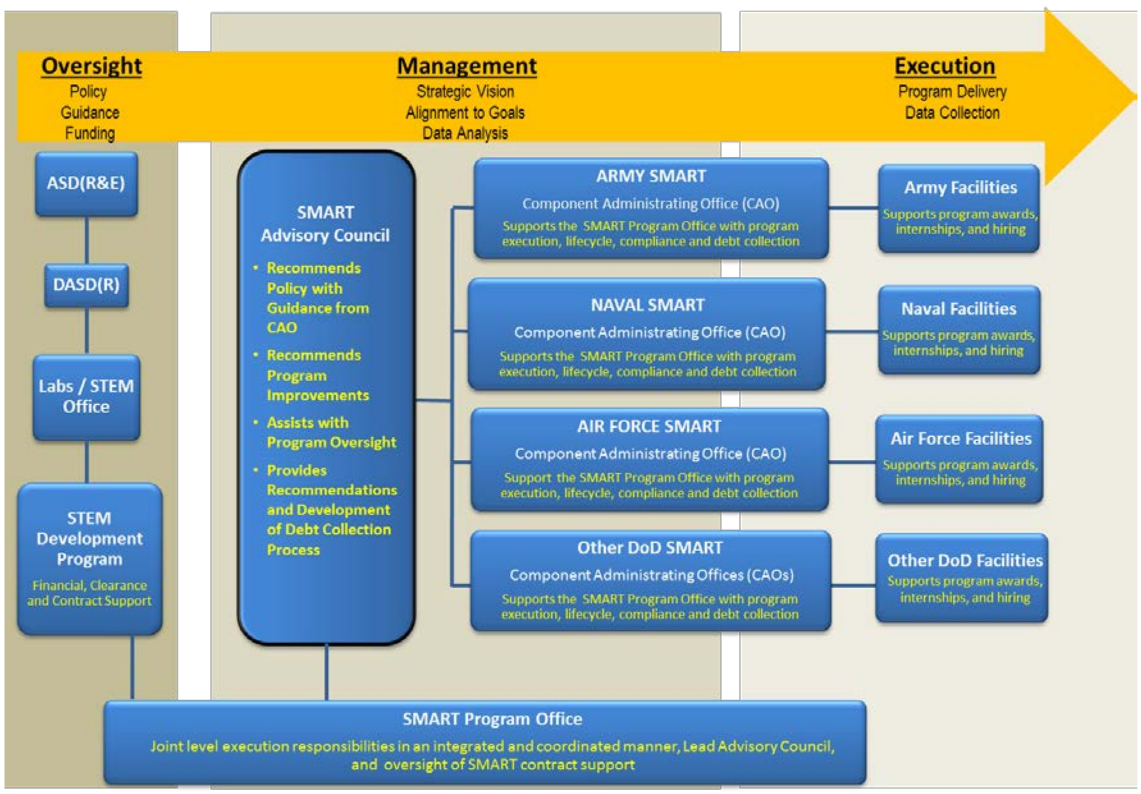
Scholars who receive a SMART scholarship but do not complete their service commitment are responsible for repaying the government an appropriate amount based on percentage of commitment completed. In 2016, a Department of Defense Instruction (DoDI) specific to the SMART program was signed (U.S. Department of Defense 2016). The purpose of this DoDI was to implement the policy of Section 2192a of Title 10, with execution of the program, including debt collection, being the responsibility of the Component that selected the scholar (SMART Defense Education Program 2006).

[2] Because data from the early years of the program distinguishing withdrawals and dismissals are inconsistent and unreliable, they are pulled together into one category.

E. Laboratories and Facilities

1. SMART Program Organization

The SMART program is administered across all three Services (Army, Navy, and Air Force) in addition to other DoD agencies.[3] The oversight of the program (Figure 4), which includes policy implementation, guidance, and funding, operates through ASD(R&E). Specifically, the financial, clearance, and contract support for the SMART program is run through the STEM Development Program within ASD(R&E).



Source: SMART program office.

Figure 4. SMART Program and Management Organization

Sponsoring facilities are responsible for a large portion of administering and delivering the SMART program. These sponsoring facilities are widely dispersed within each Component and the number of facilities is growing. During the first year of SMART program (2006), there were 19 unique sponsoring facilities; in the 2016, the program has grown to have scholars in 169 distinct sponsoring facilities.

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[3] For the purpose of this report, we call laboratories and facilities that do not fall under Army, Navy, or Air Force "DoD Other." Such laboratories and facilities typically support the intelligence community.

To become a participating SMART sponsoring facility, a DoD facility needs to express interest to the SMART program office and complete an orientation training. Note that a sponsoring facility can be removed from the program at the discretion of the SMART program office. In addition, the sponsoring facility must participate or administer key parts of the SMART program, from pre-selection process to Phase III.

2. SMART Program Data by Service and Facilities

Between 2006 and 2016, 169 distinct sponsoring facilities at different locations participated in the SMART program and had at least one SMART scholar at their sponsoring facility. The sponsoring facilities are associated with each of the three Services as well as other DoD agencies that are not part of one of the Services. The Army, Navy, and Air Force have had about an equal number of scholars over the years (see Table 4). The data show that the Navy slightly favors more scholars seeking PhD degrees than the Army and Air Force. The unique number of sponsoring facilities at which scholars are placed vary from Component to Component (see Table 3).

Table 3. SMART Scholarships Awarded by Component and Degree Level, 2006–2016

Component	Bachelor's	Master's	PhD	Total Number of Scholars	Number of Distinct Sponsoring Facilities
Army	301 (47%)	157 (24%)	186 (29%)	644	79
Navy	274 (44%)	142 (23%)	211 (29%)	627	30
Air Force	336 (50%)	178 (26%)	161 (24%)	675	51
Additional DoD Facilities	14 (19%)	13 (17%)	48 (64%)	75	9
Total	**925**	**490**	**606**	**2021**	**169**

Note: Percentages are the percent of the total in a given service.

Table 4 shows the breakdown of STEM degree fields rolled up into higher-level bins within each Component. The Components vary by the disciplines that they seek. For example, the Army tends to hire more civil engineers than other Components, while the majority of aerospace engineers are placed with the Air Force. Scholars seeking computer science degrees are in high demand and are spread across all the three Services and the other DoD agencies.

Table 4. SMART Scholarships Awarded by Component and Degree Field, 2006–2016

Degree Field	Army	Navy	Air Force	Additional DoD Facilities	Total
Biological Science	39	1	10	7	**57**
Computer Science	89	100	93	16	**298**
Earth Science	31	20	2	4	**57**
Engineering	383	418	478	33	**1312**
Mathematical Science	31	36	50	9	**126**
Physical Science	48	40	29	5	**122**
Psychology	23	12	13	1	**49**
Total	**644**	**627**	**675**	**75**	**2021**

Table 5 shows a command-level breakdown of where SMART scholars are placed. The three Services have very different organizational structures that affect how SMART scholars are distributed. For example, nearly 90 percent of Air Force scholars between 2006 and 2016 were placed within a center or laboratory in the Air Force Materiel Command (AFMC) structure. In contrast, the Army places scholars across a variety of commands, though the majority are either within the Army Materiel Command or the U.S. Army Corps of Engineers. With the Navy, about 50 percent of the Navy SMART scholars are placed within the Naval Sea Systems Command (NAVSEA).

Table 5. Breakdown of Awards by Components (2006–2016)

Organization	Defense Laboratory Enterprise (DLE)	Non-DLE	Number of SMART Scholars
Army			
U.S. Army Materiel Command (AMC)	249	25	274
U.S. Army Research, Development and Engineering Command (RDECOM)	249	4	254
Other AMC		21	21
U.S. Army Corps of Engineers (USACE)	92	123	215
U.S. Army Training and Doctrine Command (TRADOC)		47	47
U.S. Army Medical Command (MEDCOM)	11	28	39
U.S. Army Space and Missile Defense Command (USASMDC)	30		30
U.S. Army Test and Evaluation Command (ATEC)		18	18
Other Army		21	21
Total Army	**382**	**262**	**644**

Organization	Defense Laboratory Enterprise (DLE)	Non-DLE	Number of SMART Scholars
Navy			
Naval Sea Systems Command (NAVSEA)	312	21	333
Naval Air Systems Command (NAVAIR)	113	28	141
Space and Naval Warfare Systems Command (SPAWAR)	110		110
Marine Corps Systems Command (MCSC)		18	18
Naval Oceanographic Office		17	17
Naval Research Laboratory (NRL)	3		3
Other Navy		5	5
Total Navy	**538**	**89**	**627**
Air Force			
Air Force Materiel Command (AFMC)	206	413	619
Air Force Research Laboratory (*AFRL)*	206	0	206
Air Force Sustainment Center (*AFSC)*		199	199
Air Force Test Center (*AFTC)*		111	111
Air Force Life Cycle Management Center (*AFLCMC)*		62	62
Air Force Nuclear Weapons Center (*AFNWC)*		15	15
Air Force Materiel Command Headquarters		26	26
Air Force Space Command (AFSPC)		21	21
Air Combat Command (ACC)		20	20
Air Mobility Command (AMC)		11	11
Other Air Force		4	4
Total Air Force	**206**	**469**	**675**
Other DoD	6	69	75
Grand Total	**1132**	**889**	**2,021**

The DoD laboratory and facility structure is not well-defined, nor are the facilities and laboratories placed in a single office within the DoD. Each Service has a "research laboratory" that is within the purview of laboratories and facilities, but there are additional facilities or locations that hire S&E workers and by extension seek SMART scholars. For example, United States Army Corps of Engineers District Offices may not be thought of as a sponsoring facility by some, but they do engineering work and SMART scholars are placed there. Placement of scholars is based mainly on how a particular Component is organized and where its research, development, test, and experimentation activities are conducted.

Figure 5 is a map of all the laboratories and facilities considered to be part of the Defense Laboratory Enterprise (DLE). Table 5 also gives the details of how scholars have been assigned to different commands within the DLEs and outside it. The mission of the DLE is for the DoD's "in-house laboratories, warfare centers, and engineering centers to focus on research and development to deliver next generation capability to the U.S.

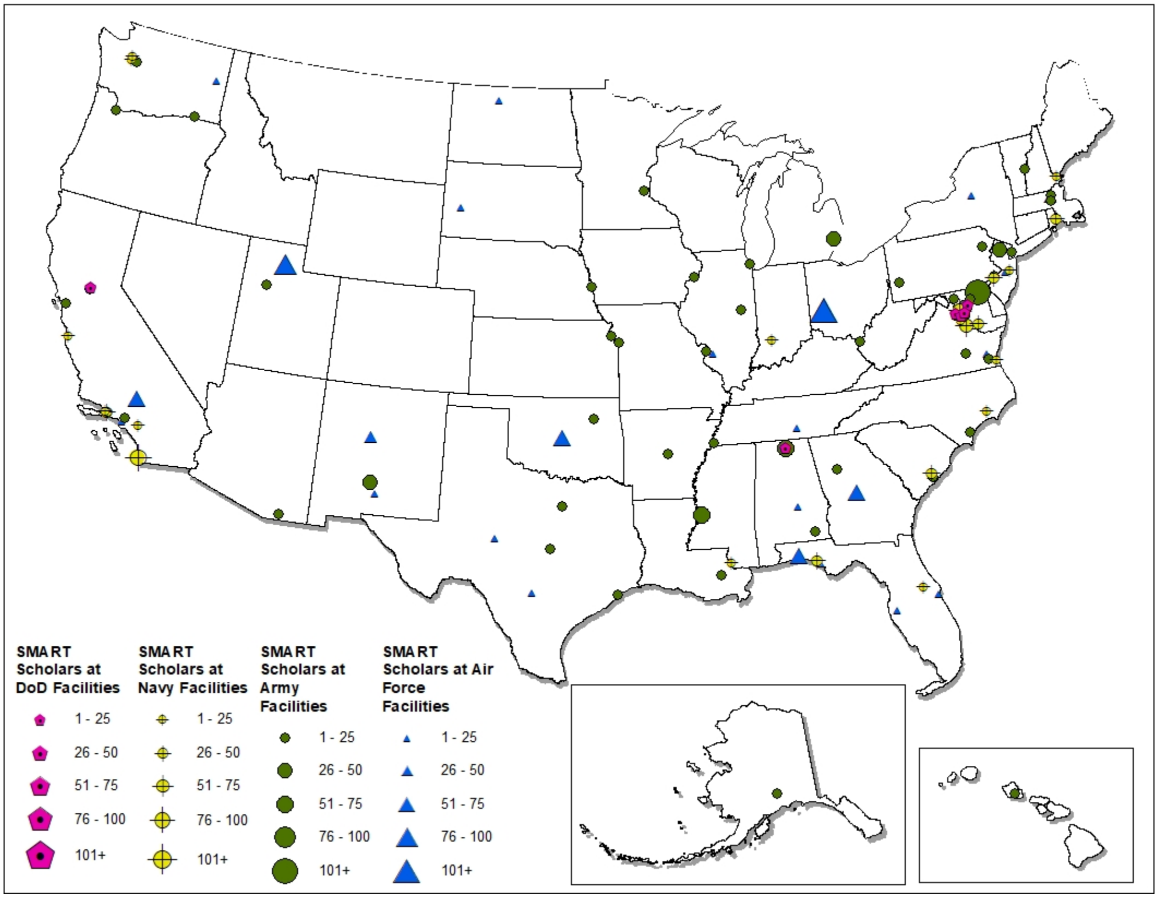


Figure 5. Map of DoD Sponsoring Facilities by Component and Location, 2006–2016

military—providing the warfighter a technical edge."[4] The laboratories and centers that are within the DLE are focused on research and development (R&D) activities, but are not the only facilities where scientists and engineers are hired. We divided the SMART scholars by those within the DLE and those at non-DLE facilities, and found differences both by degree level (BS, MS, or PhD), and by Component. For the most part, PhDs are placed at facilities and laboratories within the DLE across all Components, but at the BS and MS levels the placement varies by Component. The Army and Air Force place several SMART scholars at non-DLE facilities. In fact, AFRL is the only facility listed in the DLE at which

4 https://www.acq.osd.mil/rd/laboratories/.

Air Force places scholars. Based on the DLE structure within ASD(R&E), 56 percent of scholars are in one of the DLE Laboratories or Centers, and the remaining 44 percent are at other facilities or offices that do science and engineering work.

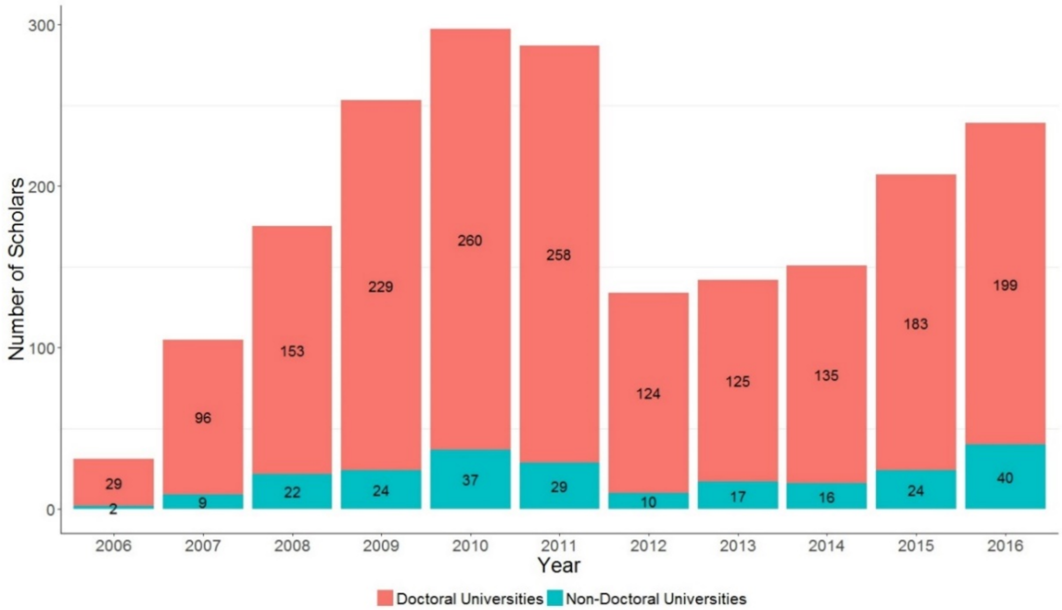
Since the inception of the program, the number of new sponsoring facilities requesting and hiring SMART scholars has risen steadily—an average of 30 new facilities per year. However, the rate of new sponsoring facilities participating in the SMART program decreased since 2012 compared with previous years. In 2016, there was a slight uptick in the number of new sponsoring facilities; this was due to more money in the program and new priorities from the Components, such as increasing the number of computer science workers.

F. Scholars' Institutions of Higher Education

Although universities are not necessarily considered a primary stakeholder of this program, analyzing features of SMART scholar universities provides insight into the quality and the breadth of scholars the program is attracting.

Figure 6 breaks down the number of scholars per year by two institutional classes: doctoral universities and non-doctoral universities. The majority of SMART scholars (89 percent) attended 211 doctoral universities, which suggests that the scholars are being trained at institutions with a strong research focus. Over the 11-year period, about 8.7 percent of scholarships (176) have been awarded to scholars studying at a top-20 university.[5] The number of new institutions of higher education that have SMART scholars in attendance has increased over the life of the SMART program. This increase has come more from the non-doctoral institutions than from doctoral institutions.

[5] Top-20 University is based on the 2016 *U.S. News and World Report* top universities and colleges list.



Note: Doctoral Universities are based on the 2015 Carnegie Classification and are a combination of the Highest Research Activity Institutions, Very High Research Activity Institutions, and Moderate Research Activity Institutions; Non-Doctoral Universities are all other institutions of higher education listed in the Carnegie Classification System.

Figure 6. Number of SMART Scholars Per Year by Type of Institution, 2006–2016

3. Recruitment

This chapter lays out findings related to two key study questions on recruiting SMART scholars: 1) *To what extent did the SMART program attract S&Es who would not have normally worked at DoD?*; and 2) T*o what extent did the SMART program attract a more diverse set of S&E workers to the DoD as compared to the broader DoD S&E workforce?* We also include a section on scholar and S&E manager perspectives relevant to recruitment.

A. Attracting Talent

1. SMART Program Awareness and Information Sources

From analysis of application data and the SMART scholar survey, we understand that overall, SMART scholars learn about the program more through word of mouth and formal recruiting efforts. Six survey items assessed SMART scholars' mode of awareness of the SMART program. The survey revealed that scholars were most likely to report becoming aware of the SMART program through word of mouth (63 percent) and through department advertisements (36 percent); see Figure 7.

Figure 7. Overall Awareness of SMART

Scholars are not necessarily learning about the SMART program through targeted recruitment efforts. In interviews with academics, we understood that academic advisors lacked information about the program. Advisors wished they had more information about the program so they could advertise it to other students. A few S&E managers also mentioned that the SMART program could be better advertised to students and administrators.

Furthermore, academic advisors remarked that an important aspect of recommending the SMART scholarship to students was whether the student had interest in performing Research, Development, Test & Evaluation applied to national security missions and pursuing a DoD career. These seemed to be prerequisites before academics recommended the SMART program to their students. In a few cases, academics did not have full understanding about the eligibility requirements and thought that the SMART scholarship was limited to DoD employees. Upon hearing that eligible candidates could be current students without prior DoD work experience, they generally responded that they would recommend the program to their students in the future. Although recruitment at academic institutions, career fairs, and conferences may still contribute overall to spread the word about SMART, it is worth considering refocusing recruitment efforts at the SMART program level. The program could build stronger ties with key academic departments and universities and rely on current scholars studying at those institutions or departments to recruit scholars and support applicants through the application process.

Similarly, there were S&E mentors and supervisors who had worked or were currently working with SMART scholars seemed unfamiliar with how the program worked. As with academic advisors, it could be useful to provide S&E mentors and supervisors at sponsoring facilities with basic information about the SMART program and its processes. These mentors and supervisors could also be reached during the recruitment and application season to spread the word about the SMART program to their professional network.

Considering that a majority of scholars hear about the SMART program through word of mouth, the SMART program, by establishing a sense of presence and prestige through branding, could influence academic advisors and mentors at sponsoring facilities to recommend students to apply to the SMART program, and students in turn might be more motivated to apply. One possible pilot that the SMART program could consider is recruiting through DoD researchers who are selected for DoD's Laboratory University Collaboration Initiative (LUCI) award or the Vannevar Bush Faculty Fellows who are academics. LUCI is designed to engage leading university scientists and their students, introduce them to the DoD research environment, and have them work with top DoD researchers to address long-term DoD basic research needs (U.S. Department of Defense 2017). In contrast, the Vannevar Bush Faculty Fellows are academics who receive DoD support to carry out cutting-edge research in areas of critical interest to DoD. Both these initiatives aim to build stronger academic ties between the DoD research laboratories and academic institutions. Focusing recruiting efforts here could result in a graduate students who bridge the research between a DoD facility and an academic institution and could also help leverage existing DoD investments in basic research.

2. Motivations to Apply

The SMART program used a variety of mechanisms to recruit scholars to the program. The survey results reveal some interesting findings regarding the motivation for scholars to apply to the program, and these motivations differ slightly between recruitment scholars and retention scholars. Figure 8 describes the responses to survey questions regarding scholar's motivation for applying. Nearly all survey respondents (98 percent) indicated that *financial assistance* was an important or somewhat important factor in their decision to apply to the SMART program. This reason was followed by recruitment scholars receiving a *guaranteed job* after graduation (65 percent) and an *interest in serving the DoD mission* (74 percent). We felt that understanding the extent to which a scholar's interest in serving the DoD mission could be an important factor in predicting or explaining outcomes such as retention or a scholar's overall satisfaction with the program and have incorporated this variable into statistical models described later in the report.

The SMART scholarship drew from a group of students applying as recruitment scholars who may not have otherwise worked for the DoD had it not been for this scholarship opportunity. Figure 9 describes findings based on career plans of scholars at the time of the application. About one third (30 percent) of scholars strongly agreed or somewhat agreed *they were not aware of S&E workforce opportunities at DoD* prior to applying to the SMART program. In contrast, about half (53 percent) of recruitment scholars strongly agreed or somewhat agreed that they w*anted to work for the DoD regardless of their acceptance to the SMART program*, and about one third (36 percent) of recruitment scholars strongly agreed or somewhat agreed they *wanted to work at their Sponsoring Facility regardless of their acceptance to the SMART program.* These variables were also used as factors to better understand the outcomes of the SMART program, and are used later in the report.

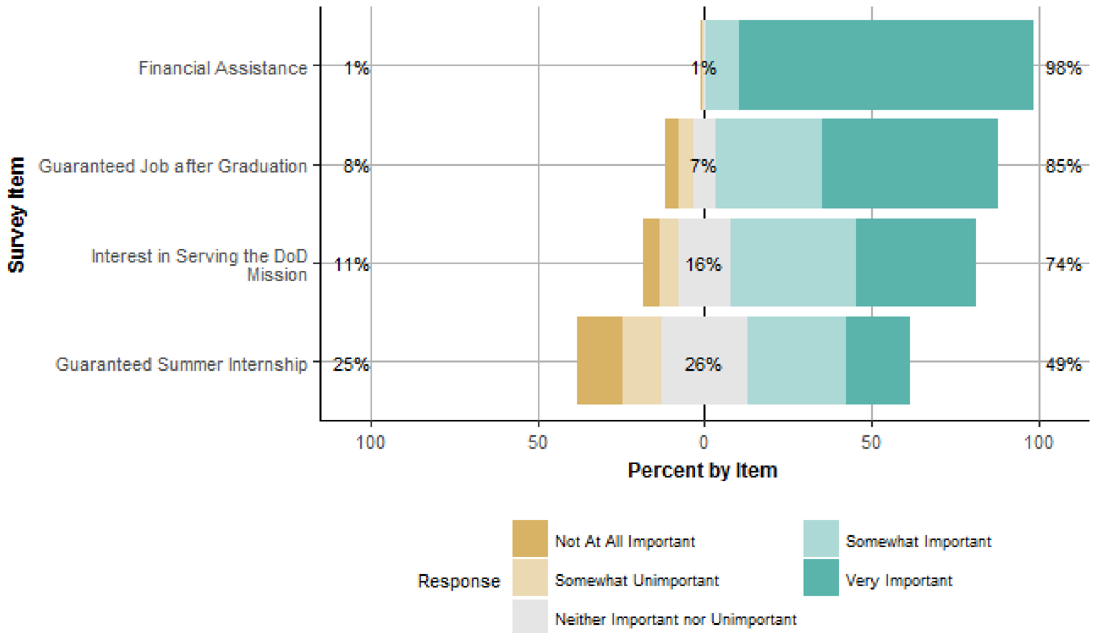


Figure 8. Motivation for Recruitment Scholars Applying to SMART Scholarship

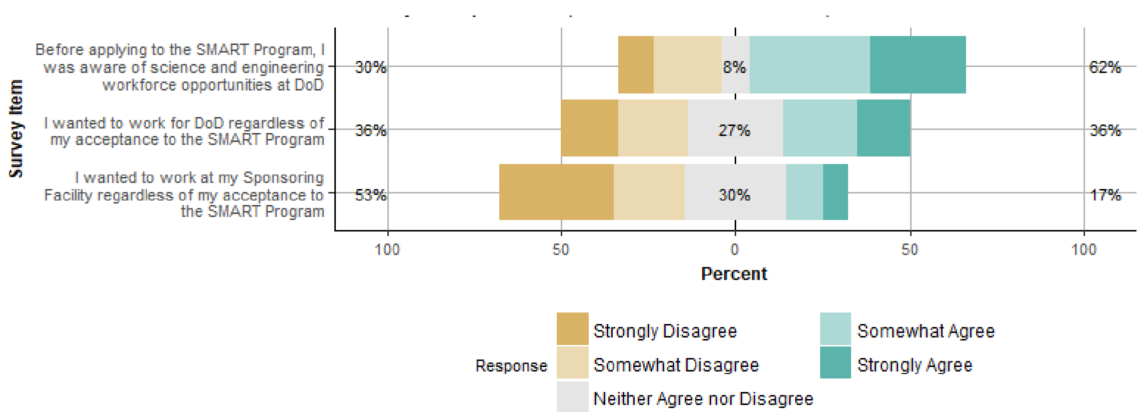


Figure 9. Knowledge and Interest in DoD Employment at Time of Application

3. S&T Manager Perspectives' on Applicants

S&T managers who had been involved in hiring both traditional employees and SMART Scholars were asked a series of questions regarding their experience with hiring. In particular, S&T managers were asked to compare applicant pools between traditional employees and SMART Scholars (*SMART applicants come from a larger pool of universities than traditional applicants*) and (*SMART applicants fill a niche area/discipline*) (Figure 10).

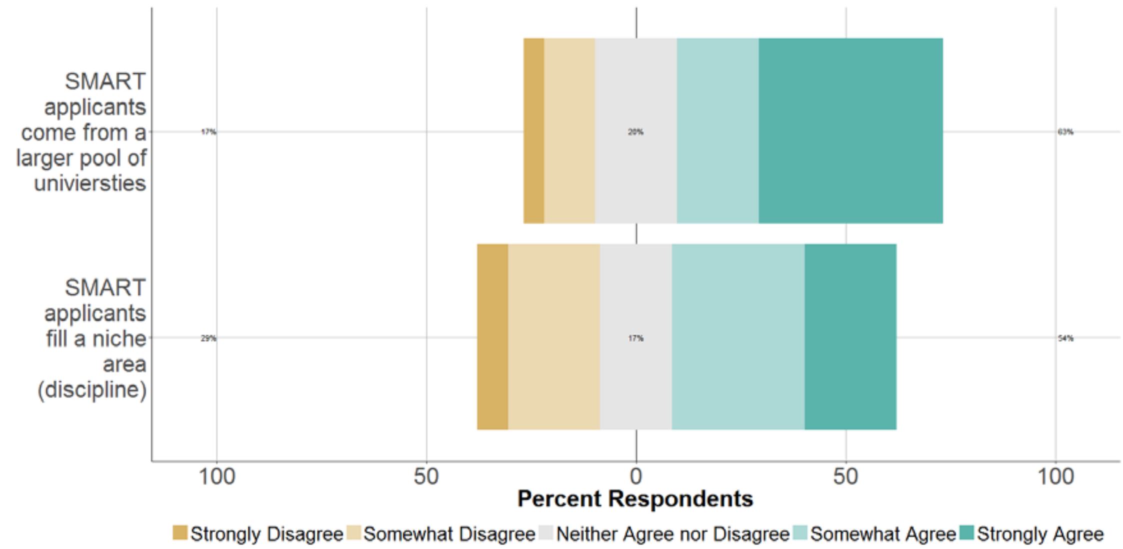


Figure 10: S&T Manager Comparisons between SMART Scholars and Other S&E Workers

A majority of S&T managers (63 percent) strongly agreed or somewhat agreed with the statement *SMART applicants come from a larger pool of applicants as compared to traditional applicants*. One S&T manager even indicated that one of the main advantages of relying on the SMART program is the ability to bring in new talent from universities they would not normally hire from, in particular, non-local universities. This S&T manager saw the ability to hire scholars from a broader range of universities as a way to diversify the workforce. Other interviewees (20 percent) neither agreed nor disagreed with the statement and less than a fifth (17 percent) of interviewees strongly disagreed or somewhat disagreed.

Fifty-four percent of S&T managers strongly agreed or somewhat agreed with the statement *SMART applicants fill a niche area (discipline*); seventeen percent neither agreed nor disagreed; and twenty-nine percent strongly disagreed or somewhat disagreed. Some interviewees who responded neutrally or negatively to this construct indicated that they are able to get talent with similar backgrounds or disciplines with their traditional hiring avenues as compared to SMART scholar applicants. Other S&T managers said they do not necessarily use the SMART program to fill one specific (or niche) discipline. Several S&T managers who responded negatively to this construct clarified that even though SMART scholars do not necessarily fill a niche, they still thought the SMART program is valuable and that their scholars are well prepared to execute their jobs.

Additional comments included an emphasis that SMART program brings applicants with a high level of quality even if they do not fill a niche area or come from a larger pool of universities. For example, one S&T manager thought that applicants in the SMART pool tended to have higher GPAs than those in the traditional-recruitment pool of candidates.

B. SMART Attracting A More Diverse Worker

In this section, we lay out findings describing whether the SMART program attracted a more diverse set of S&E workers to the DoD as compared to the broader DoD S&E workforce. Recruiting a more diverse S&E population is not an explicit goal of the program under its legislative authority. However, in 2011 ASD(R&E) issued a memo regarding their commitment to reinvigorating their relationship with Historically Black Colleges and Universities (HBCUs) and Minority-Serving Institutions (MIs) (Lemnios 2011). In this memo, ASD(R&E) asked its offices to: (1) ensure HBCUs and MIs are aware of activities and opportunities within the DoD; better connect with talent at HBCUs and MIs; and (2) emphasize recruiting and selection from HBCUs; and MIs for STEM scholarships, fellowships, and internships. Responding to this direction, the SMART Program has adopted diversity through HBCU and MI recruitment as a goal.

In addition to receiving direction from leadership regarding diversity, other stakeholders in the SMART program have also indicated they value diversity and look to the SMART program for increasing diversity in their workforce. S&E mentors and managers indicated in interviews that they are interested in using the SMART program as a hiring tool to increase diversity in their workforce. The following sections detail the SMART program's recruitment strategy, application selection, comparison to the DoD S&E workforce, and overarching findings regarding diversity.

1. Strategy for Increasing Diversity

Over time, the SMART program office has developed a strategy for recruiting students from underrepresented minorities (URM) groups. Since at least 2011, diversity has become more of a focus for recruiting efforts. When interviewed in 2015, SMART program support contractors, primarily the SMART Service Liaisons, recruited URM SMART scholar candidates by attending recruiting events focused on URM populations at professional association meetings, such as the Society of Women Engineers, the National Society of Black Engineers, and the Society of Hispanic Professional Engineers.

The SMART program office also works with established HBCU and MI programs within the STEM development office as a part of their recruiting effort. There are limitations, however, to recruiting from HBCUs and MIs. The SMART program office has expressed challenges using this approach only. Additionally, the SMART program office may consider recruiting at universities that have large percentages of URM students.

2. Demographics of S&E Degree Holders

The population of S&E degree seekers who are eligible to apply to the SMART program is large, and the diversity of this group is not at parity with the overall population of the U.S. or even U.S. college graduates as a whole. We analyzed the U.S. Citizen and Permanent Resident S&E degree recipient data based on National Science Foundation

(NSF) Science and Engineering Indicators by race and ethnicity (Table 6). For bachelor's degree holders, 63 percent of the population was White; 12 percent Asian; 11 percent Hispanic; and 6 percent Black or African American (National Science Foundation 2018).[6] The percentage breakdown is similar for master's degree recipients. However, the percentage of White individuals increases for doctoral degree recipients; 69 percent of doctoral degree recipients are White. This trend holds for sex as well—62 percent of bachelor's degree recipients are male and 65 percent of doctoral degree recipients are male. The values in Table 6 represent the potential applicant pool that the SMART program can draw from and provide a baseline comparison of demographics of this potential candidate pool.

Table 6. S&E Degree Recipients in 2015 by Ethnicity, Race, and Sex

	Category	Bachelor's Degrees (*N* = 357,571, %)	Master's Degrees (*N* = 125,058, %)	Doctoral Degrees (*N* = 41,098, %)
Ethnicity	Hispanic	11%	8%	6%
Race	American Indian or Alaska Native	<0.5%	<0.5%	<0.5%
	Asian	12%	13%	10%
	Black or African American	6%	7%	5%
	Native Hawaiian or Pacific Islander	NA	<0.5%	<0.5%
	White	63%	62%	69%
	Multiracial	3%	3%	2%
	Unknown or Do not wish to respond ethnicity	4%	8%	8%
Sex	Male	62%	66%	65%
	Female	38%	34%	35%
	Unknown	0%	0%	0%

Source: NSF S&E Indicators 2018.

Note: Ethnicity and race are mutually exclusive and should add up to 100 percent. This is different from how DoD and the SMART program classifies race and ethnicity.

3. Diversity of SMART Candidate Pool through the Application Process

Since 2014, the SMART program has collected statistics on the number of accounts created on the application portal (started applications) and the number of applications

6 The racial breakdown is for all non-Hispanics.

completed. In 2016, the program started collecting data on the number of applications "submitted" which differentiates between applicants who completed the applications and the completed applicants who met the eligibility criteria. Table 7 shows the percentage of each race, ethnicity, and sex at each point of the application process.

Table 7. Percentage of SMART Applicants by Ethnicity, Race, and Sex and by Phase of Selection Process, 2016

	Category	Started	Completed	Submitted	Awarded
Ethnicity	Hispanic	14%	9%	10%	5%
Race	American Indian or Alaska Native	3%	2%	2%	2%
	Asian	9%	8%	8%	8%
	Black or African American	26%	15%	17%	9%
	Native Hawaiian or Pacific Islander	1%	1%	1%	<.5%
	White	53%	67%	66%	75%
	Two or more races	NA	NA	NA	NA
	Unknown or Do not wish to respond	8%	6%	6%	6%
Sex	Male	53%	61%	62%	69%
	Female	46%	37%	37%	31%
	Unknown	1%	1%	1%	0%

Source: SMART administrative data.

Note: Values within a column may not sum to 100% due to rounding errors. Data are not strictly comparable as NSF data only includes non-Hispanic for race whereas SMART program data considers race and ethnicity independently. The awarded data are scholarship offers and not award acceptances.

We find that over the course of the application process, the candidate pool becomes less diverse. White applicants become a larger percentage of the population as the application process progresses; 53 percent of applicants who start are White while 75 percent of applicants offered an award are White. In contrast, URMs tend to make up a smaller percentage of population as the application process progresses. For example, Black applicants make up 26 percent of those who start an application. However, out of those applicants selected for an award, only 9 percent of the population are Black. Similarly, the data on applicant's sex as reported by the SMART program office indicates that that as the application process progresses and gets more selective, males tend to make up an increasingly larger percentage of the candidate pool. Fifty-three percent of applicants who start an application are male, and 69 percent of those awarded a scholarship are male.

When comparing these data to those of S&E degree holders, we find that the population starting the applications is more diverse than the S&E degree holders, but by the end of the application process when comparing with awards, the demographic breakdowns are comparable with some slight differences. For example, 26 percent of individuals who started the application process in 2016 were Black and 9 percent of those who were awarded a 2016 SMART scholarship were Black. The S&E degree holder data indicates that 6, 7, and 5 percent of bachelor's, master's, and doctoral degree S&E recipients are Black, respectively. The trend is similar for ethnicity and sex whereby applicants who start the application are more diverse, but those who ultimately get the scholarship are within a 5 percent margin to the S&E population.

4. SMART Awardee Trends

Table 8 describes the demographic breakdown of all 2021 scholarships from 2006–2016 based on SMART program office administrative data. For ethnicity, Hispanic students make up 4 percent of scholarship awards. By race, 79 percent of awards went to White students, 6 percent of awards went to Asian students, and 5 percent went to Black or African American students. Seventy percent of scholarships went to male students and 28 percent went to female students. The section on the S&E Workforce Comparison provides data on these individual's DoD counterparts.

Table 8. Percentage of SMART Scholarships by Race, Ethnicity and Sex, 2006–2016

	Category	% of Scholarships
Ethnicity	Hispanic	4%
	Not Hispanic	87%
	Do not wish to respond	10%
Race	American Indian or Alaska Native	1%
	Asian	6%
	Black or African American	5%
	Native Hawaiian or Pacific Islander	1%
	White	79%
	Two or more races	NA
	Unknown or Do not wish to respond ethnicity	7%
Sex	Male	70%
	Female	28%
	Unknown	2%

Source: SMART administrative data.

Over the past 5 years, the number of applicants to the SMART scholarship program has been steadily increasing. However, the diversity of the awardees has changed by sex, but not race ethnicity. Figure 11 shows the percentage of awardees by race from 2006 to 2016. The breakdown of started, completed and submitted applications over time by race follows a similar trend.

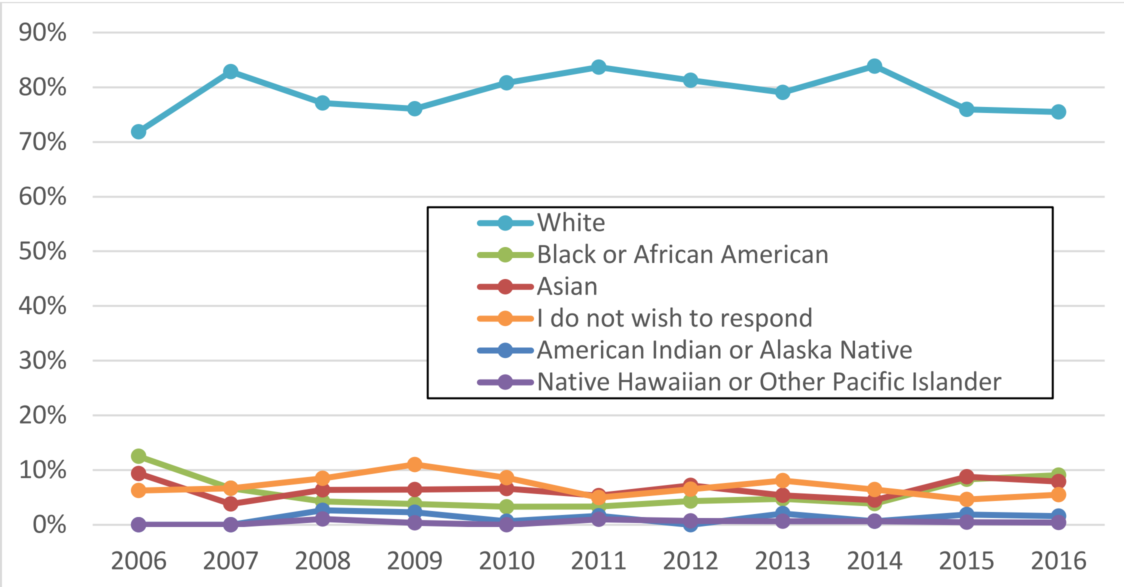


Figure 11. Percentage of SMART Scholar Awardees by Race over Time

As shown in Figure 12, changes in the ethnicity of SMART awardees over time follow the same trends as race. The participation trends at each stage of the application process have been fairly flat over time, though in 2015, there was a huge uptick in the number of applicants that chose "do not wish to answer" for the ethnicity question.

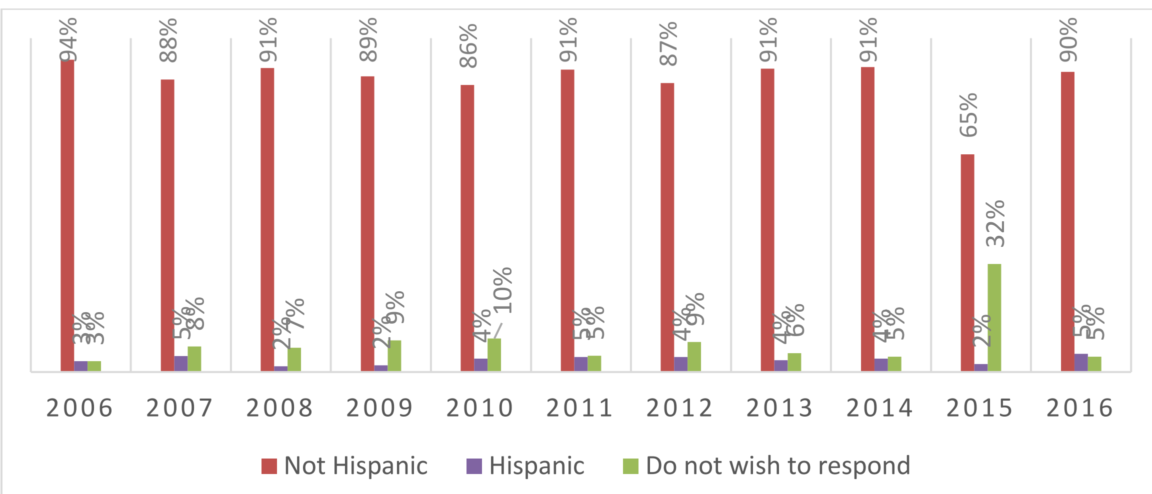


Figure 12. Percentage of SMART Scholar Awardees by Ethnicity over Time

In Figure 13, the trend is more favorable for SMART scholar awardees in terms of gender diversity over time. The percentage of SMART scholar awardees that are female has risen from 16 percent in 2006 to 31 percent in 2016.

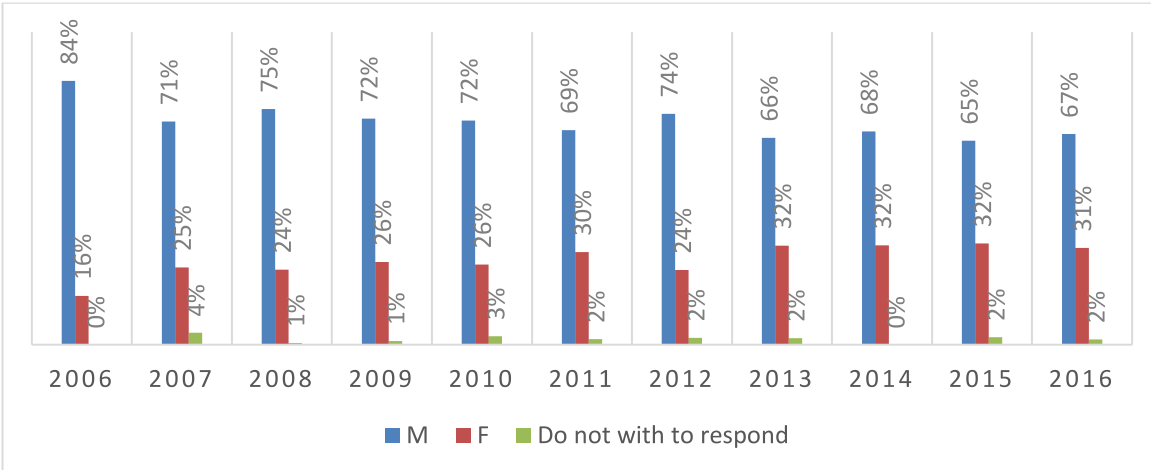


Figure 13. Percentage of SMART Scholar Awardees by Gender over Time

5. S&E Workforce Comparison

To determine whether SMART scholarship recipients are more diverse than their counterparts, we compared the population of the SMART scholars found in DMDC (*N* = 1,244) to the DoD civilian S&E population (*N* = 188,904) using a one sample proportions test.[7,8] These data also demonstrate that as of 2016, SMART scholars hired into the DoD workforce represented about 0.7 percent of the DoD S&E civilian population. There are two main findings from this comparison. First, the percentage of SMART scholars who are female is statistically significantly larger than the percentage of the DoD civilian S&E population who are female; 26 percent of SMART scholars are female while 21 percent of the DoD civilian S&E population is female. These percentages reported in Table 9 differ from those reported in Table 9 because Table 9 reflects the population of scholars hired into the DoD between 2006 and 2016. Second, in terms of race and ethnicity, SMART scholars are less diverse than the DoD S&E civilian population. Three percent of SMART scholars hired into the DoD civilian S&E workforce are Black while 8 percent of the DoD S&E civilian population is Black, and 3 percent of SMART scholars hired are Hispanic while 4 percent of the S&E civilian population is Hispanic. The population of White

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7 The S&E civilian population is based on individuals that have one of 77 occupation codes defined by OPM as S&E occupations.

8 The population found in DMDC is similar to SMART scholars in all phases. However, because the way demographic data was collected, it is difficult to make a direct comparison.

SMART scholars is significantly higher than the DoD S&E civilian population—91 percent of SMART scholars hired are White while 78 percent of the comparison is White.[9]

Table 9. Ethnicity, Race, and Sex for Hired SMART Scholars and DoD S&E Civilian Population

	Category	DMDC SMART Scholars (*N* = 1,244)	DMDC SMART Scholars (%)	S&E Civilian Population (*N* = 188,904)	S&E Civilian Population (%)
Ethnicity	Hispanic **	32	3%	7,863	4%
	Not Hispanic ***	1195	96%	177,069	94%
	Unknown	17	1%	3,972	2%
Race	African American or Black ***	40	3%	14,617	8%
	American Indian or Alaskan Native	10	1%	1,604	1%
	Asian	45	4%	8,534	5%
	Multiracial *	19	2%	1,769	1%
	Native Hawaiian or Pacific Islander	3	0%	782	0%
	Unknown ***	35	3%	17,283	9%
	White ***	1130	91%	148,116	78%
Sex	Female ***	323	26%	40,605	21%
	Male ***	921	74%	148,292	79%
	Unknown			7	0%

Source: DMDC civilian S&E workforce dataset.

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***. Individuals that are multiracial are represented in the table more than once, thus the percentages do not add up to 100%. All statistics are based on a one sample Z test of proportion with continuity correction. Significant test results are as follows: Hispanic (Z = 2.74, p = 0.0062), Not Hispanic (Z = 3.33, p < 0.001), African American or Black (Z = 5.92, p < .001), Multiracial (Z = 2.02, p = .044), Unknown Race (Z = 7.70, p < .001), White (Z = 10.62, p < .001), Female (Z = 3.80, p < .001), Male (Z = 3.80, p < .001).

9 The population of those that are Multiracial or are of unknown race is also significantly different. However, those that began in the dataset in 2006 are coded as unknown rather than multiracial even if they are, in fact, multiracial. Therefore, this discrepancy may be likely that more of the S&E population was in the dataset in and prior to 2006.

C. Other Findings Related To Recruitment

1. Recruiting Process for Other Scholarship for Service Programs

IDA conducted another study of other Scholarship for Service (SFS) programs and found that other SFS programs, similar to the SMART program, engage in a wide range of practices to attract applicants, including preparing program documents and other marketing materials and maintaining a social media presence (Peña et al. 2016). In discussions at the workshop, program officials generally viewed scholarships for full tuition as having sufficient appeal to draw highly qualified applicants. However, there are differences in visibility of programs across university faculty and students. The discussion focused primarily on three areas of recruitment: branding and direct interactions, online presence, and leveraging alumni networks. From the study of other programs, we learned that the program-university relationship is extremely important for shaping and guiding students through the application and review processes. In some programs, such as the Reserve Officers Training Corps (ROTC), the visibility of the program is widespread because it is integrated into the university through the development of curricula and other academic programs. Similarly, programs with greater involvement of universities in the review and selection of scholars may also have greater reach into those universities. An example is the Truman program, which by design, has dedicated representatives in college offices. These representatives are typically fellowship, study abroad, or career advisors. The Truman program uses these representatives to disseminate information about the program to the university's student body. The Truman program officials also interact with faculty representatives from universities through informal discussions, by visiting universities and hosting seminars to explain policies, and by attending university scholarship conferences, among other means.

Other programs, such as The Pickering program, have ongoing relationships with education professional societies and university career services staff to the same end. For example, the Truman and Pickering programs engage with faculty through the National Association of Fellowship Advisors and the Association for Professional Schools in International Affairs to raise awareness of their programs and address program policies and issues with the broader faculty community (National Association of Fellowship Advisors 2015, Association of Professional Schools of International Affairs 2016). These connections provide resources to faculty and may contribute to a broader applicant pool for programs.

Regardless of how connections were made, workshop attendees agreed that it was important to have sustained and quality contact with colleagues at universities. In particular, it was viewed that these points of contact are important to disseminating information about scholarship programs to students. Some workshop attendees also discussed the importance of establishing the branding and reputation of the program itself.

Branding may involve emphasizing the benefits, competitiveness, and prestige of the scholarship or fellowship itself or the prestige of working in a particular area within the Federal Government. Branding may require educating the public on professional opportunities within the U.S. Government and potentially tailoring that message, depending on the target audiences.

Establishing ties with universities can also be facilitated through program alumni and by word of mouth, which SFS programs noted was the primary source by which awardees heard about their programs. Some discussed the potential of leveraging alumni communities for helping spread the word about program opportunities. Alumni networks may be able to help advertise the scholarship programs at their alma maters, at local universities, or within their professional networks.

2. Comparison to other SFS Programs: Diversity

There are a variety of diversity strategies employed by other SFS programs that are beneficial for those programs—for example, explicitly stating that increasing diversity *is* a goal and designing programs to address that goal. In some programs, such as the Central Intelligence Agency's Undergraduate and Graduate Scholarships and DoD's Information Assurance Scholarship Program, financial need is an eligibility criterion that factors into goals to increase the diversity of scholars in the hiring pipeline. Another way that SFS programs have addressed diversity is by exchanging candidates' information with other SFS programs. For instance, ROTC works with the offices of congressional representatives to obtain information about those candidates who were not nominated but were finalists for the Congressional Black Caucus scholarship program. Another approach by some SFS programs is being more aware of their audience and how to present their programs to that audience. For example, students coming from lower socioeconomic status backgrounds may not be as familiar with opportunities and may need more support navigating the application process.

D. Overall Recruitment Findings

There are two main themes associated with the recruitment findings. The first addresses the extent to which the SMART program attracted S&E workers who would not have normally worked at the DoD. The second theme addresses findings related to the diversity of the SMART scholars as compared to the broader DoD workforce and even the pool of candidates from which the SMART program is recruiting.

Regarding attracting new workers, we found that about 30 percent of SMART scholars surveyed were not aware of S&E workforce opportunities at DoD prior to applying indicating that a number of scholars who join the DoD workforce through the SMART scholarship would not have otherwise come. Furthermore, almost all scholars said they were motivated to apply for financial assistance, and about three-quarters said they were interested in serving the DoD mission indicating that their motivation to apply were driven more by financial interest than interest in the work or mission itself.

The other theme relates to diversity. We found that the SMART program has greater gender diversity (26 percent of scholars hired into DoD) than the DoD S&E workforce (21 percent). The gender diversity of SMART scholars has been increasing since the start of the program. In 2006, 16 percent of SMART scholars were female and by 2016, 31 percent were female. However, as compared to S&E degree holders or the pool of applicants from which they are recruiting, SMART scholars have less gender diversity. In 2015, female degree recipients made up 38 percent, 36 percent and 35 percent of the S&E degrees, while females only made up 28 percent of SMART scholarships awarded that same year.

In contrast, the racial diversity of the SMART scholars has not changed over time and SMART scholars are less diverse than both the pool of S&E applicants receiving STEM degrees and the overall DoD S&E workforce.

4. Quality

Measuring the quality of a worker or work is challenging, but we attempted to do so in order to answer one of the main study questions: *To what extent did the SMART program improve the quality of the civilian S&T workforce?* Several approaches were taken to assess the quality of the SMART scholars.

We first looked at the quality of the scholar prior to being hired into the DoD workforce using three metrics: 1) quality of PhD institution, 2) quality of publications published during PhD, and 3) starting salary of scholar. We then looked at the quality of the scholar once they were hired at the DoD by evaluating their: 4) rate of salary increase, 5) promotion rate, 6) perceptions of performance by S&E managers, and 7) quality of all publications.

A. Pre-Hiring Quality

1. PhD Institutions

Measures of worker quality are hard to quantify, but one approach many suggest is looking at the caliber of higher education institution attended by the SMART scholars and their comparison group. We analyzed this for just the PhD scholars in their service commitment phase and their post-service commitment phase, and their comparison group PhD S&E worker matched pairs identified using the propensity score matching technique (see Appendix C).

Table 10 shows the breakdown of the Carnegie Classifications of PhD institutions for the two groups, SMART PhD scholars and comparison group S&E PhD workers. We know all the SMART scholar’s PhD institutions based on administrative data, and had to look up the PhD institutions of the comparison group workers. We were able to disambiguate and identify the higher education instructions of 191 PhD comparison group S&E workers—about 80 percent of the comparison group. Based on a Fischer Exact Test, we found a statistically significantly higher percentage of SMART scholars attended institutions classified as Doctoral Research University-Highest Research Activity than the S&E comparison group.

Table 10. Carnegie Classification of SMART Scholars with PhD Hired into DoD Compared with Comparison Group PhD Civilians

Carnegie Classification	SMART Scholar PhD Institutions *N* = 240	Comparison Group S&E PhD Institutions *N* = 191
Doctoral Universities: Highest Research Activity	83%*	70%
Doctoral Universities: Higher Research Activity	12%*	20%
Doctoral Universities: Moderate Research Activity	3%	4%
Master's Colleges & Universities: Larger Programs	0%	3%
Master's Colleges & Universities: Medium Programs	0%	1%
Master's Colleges & Universities: Small Programs	0%	0%
Baccalaureate Colleges: Arts & Sciences Focus	0%	1%
Special Focus Four-Year: Medical Schools & Centers	0%	1%
Special Focus Four-Year: Engineering Schools	0%	0%

Source: Carnegie Classification 2015

Note: PhD Institution Affiliations for 49 S&E civilians in the comparison group were not found. Statistics are based on a Fisher's Exact Test. $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

We also compared the 2016 average R&D expenditures associated with each group's PhD institutions at three levels—average DoD R&D expenditures, average Federal R&D expenditures, and average total R&D expenditures using a Wilcoxon rank-sum test. R&D expenditures of an institution can be an indicator of an institution's capacity to conduct R&D and train students—another metric of quality.

Table 11 shows the results of the R&D expenditures analysis. We found that for all three indicators, SMART scholars' PhD institutions had statistically significantly higher average R&D expenditures than the PhD institutions of the S&E comparison group. For SMART scholar PhD institutions, the average DoD R&D expenditure in 2016 was approximately $53,000 per scholar while the PhD institutions of the comparison group spent on average approximately $42,000 per comparison group worker. This difference held for the average Federal R&D expenditure per person as well as the average total R&D expenditure per person.

Table 11. Average R&D Expenditures Per Person for SMART and Comparison Group PhD Institutions, 2016

	SMART Scholar PhD Institutions, N = 240	Comparison Group S&E Civilians PhD Institutions, N = 191
Average DoD R&D Expenditures	$53,052	$42,007***
Average Federal R&D Expenditures	$281,288	$248,161***
Average Total R&D Expenditures	$536,560	$457,019***

Source: Higher Education Research and Development Survey, 2016, https://www.nsf.gov/statistics/srvyherd/
Note: Statistics are based on a Wilcoxon rank sum test $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***.

2. Bibliometrics During PhD

We analyzed the differences between the "quality" of publications for SMART PhD recruitment scholars and their PhD S&E comparison group.[10] Using the field weighted citation index (FWCI) and the number of highly cited papers in a field (see Appendix C for more details), we were able to determine if the quality of PhD workers hired at the facilities differed between the SMART scholars and traditional S&E PhD hires. The FWCI calculates the number of citations a given research has received divided by the average number of citations in a field. But normalizing the metric by a field of science, we can compare researcher's citation rates across fields. Because we used the propensity score matching technique to identify the PhD S&E comparison group, we only analyzed PhD scholars who were hired at the sponsoring facility. We found PhD institutions and unique identifiers in Elsevier's Scopus Database for 207 of the 240 PhD SMART scholars and 195 of the 240 comparison group PhD S&E workers. We analyzed the FWCI for both groups, and looked at the number of highly cited papers for each group. We found no statistically significant difference between SMART PhD scholars and their S&E comparison group during their doctoral pursuit.

3. Starting Salary

Using the salary data from the DMDC database, we modeled the starting salary for recruitment scholars and their comparison group using linear regression, and controlled for demographic and occupation related characteristics of the individual. We found that SMART recruitment scholars have a lower starting salary than their counterparts, controlling for other variables.[11] Descriptively, this is also evident from Figure 14, which indicates that the salary of SMART recruitment scholars does not catch up to the salary of their comparison group using the propensity score matching approach. Additionally, there

[10] Given approach used in matching, it was not possible to determine an appropriate S&E comparison group to find PhD retention scholars hired at the same time.

[11] $\hat{\beta}$ = -$4,756.38, $p < 0.001$

are some variables are associated with lower starting salaries for both SMART scholars and their comparison group, controlling for everything else—S&E civilians in the Army have a lower starting salary compared to other Services. Also younger civilian S&E workers, S&E civilians with bachelor's degrees, and S&E civilians who did not report ethnicity compared to non-Hispanic employees also have a lower starting salary. Because we did not obtain salary data prior to 2006, we did not have the starting salary for several SMART retention scholars and their comparison groups, therefore they are excluded from this analysis.

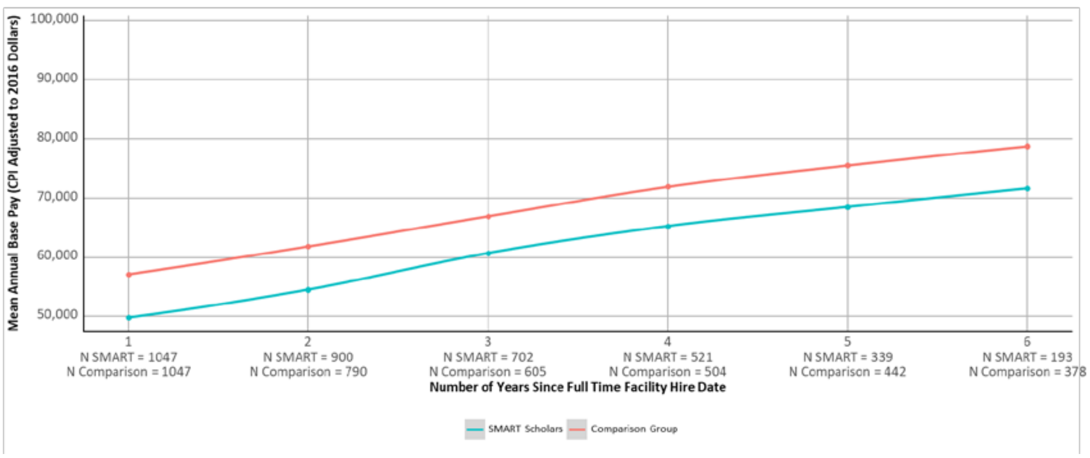


Figure 14. Salary for Recruitment Scholars and Comparison Group

We also used a multi-level modeling approach (in contrast to the propensity score matching approach) to understand differences between SMART scholars and their counterparts. This statistical approach affords the ability to handle individuals assessed at different chronological times, unevenly spaced time intervals, and individuals who contribute different numbers of observations. See Appendix E for more details on how the predicted values are generated. Across all education levels, we found that SMART recruitment scholars have lower starting salaries, controlling for age, sex, race, and occupation. This effect is more pronounced at the master's and doctoral levels (Table 12).

Table 12. Predicted Salary Differences across Degree Level for SMART Recruitment Scholars and Comparison Group Scholars

Degree Level	SMART Status	Starting point	Predicted increase in salary every two years	Predicted salary 5 years post-grad
Bachelor's	SMART Scholar	$40,632	$5,682 + $2,110	$62,924
	Comparison Group	$41,249	$5,682	$61,399

Degree Level	SMART Status	Starting point	Predicted increase in salary every two years	Predicted salary 5 years post-grad
Master's	SMART Scholar	$45,423	$2,364 + $980	$60,902
	Comparison Group	$55,395	$2,364	$64,022
Doctoral	SMART Scholar	$60,794	$2,876 + $616	$71,305
	Comparison Group	$67,279	$2,876	$74,610

Note: Predicted salaries across these 500 bootstrapped samples for *N* = 1,067 SMART scholars and sampled comparison group S&E workers. The predicted salary is in reference to graduation date not hire date Statistical significance can be inferred from Appendix E in the interval from the 2.5th percentile and 97.5th percentile contains 0.

In 2014, the SMART program office started looking into this starting salary difference issue and produced guidance to discourage facilities from paying SMART scholars beginning Phase II less than their counterparts. Results of our analyses of starting salary by cohort are inconclusive, in large part, because few individuals, especially few doctoral scholars, in the 2014 cohorts and after have started Phase II. Therefore, not enough data exists to see the effects of these program changes. The SMART program office should continue to monitor starting salary over time to determine if facilities are paying scholars fairly.

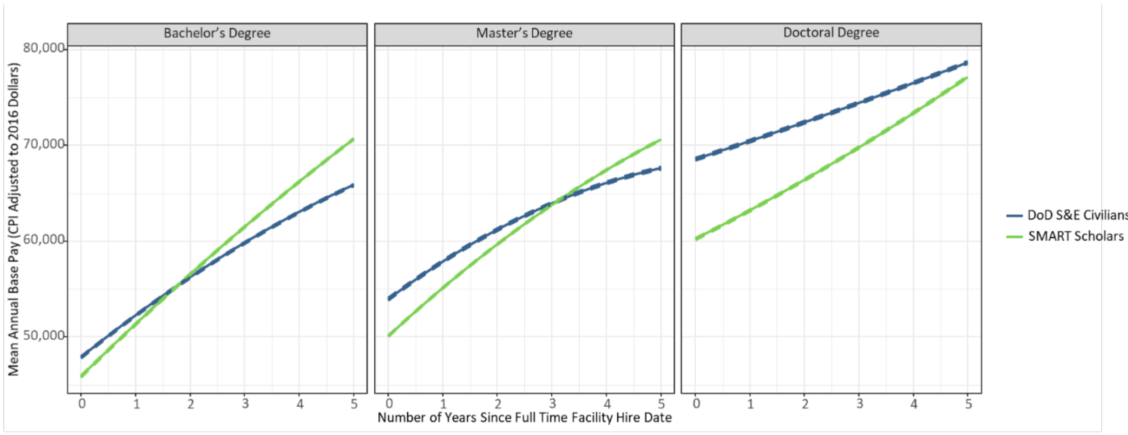
On the survey, SMART scholars were asked whether *they believe their salary is comparable to, or higher than, the salary of other positions for which they I are qualified.* These items were presented on a five-point Likert-type response scale (–2 = strongly disagree, +2 = strongly agree). Thirty-two percent of scholars strongly or somewhat agreed that they were being paid comparable to other positions. In contrast, 55 percent disagreed with the statement indicating that SMART scholars felt underpaid for the type of work they did.

B. Quality Post-Hiring at DoD

We used four metrics to better understand the quality of SMART scholars after they had been hired at DoD facilities: 1) Changes in salary, 2) Promotion rates, 3) S&E managers perspectives when asked specifically about how SMART scholars compared to other hires at their facilities, and 4) Overall publication quality.

1. Salary Change

Though SMART recruitment scholars begin at salaries lower than their counterparts, their salaries increase more rapidly over time and for bachelor's and master's degree holders, overtake their counterparts salaries. At the doctoral level, salaries for SMART scholars are not at parity with their counterparts 5 years post-hire (Figure 15). Table 12 details differences between the two groups across all degree levels.



Note: Across *N* = 500 bootstrapped samples. Shows White females, pooling across occupation bin.

Figure 15. Model Predicted Trajectories, Ensembles, across Bootstrapped Samples

In addition to looking at starting salaries, we also modeled percent salary change before and after the SMART program for retention scholars using a differences-in-differences linear regression based on propensity score matches. The statistical findings from this model do not show that retention scholars had higher percent salary increases after the SMART program. This result is descriptively supported by the trajectories seen in Figure 16. For details on the models used, see Appendix E.

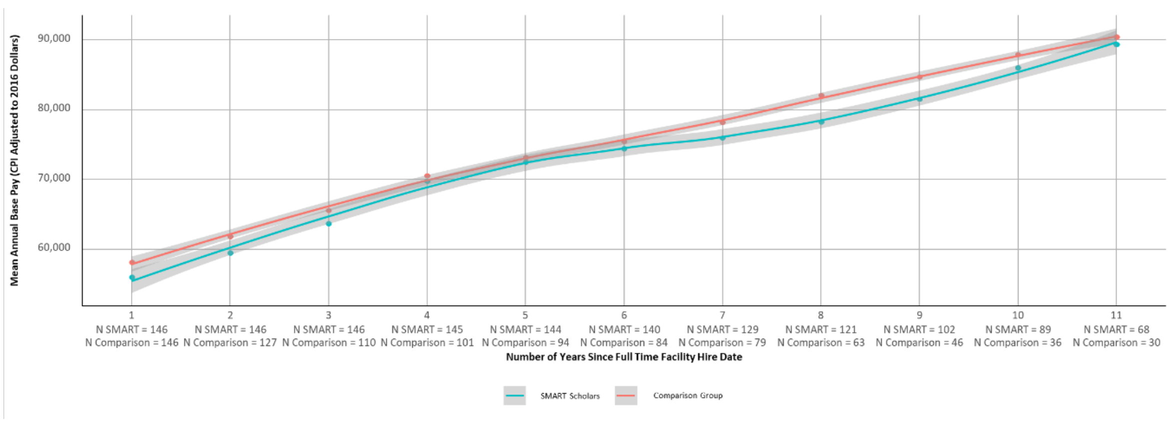


Figure 16. Salary for Retention Scholars and Comparison Group

2. Promotion

We quantitatively measure and analyze career progression for SMART scholars and their comparison group of S&E workers at their facilities with similar characteristics as SMART scholars. This comparison group was developed using DMDC data and more information can be found in Appendix C. All of the DoD civilian S&E workers in the matched dataset are on a tiered pay plan; however, most of these pay plans cannot be consolidated into a single structure. We found over 50 unique pay plans with no crosswalk between them, rendering it impossible to compare worker career levels. We chose to analyze career progression for only those employees on the General Schedule (GS) payment plan because nearly 50 percent of the scholars were on the GS schedule compared to other pay plans.

We found SMART recruitment scholars were twice as likely to be promoted every year compared to their comparison group, controlling for other variables.[12] Additionally, six other variables were significant in the regression and associated with a higher promotion rate for both recruitment scholars and their comparison group, controlling for everything else. Irrespective of being a SMART scholar or in the comparison group, we found that having a lower starting grade-step, being a female civilian employees, employment in engineering, mathematical sciences, and medical, dental, and public health occupations compared to the biological sciences occupation were associated with higher promotion rates. Also, Air Force civilian employees compared to Army civilian employees were associated with higher promotion rates.

We found that retention scholars do not have a statistically significant different promotion rate compared to their comparison group, controlling for other variables.[13] Retention scholars' data from when they are pursuing their degree is removed in their promotion rate calculation. Higher first grade-step in the data (retention scholars could have started before our first year of data, 2006) and higher age are both associated with lower promotion rate for both retention scholars and their comparison group, controlling for everything else. The significance and direction of these variables is most likely due to first grade-step and age being proxies for experience, with more experienced employees having less space for promotion given their already higher status.

3. S&E Manager Perspectives

We developed a series of interview constructs to understand S&E managers' assessments of SMART scholars' performance and attitudes compared to those of S&E workers hired through traditional mechanisms ("traditional workers"). These constructs serve as a proxy for quality of SMART scholars from the perspectives of S&E mentors and managers.

For performance comparison, S&E managers were asked to select one of three options—SMART scholars are better, traditional workers are better, or no discernible

[12] Odds ratio: 2.05, $p < 0.001$

[13] Odds ratio: 1.15, $p > 0.05$

difference—for the following constructs: quality of work, quantity of work products, impact of work produced, timeliness of work products, creativity of work products, and technical capabilities (Figure 17).

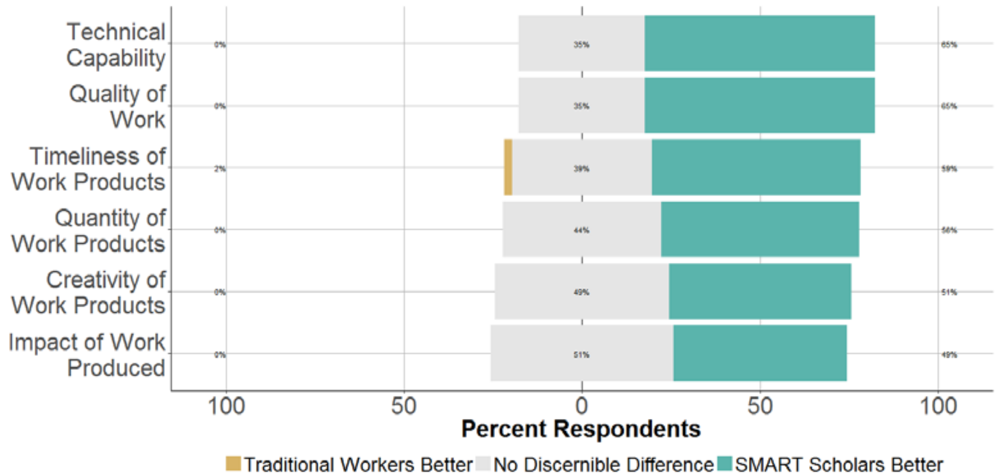


Figure 17. Comparison of SMART Scholar and Traditional Worker Performance

A majority of S&E managers agreed that SMART scholars are better as compared to traditional workers across the various metrics of quality. Sixty-five percent thought SMART scholars were more technically capable. Sixty-five percent also thought SMART scholars had better quality of work. Some S&E managers thought of their SMART scholars as being some of their best and most highly skilled employees. Another interviewee indicated that SMART scholars are willing to take initiative with their work and do not need as much guidance as other workers. Fifty-nine percent believed SMART scholars were better with the timeliness of their work and 56 percent believed SMART scholars were better in terms of the quantity of their work. Several interviewees indicated that SMART scholars come in with an advantage or clearly start stronger than their peers in terms of technical expertise. Some S&E managers indicated that SMART scholars outperform their peers because SMART scholars have the opportunity to participate in one or more summer internships at their sponsoring facility prior to starting work full-time. Thus, the SMART scholars "know the system" and are able to "hit the ground running." Two interviewees believe the SMART scholars are more skilled because they are recruited from a higher quality pool of candidates. Those who indicated there is no discernable difference between SMART scholars and traditional workers across the constructs tended to say there was no or a marginal difference between the two. One person indicated that it was difficult to make a comparison because SMART scholars make up small subset of the overall S&E workforce population.

About half of S&E managers thought SMART scholars and traditional workers were about equal in two regards: creativity of their work products (49 percent saw no discernable difference) and impact of the work they produce (51 percent saw no discernable difference). Regarding creativity of work, some indicated that it depends on the individual, regardless of being a part of the SMART program or not. One person said that creativity is not something valued in their sponsoring facility: “We like standardized work. I don’t want [my workers] to be creative.” Regarding conducting impactful work, one interviewee felt that once SMART scholars start full-time, they tend to have a greater impact sooner than traditional workers. Another interviewee indicated that SMART scholars are specifically selected to work in high priority areas immediately. However, others felt that their S&E employees get to participate in equally impactful work. One interviewee indicated that all entry-level workers need to gain practical work experience before getting to do higher impact work. Another interviewee indicated that there are workers—both SMART scholars and those hired outside of the SMART program—who stand out in terms of doing impactful work.

For comparison of attitudes towards work, S&E managers were asked to indicate if SMART scholars are better, traditional workers are better, or no discernible difference for the following constructs: potential for career advancement, eagerness to learn, enthusiasm towards work, worker fit with sponsoring facility (culture), and enthusiasm to serve the DoD mission (Figure 18).

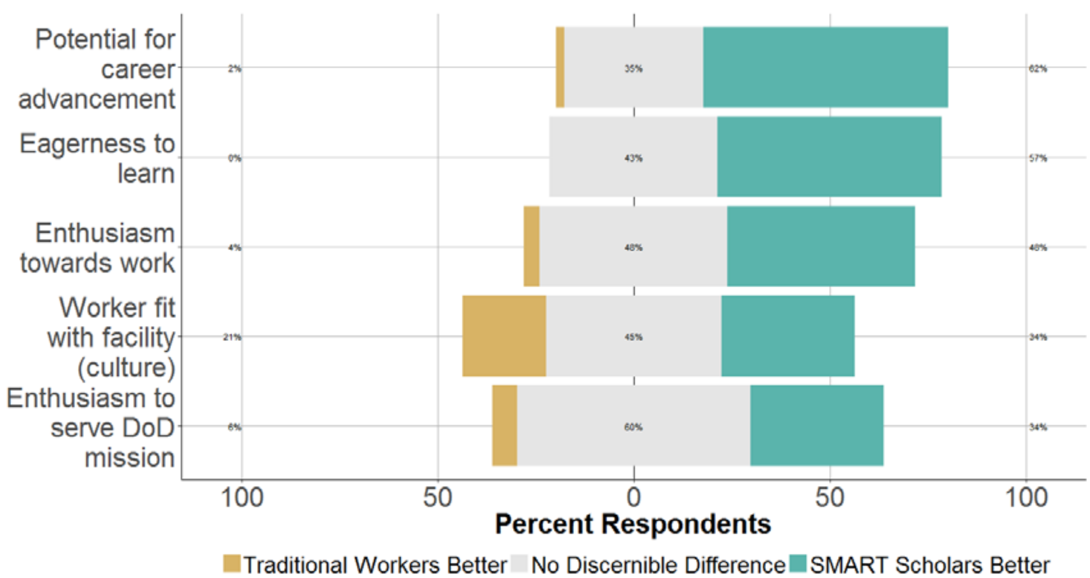


Figure 18. Comparison of SMART Scholar and Traditional Worker Attitudes Towards Work

A majority of S&E managers thought SMART scholars were ranked better in terms of potential for career advancement (62 percent) and eagerness to learn (57 percent). For career advancement, some said that because SMART scholars are high achievers and performers they may have more potential to be promoted. However, others indicated that there are many factors that go into career advancement, thus making it hard to assess if one group (SMART scholars versus traditional workers) is necessarily better than the other.

An equal number of interviewees thought SMART scholars fared better or equally compared to other workers in terms of worker enthusiasm towards work (48 percent). About a third of interviewees (34 percent) thought SMART scholars were a better fit at their sponsoring facility than traditional workers. Some said this was in part because they were already familiar with their work and co-workers through their summer internship. Others saw no difference (45 percent) or thought it simply depended on the person. Some S&E managers thought traditional workers were a better workplace fit (21 percent). One S&E manager felt that workplace fit was developed over time and was a function of how long the worker has been at the facility. Another S&E manager thought that it was easier to determine worker fit at the front end of the traditional recruitment and hiring process while another interviewee thought that because SMART scholars come from a diversity of geographical locations, it is harder for them to adjust to new places.

A majority of S&E managers (60 percent) saw no discernable difference between SMART scholars and traditional workers in terms of enthusiasm to serve the DoD mission. Several interviewees felt that it was important for all workers—SMART scholars or otherwise—to feel compelled to serve the DoD mission.

4. Overall Publication Quality

Lastly, we analyzed the differences between the "quality" of publications for SMART PhD scholars and their comparison group PhD S&E workers over the course of their careers using FWCI and the number of highly cited papers in a field. In this analysis, we answer the question: Do SMART PhD scholars produce higher quality publications than their comparison PhD S&E workers throughout their careers? We found unique identifiers for 214 of the 240 SMART PhD scholars and 206 of the 240 PhD S&E comparison group. We analyzed the FWCI for both groups, looked at the number of highly cited papers for each group, and found no statistically significant difference between the two groups.

C. Overall Quality Findings

Looking across all the metrics for quality collected, it is our assessment that SMART scholars on balance are of a higher quality than comparison group S&E workers hired into the facilities. For some measures such as S&E manager perspectives, promotion rates, increase in salary over time and quality of PhD institutions, SMART scholars are clearly better. For other metrics SMART scholars are at least as good if not clearly better than other S&E workers. For the quality of publications for PhD scholars and their comparison group, SMART scholars are no different than their comparison group. Table 13 provides a summary of all eight quality metric findings.

Table 13. Summary of Quality Metrics

Quality Findings: Job Performance	
Change in Salary—recruitment scholars only	On average, recruitment scholars received an increase of $2,110 (bachelor's), $980 (master's), and $616 (doctoral) more in salary every two years than their comparison group.[#]
Promotion—recruitment scholars	Recruitment scholars are twice as likely to be promoted every year relative to their comparison group.[#]
Promotion—retention scholars	No difference in promotion rate with comparison group.
S&E Manager Perspectives	50 percent indicated SMART scholars perform better than comparison group; 50 percent indicated SMART scholar performance is equal to comparison group.
Quality Findings: Background	
Carnegie Classification of PhD Institutions—recruitment scholars only	83 percent of SMART scholars at Highest Research Activity institutions versus 70 percent of their comparison group.[#]
Average PhD Institution R&D Expenditures—recruitment scholars only	Average total R&D expenditures for SMART scholars' PhD institutions is $536,000 versus $457,000 for their comparison group.[#]
Bibliometrics—recruitment scholars only	No difference in field weighted citation index and number of highly cited papers with comparison group.
Starting Salary—recruitment scholars only	SMART scholars earn $4,756 less on average than their comparison group to start.[#]

Note: [#] Indicates difference is statistically significant

5. Retention

A major study question in this evaluation is, “To what extent does the SMART program contribute to the retention of SMART scholars at the facilities post-service commitment?” The SMART program office has been interested in tracking the retention rates of the SMART scholars since the program began. In addition, SMART S&T managers and Facility POCs often mentioned that a major goal of the program was retention. In the past, the program had held to the metric of “retention”—meaning that it is evaluated based on the percentage of SMART scholars who stay employed at the DoD after completing their service commitment. In the Final SMART Process Evaluation Report, IDA recommended that the SMART program office reevaluate the utility of retention as a metric, and expand the definition of a successful program to go beyond retention (Balakrishnan et al. 2018). Nonetheless, rightfully so, retention remains a metric of interest, thought careful interpretation must be made.

A. SMART Program Retention

1. Calculating Retention

For retention to be a meaningful metric, it should be associated with a length of service. If not, someone who stays in the government for 1 day will be considered the same as someone who stays for 3 years. We analyze retention in two ways: the percent retained at a given time and the cumulative probability of being retained. First, the percent retained is the number of individuals that are *still working* in the DoD S&E workforce in a given year divided by the number that *could have* been working in a given year. As a result the percent retained is associated with the number of years someone could have been retained. Because not all individuals in this dataset are hired at the same time, there is variability in the number of years an individual could have been retained. For example, an individual hired in October 2014 that is still in the data could only be retained up to two years based on our data (given our cutoff is 2016). For a one year retention rate, this individual would contribute to both the numerator count (the number of individuals still working in the government) and the denominator (the number of individuals that could have been still working in the government). However, for a three year retention rate, this individual would be removed from both the numerator and denominator in retention rate calculation. Second, the cumulative probability of being retained is the probability an individual will be retained at a given point in time given that they were retained up until that point in time and is generated from a Cox Proportional Hazards model. While this cumulative probability is slightly different from a retention rate, it allows us to make statements about whether certain groups are more likely to be retained than others. We also generated Kaplan-Meier survival curves that show the estimated cumulative probability of retention (Kaplan and Meier 1958). However, because Kaplan-Meier plots are not as interpretable as the line plots with retention rate, retention analysis will be shown as the retention rates. Kaplan-Meier plots can be found in Appendix E.

2. S&E Civilian Retention

We first observed trends from the overall DoD civilian S&E workforce. Voluntary attrition occurs in all occupations and across all industries and can be a result of numerous factors including financial, health, and family. As a baseline, we use the changes in the DoD S&E civilian workforce to understand expected retention in DoD. In 2016, roughly 19 percent of the overall DoD workforce was considered part of the S&E workforce based on the 77 occupations that the Office of Personnel Management (OPM) classifies as scientists and engineers.[14] From 2011 to 2016, SMART scholars made up anywhere from 1 percent to 5 percent of new hires in a given year into the overall DoD civilian S&E workforce. The percentage of the S&E civilian workforce retained at 3 years, 6 years, and 9 years is 86 percent, 75 percent, and 63 percent respectively (Table 9, Figure 19).

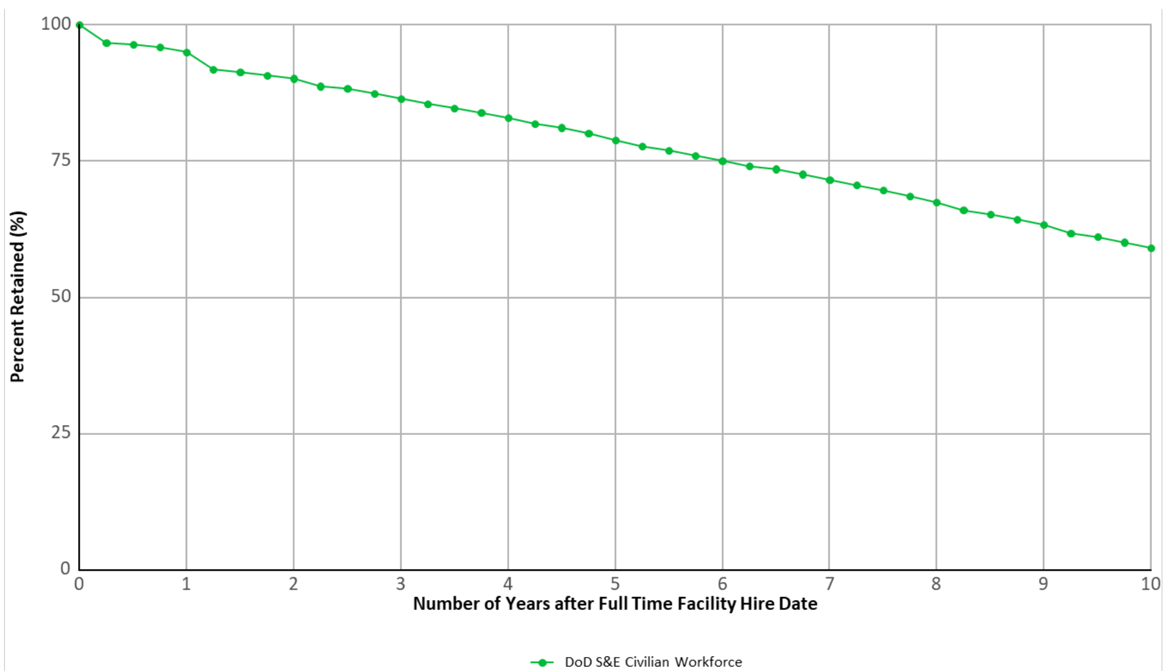


Figure 19. Retention Rate Among DoD S&E Civilians, 2006–2016

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[14] IDA analysis of DMDC data.

We also analyzed retention patterns in the overall Federal civilian S&E workforce using OPM Data. While retention data similar to what we obtained from DMDC was not publicly available, we found that of the 301,812 civilian S&E employees in the Federal government in September 2016, about 50 percent of them had been employed between 10 and 14 years.[15] Extrapolating from Figure 19, we find that 50 percent of DoD civilian S&Es are retained at 12 years since hire date. These two statistics indicate that DoD civilian S&Es stay in Federal government service for about the same amount of time as other Federal civilian S&E workers.

3. Comparison Group

In order to determine whether the SMART scholars are leaving at the same rate as their counter parts, we constructed a comparison group of scholars from the DoD civilian S&E workforce who had characteristics similar to SMART scholars across many dimensions. We used the propensity score matching method to identify a comparison group. The method matches up to three DoD civilian S&E workers for every one SMART scholar and matched exactly on specific worker characteristics: degree level, occupation bin and sponsoring facility location of SMART scholars. For example, for every PhD SMART scholar engineer hired AFRL's Sensors Directorate at Wright-Patterson Air Force Base, we found at least one other DoD civilian S&E workers with a PhD in engineering at the same sponsoring facility. The same method is used in other analyses in this report; however, for the retention analyses we match up to three DoD civilian S&E workers to obtain more statistical power. We further matched the SMART scholars to their counterparts on several other characteristics such as degree field, hire date, length of service, birth year, race, gender and ethnicity, but this was done in aggregate rather than exactly matching the characteristic to the SMART scholar. That means, the distribution of the other characteristics for SMART scholars matched the distribution of those characteristics for their comparison group. The hire date for recruitment scholars is considered to be the date they were hired after they obtained their SMART degree or at the beginning of Phase II; however, for retention scholars the hire date is considered to be the their hire date prior to receiving the SMART scholarship. For retention scholars that were hired before 2006, their hire date is considered to be 2006. For more details on the propensity score matching methodology and decisions made in developing the comparison group of scholars, see Appendix C.

Figure 20 shows the percent of the comparison group identified through the propensity score matching method and the DoD S&E civilian workforce retained. The two groups leave the civilian workforce at very similar rates. One main difference between

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[15] OPM Employment Data Cube, Length of service of employees with STEM occupations, September 2016.

these two populations is age—the DoD civilian S&E workforce median age is 51 while the comparison group median age is 35. Despite this difference, there is not a large difference between the two groups' attrition—at least at 10 years since hire date.

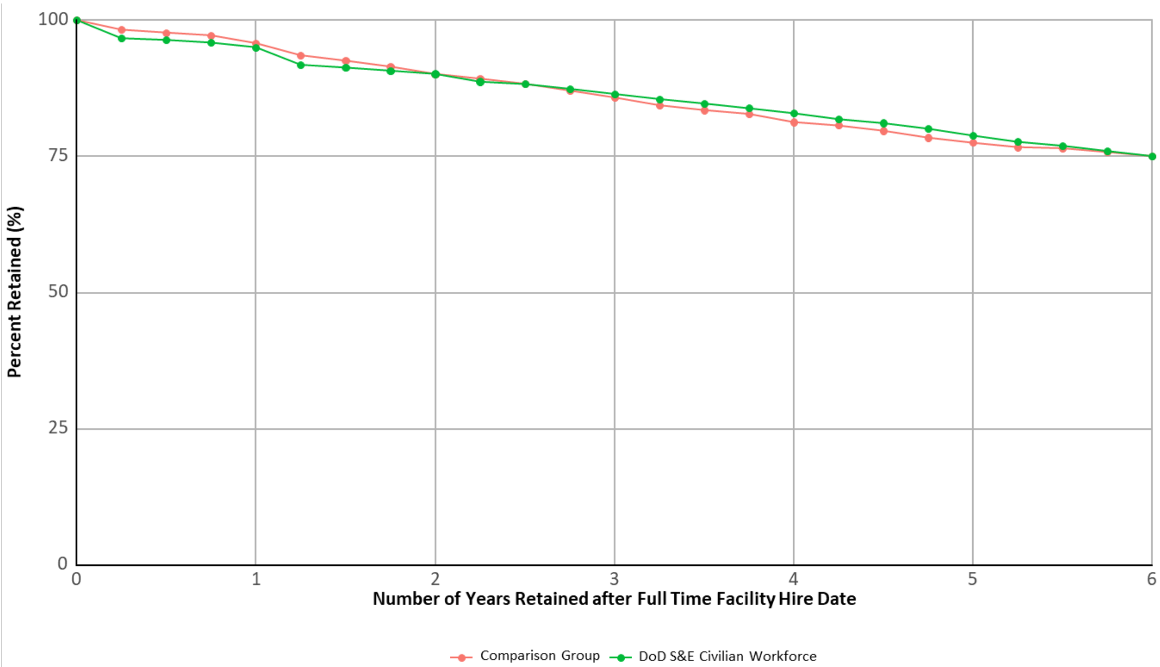

Figure 20. Retention Rate Among DoD S&E Civilians and the Comparison Group

4. Recruitment Scholars

When comparing SMART recruitment scholars to their comparison group, we found that recruitment scholars are more likely to leave the DoD workforce than their counterparts. The percentage of recruitment scholars retained at 1 year, 3 years, and 5 years is 96 percent, 73 percent, and 55 percent, and the percentage of their comparison group retained at 1 year, 3 years, and 5 years is 96 percent, 86 percent, and 78 percent (Table 8)[16].

Figure 21 reports the retention rate up to six years. Beyond six years there is a very small sample size. The median number of years funding years for bachelor's and master's scholars is two years after hire date, and at approximately two years, the retention rate for recruitment scholars drops below the retention rate for their comparison group. Controlling for the matching structure which incorporates degree level, location, and occupation bin; starting salary; race; sex; ethnicity; and birth year, we found that recruitment scholars are likely to leave statistically significantly faster than their comparison group. Additionally, recruitment scholars and their DoD counterparts with lower starting salaries are likely to

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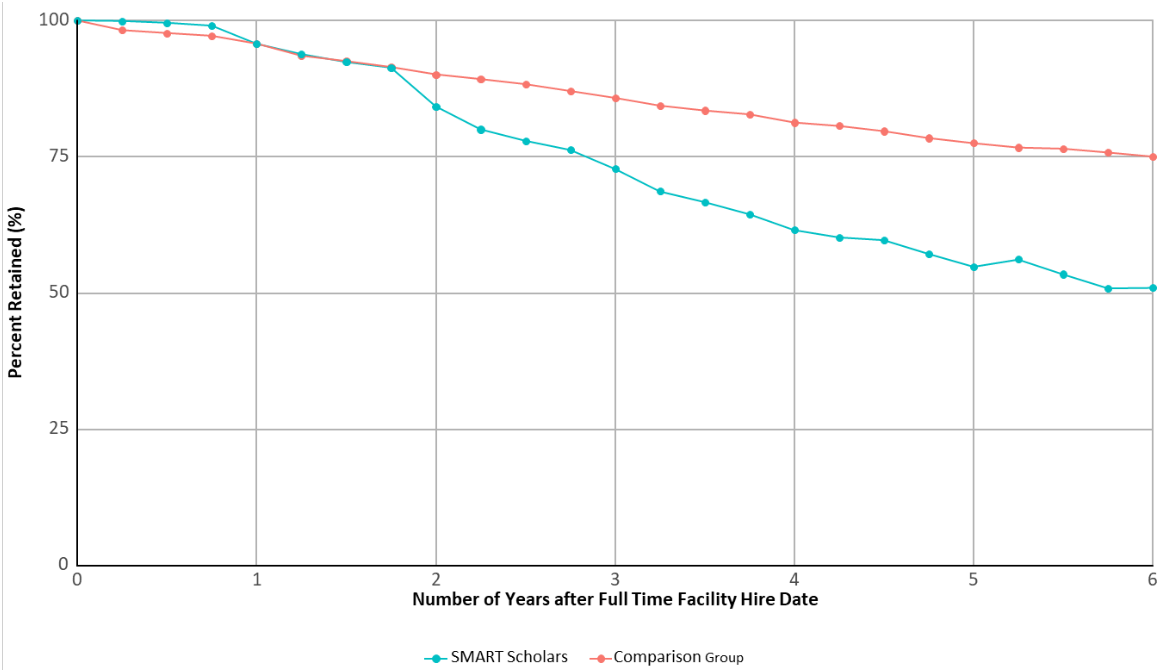
[16] Note: Based on a cox proportional hazards model, recruitment scholars are likely to leave at faster rates ($p < .001$), and those with lower starting salaries are likely to leave at faster rates ($p < .01$)

leave DoD more quickly. See Appendix E for more detail on the cox proportional hazards model and other sensitivity testing.



Note: Based on a cox proportional hazards model, recruitment scholars are likely to leave at faster rates ($p < .001$), and those with lower starting salaries are likely to leave at faster rates ($p < .01$).

Figure 21. Retention Rate among Recruitment Scholars and their Comparison Group

5. Retention Scholars

The SMART program functions differently for recruitment and retention scholars, and the way in which the retention rate is analyzed reflects this difference. We consider the hire date differently for recruitment and retention scholars differently in the propensity score matching process. Recruitment scholars are matched with counterparts based on their hire date after completing the degree pursuit phase of the SMART scholarship while retention scholars are matched with counterparts based on their hire date or the first time they appear in the dataset prior to receiving the SMART scholarship. Therefore, the time in which retention scholars are in the degree pursuit phase will be counted towards the amount of time for which they are retained post hire date. In order to understand retention scholars' career progression factoring in the SMART program, it is important to consider counterparts prior to receiving the SMART scholarship. We found many of the matching approaches to be challenging, but settled on matching based on hire date when first hired in to the civilian workforce. Had we matched retention scholars based on the hire date after the SMART program, the matching process would not have taken prior Federal service into account.

We found that retention scholars leave DoD are statistically significantly less likely to leave DoD up until 7 years after hire date. The percentage of scholars retained at 3 years, 6 years, and 9 years is 99 percent, 95 percent, and 89 percent respectively. The percentage of the comparison group retained after 3 years, 6 years, and 9 years is 86 percent, 76 percent, and 67 percent respectively (Table 8, Figure 22). The percentage of retention scholars retained is significantly higher than their comparison group for years 2 through 9.[17] These values are the percentage retained, and in this case after year 7, are not necessarily reflective of the rate at which certain populations leave.

Based on the Cox Proportional Hazard model, we found that after year 7, they are more likely than their comparison group to leave the DoD. In other words, on average, an individual is more likely to stay than their counterpart until they have been in DoD for 7 years at which point they are more likely to leave DoD. Figure 23 shows the predicted hazard ratio over time for retention scholars. If the hazard ratio is less than 1, retention scholars are likely to leave at faster rates than their comparison group, and we see this inflection point just after year 7.

Because the percent retained is still higher, SMART scholars' leaving at faster rates after year 7 may not seem intuitive (Figure 22). Even though the percent retained is higher for retention scholars even after year 7, statistical analyses indicate they are going to be more likely to leave during those years based on results of the Cox Proportional Hazards Model (Figure 23). However, the Cox Proportional Hazard model controls for additional variables including the matching structure which incorporates degree level, location, and occupation bin; starting salary; race; sex; ethnicity; and birth year; this along with the shape of the time transformation we chose accounts for the difference between what we observe in Figure 22 (Appendix E). Additionally, had we had several more years of data, we would likely see the percent retained for retention scholars become lower than their comparison group (Figure 22, Table 14).

For additional context, on average retention scholars are present in our dataset for 3 years prior to receiving the SMART scholarship and the median number of award years for retention scholars found in DMDC is 2. Therefore, we expect that around year 7, these retention scholars are completing their service commitments. It could be reasonably inferred, therefore, that after their service commitment retention scholars are more likely to leave than their comparison group. However, without several more years of data, it is difficult to observe the magnitude and the extent to which this trend will bear out. See Appendix E for more detail on the Cox Proportional Hazards model and other sensitivity testing.

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[17] Year 10 presents low sample size and is not tested.

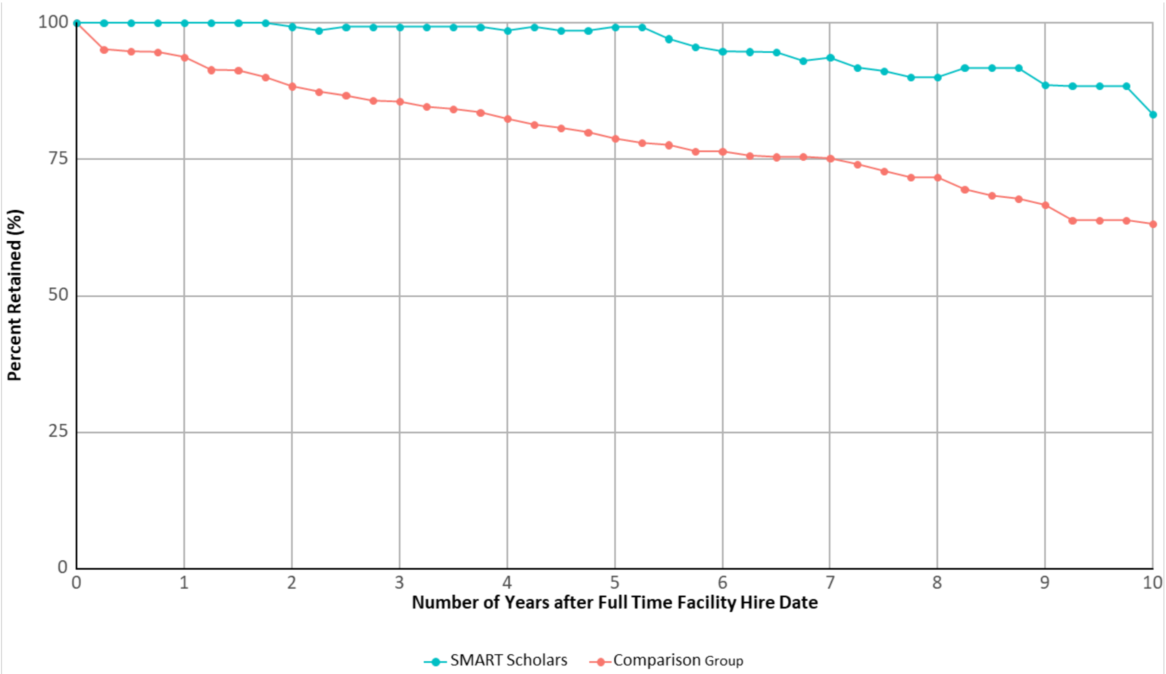
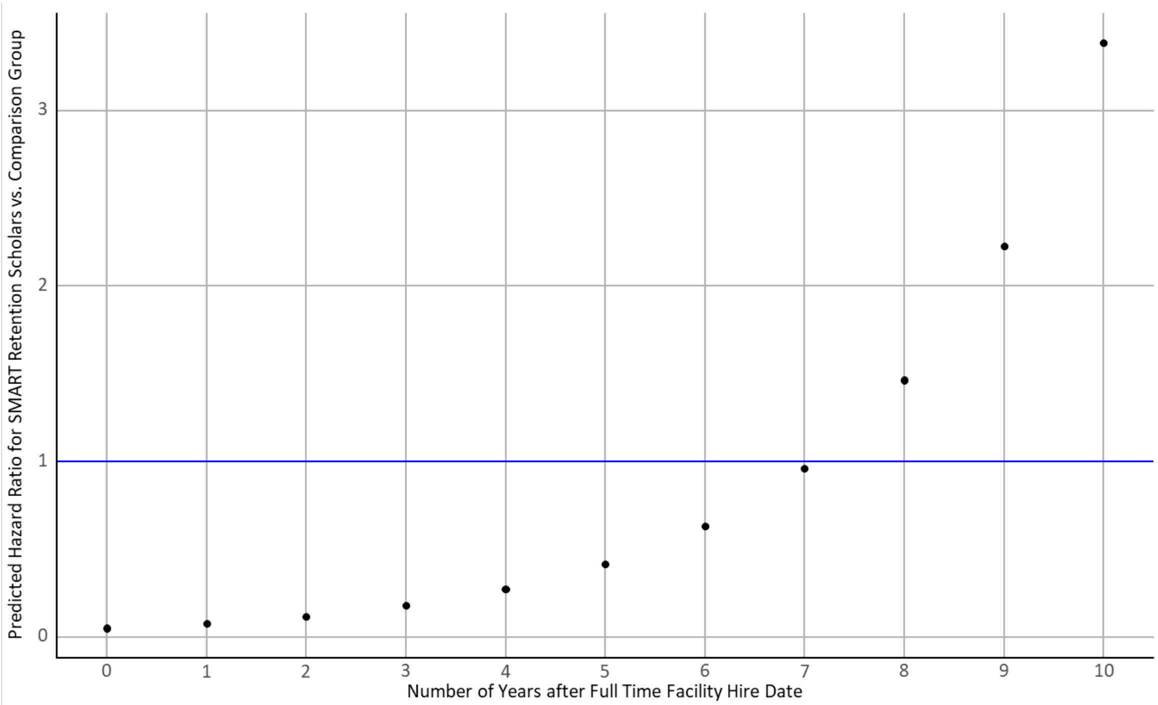


Figure 22. Percent Retained among Retention Scholars and their Comparison Group



Note: Based on a Cox Proportional Hazards model, retention scholars are likely to leave at slower rates ($p < .001$) until year 7. Based on a conditional logistic regression, the retention rate is higher for retention scholars in years 2 through 9 ($p < .01$ in year 2 and $p < .001$ for all other years).

Figure 23. Hazard Ratio over Time for SMART Scholars

Table 14. Percent Retained by Number of Years Since Fulltime Hire for DoD S&E Civilians, Comparison Group, and SMART Scholars (in thousands)

Group	Value	Hire Date	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
S&E Civilians	Number retained	184,906	167,028	150,292	139,481	130,017	118,752	106,459	91,817	77,755	67,662	59,428
	Number could have been retained	184,906	175,777	166,729	161,289	156,748	150,578	141,749	128,231	115,266	106,751	100,471
	Percent retained	100%	95%	90%	86%	83%	79%	75%	72%	67%	63%	59%
Comparison Group (RC)	Number retained	2,523	1,944	1,480	1,253	1,079	921	759	548	345	265	218
	Number could have been retained	2,523	2,030	1,642	1,460	1,327	1,188	1,011	732	480	382	321
	Percent retained	100%	96%	90%	86%	81%	78%	75%	75%	72%	69%	68%
SMART Scholars (RC)	Number retained	1,047	897	701	514	308	163	75	29	4	-	-
	Number could have been retained	1,047	937	832	706	500	297	147	56	10	1	-
	Percent retained	100%	96%	84%	73%	62%	55%	51%	52%	40%	0%	-
Comparison Group (RT)	Number retained	403	346	305	285	263	242	221	188	142	116	91
	Number could have been retained	403	369	345	333	319	307	289	250	198	174	144
	Percent retained	100%	94%	88%	86%	82%	79%	76%	75%	72%	67%	63%
SMART Scholars (RT)	Number retained	146	145	143	142	140	138	128	118	100	86	65
	Number could have been retained	146	145	144	143	142	139	135	126	111	97	78
	Percent retained	100%	100%	99%	99%	99%	99%	95%	94%	90%	89%	83%

Source: DMDC dataset.

Note: S&E Civilian column does not include SMART Scholars or their comparison group. The percent retained is the percent that could have been retained.

6. Modeling SMART Scholar Retention

We used the SMART scholar survey and other characteristics known through administrative data only of SMART scholars to better understand factors associated with SMART scholar retention. We did not have access to these data for the comparison group, so the analyses presented in this section is only for SMART scholars. The additional variables included: service commitment length, the number of miles their sponsoring facility address is from their home address, scholar mean satisfaction with the SMART program, mean satisfaction with work assigned, scholar interest in serving DoD mission, and scholar perspectives on workplace culture. The results of a Cox Proportional Hazards model using retention after Phase II indicate that the following groups of individuals are statistically significantly more likely to leave at lower rates:

- SMART scholars with a higher mean satisfaction with the SMART program[18]
- SMART scholars that are in Navy compared to scholars in the Air Force[19]
- SMART scholars that live closer to home[20]

The Cox Proportional Hazards model reports the hazard ratio which describes the rate at which two groups will be retained. For example, SMART scholars in the Air Force are expected to have a 85percent higher rate of departure compared to scholars in the Navy, and SMART scholars that have a one point higher self-reported satisfaction are expected to have a 36 percent lower rate of departure. The results of these models indicate that SMART scholars are not retained at faster rates than recruitment scholars when controlling for these additional characteristics including mean satisfaction. However, it is possible that using a similar Cox Proportional Hazards model, we tested the effect of service commitment length on retention post-service commitment (Phase III). Despite our hypothesis, this model indicated that service commitment length does not, in fact, impact retention after SMART scholars have completed their service commitment.

B. Where Do SMART Scholars Go?

We used the SMART scholar survey to address the study question of "To what extent do SMART scholars who leave DoD facilities join organizations that serve DoD interests such as DoD contractors or FFRDCs?"

In the SMART scholar survey, scholars that left the program or their sponsoring facility in any phase of the program were asked their current job status. Overall, the

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18 Hazard ratio = .64; $p < 0.001$. Departure based on base value of one, so we subtract 64 from 1 to find a 36% rate of departure.

19 Hazard ratio = 1.85; $p < 0.01$

20 Hazard ratio = 1.26; $p < 0.001$

majority of scholars are currently working in the private sector (46 percent), went back to pursue an additional degree (15 percent), or are working for a DoD contractor or DoD non-profit (12 percent) (Figure 24). Scholars were also asked in the survey if they were working in a Science, Technology, Engineering, or Mathematics (STEM) or STEM related field. The vast majority of scholars are working in a STEM (85 percent) or STEM related field (6 percent) (Figure 25).[21]

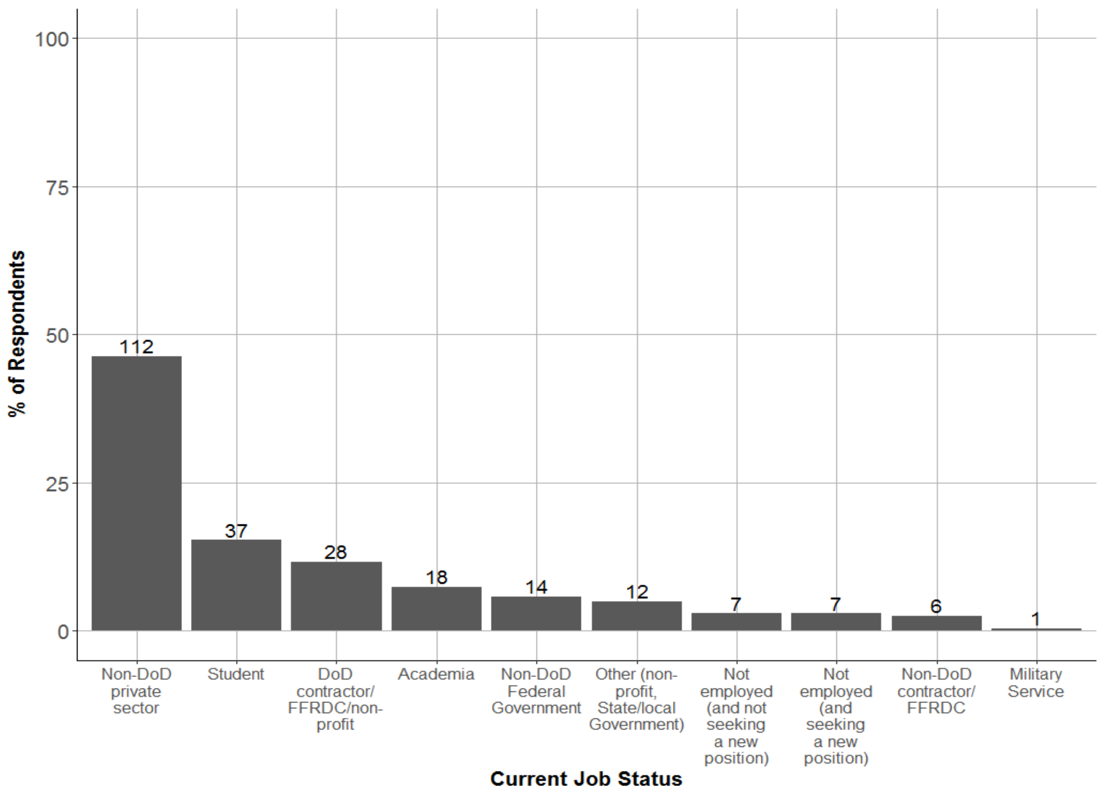
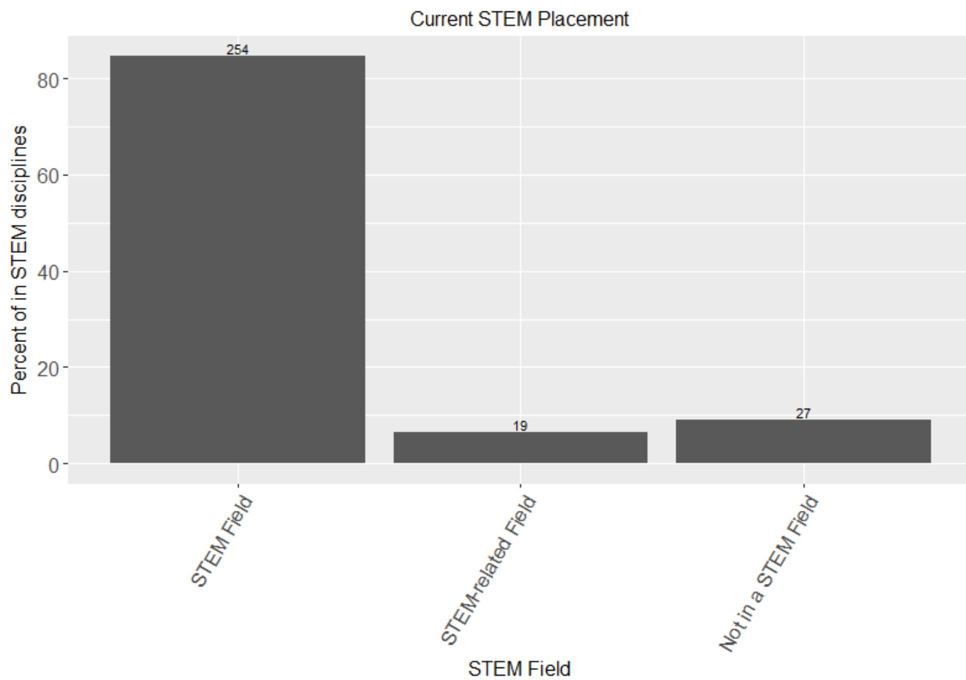


Figure 24. Job Placement of Separated or Dismissed Scholars

[21] In the survey STEM fields STEM field (i.e. Engineer, Life scientist, Physical scientist, Biological scientist, Computer or mathematical scientist, STEM post-secondary teacher).



Note: Counts include individuals that are working at a different DoD sponsoring facility. Results to this question are similar if they are removed.

Figure 25. STEM Placement after the SMART Program

C. Additional Findings on Retention

There are several additional findings related to retention that are useful to understand. First, many programs use retention as a metric, and understanding the findings from studies reviewing those programs will help the SMART program contextualize SMART retention findings. Second, SMART scholars shared perspectives on why they leave and S&E managers share perspectives on why they think SMART scholars leave. Third, we take a very simple algebraic approach to understanding the value of the SMART program.

1. Retention after Monetary Incentives

“For-service” programs are not unique to the Federal government or the DoD. In the United States, military officers are commissioned from various sources, with some of these commissioning sources providing college scholarships with the requirement that scholars will then serve in the military. The service academies (e.g., U.S. Military Academy at West Point, U.S. Naval Academy at Annapolis, and the U.S. Air Force Academy in Colorado Springs) are highly selective universities that provide 4-year scholarships paired with extensive military training in return for active-duty service obligations. Likewise, the ROTC provides some scholarships (0–4 years) along with military training in exchange for a service obligation. There are other ways to become an officer that don’t include a scholarship, such as Officer Candidate School (enlisted personnel are selected/receive training that enables the commission), and direct commissioning (civilians with special skills like medicine, law, or science who are trained to be specialized officers in the military). All of these commissioning sources have a minimum service obligation, but the length of the obligation differs across sources and the circumstances of the situation. Analyses of these commissioning sources has shown differing retention rates beyond the initial service obligation.

An analyses across all of the services by Demirel (2002), found differences in retention rates from commissioning sources, but these effects were not consistent across all of the services. In the Army, Academy graduates were less likely to stay in the military beyond minimum service requirement than ROTC graduates, but that relationship was reversed for Air Force, Navy, and Marine Corps. For those commissioned through ROTC, non-scholarship graduates were more likely to stay in the military beyond minimum service requirement than those that received scholarships for both the Army and the Air Force, but there was no significant difference for the Navy and Marine Corps (Demirel 2002).

These findings demonstrate that financial incentives do not necessarily yield higher retention rates.

2. Why Do SMART Scholars Leave?

In the scholar survey, scholars that left the program or their sponsoring facility in any phase of the program were asked to select one factor that best described their reason for departure and to what extent certain factors influenced their decision to leave (Figure 26). The first question, *Please indicate which of the following best describes the reason for your departure from your Sponsoring Facility* allowed scholars to select one option, such as *I left for a different job* or *I pursued further education.* The majority of scholars indicated that they left for another job (66 percent) while fewer indicated leaving to pursue higher education (17 percent), for personal reasons (11 percent), or for other reasons (5 percent).

The second question which asked scholars to indicate to what extent certain factors contributed to their departure was presented on a five-point Likert-type response scale (–2 = strongly disagree, +2 = strongly agree). For example, scholars could indicate to what extent factors such as *I wanted to pursue opportunities for career growth* and *I wanted to be closer to family or friends* impacted their decision to leave. Scholars indicated that professional reasons tended to impact their decision more than personal reasons. Career growth (79 percent), interesting work (73 percent), salary (67 percent), finding work that matched skillset (66 percent), and facility work culture (59 percent) all impacted scholars' decisions to leave. Personal reasons such as proximity to family and friends (42 percent), living in an urban environment (26 percent), and the cost of living of the sponsoring facility (10 percent) all impacted scholars' decision less so than more professionally oriented factors.

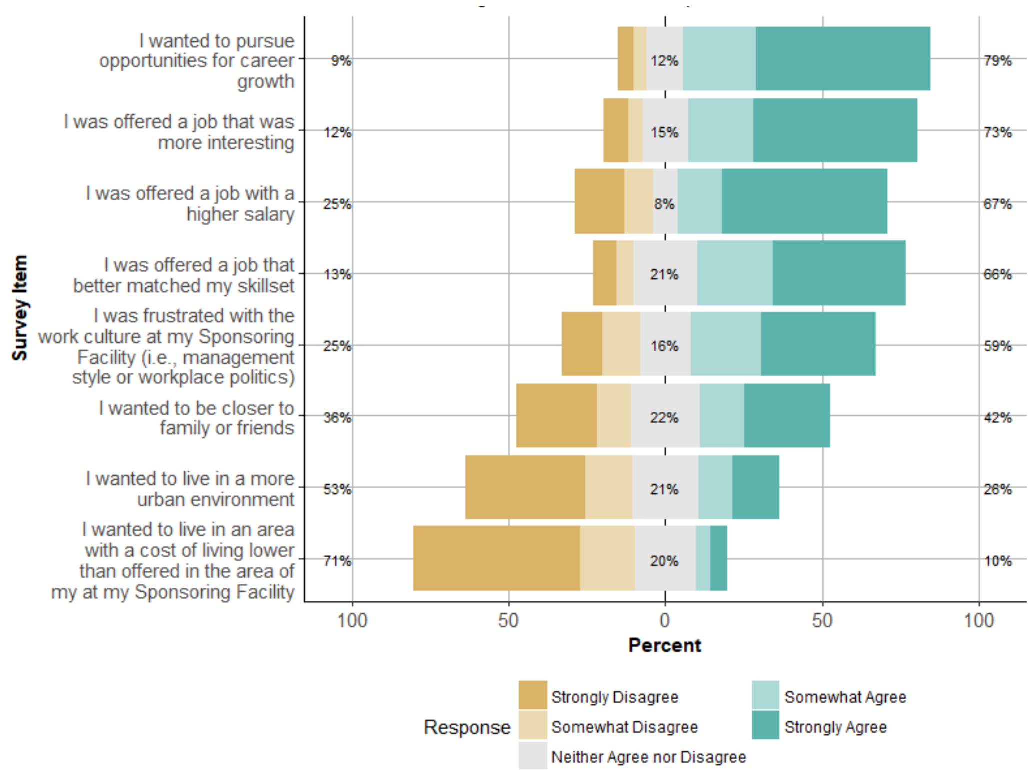


Figure 26. Reasons for Departure

3. S&E Mentor and Supervisor Perspectives on Retention

Interviewees who indicated they were a mentor, supervisor, or SMART POC were asked a series of questions regarding their views on the retention of SMART Scholars. For these questions, retention references the post-service commitment timeframe, in other words Phase III. Interviewees were asked to give their definition of successful SMART retention based on the graphic represented in Figure 27.

In this figure, each of the definitions represented by a larger circles subsumes the definitions represented by smaller circles. For example, retention at the Service level includes retention at the sponsoring facility. Interviewees were asked to select only one definition with which to identify.

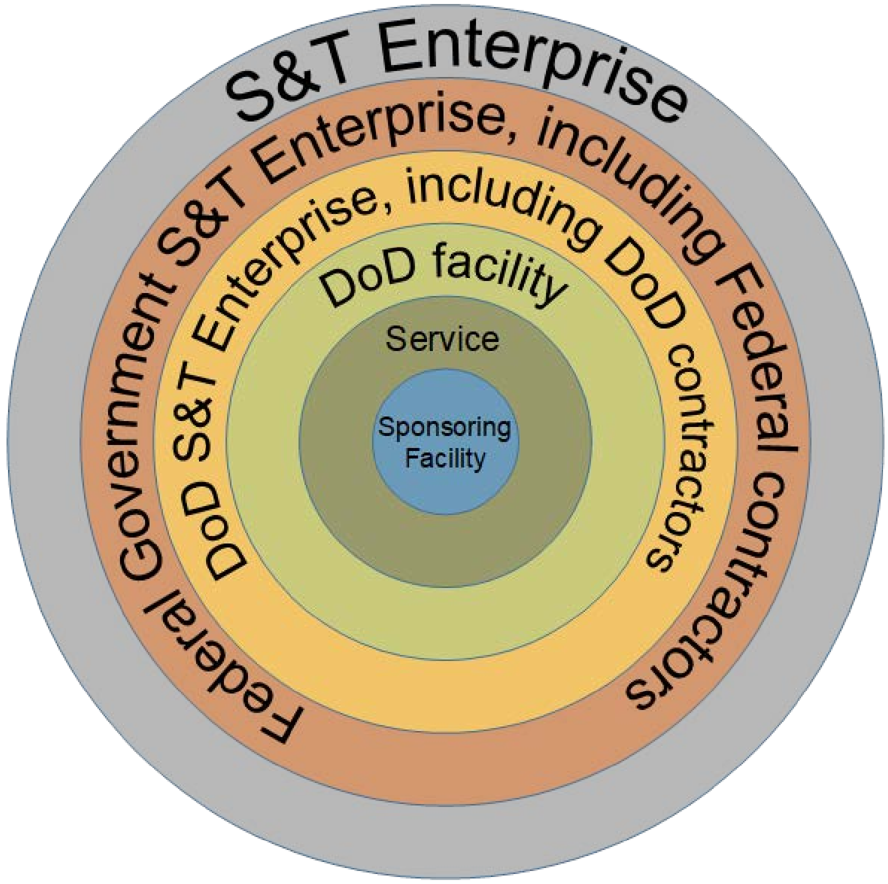


Figure 27. Definitions of Retention

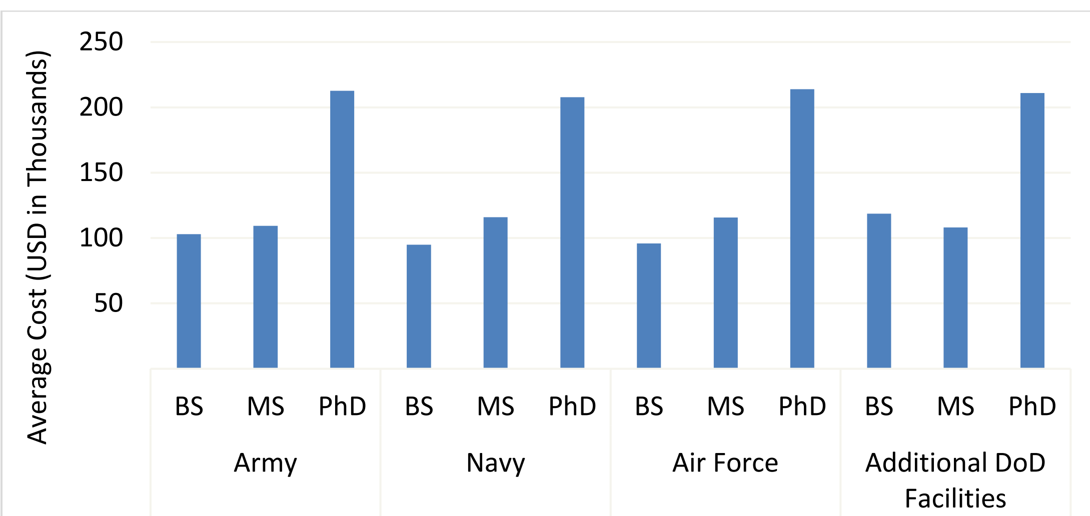
Over 30 percent of interviewees indicated they thought successful retention was at least at any DoD facility; over 25 percent thought successful retention was at the sponsoring facility; over 15 percent indicated retention is at the DoD S&T enterprise including federal contractors; over 10 percent indicated retention is at the federal government S&T enterprise including federal contractors; under 10 percent indicated retention is anywhere in the S&T enterprise; and less than five percent indicated successful retention is at the service. Some interviewees who were asked this question said that overall their interest was in having SMART Scholars serving the DoD mission which they acknowledged could be manifested in different ways. Other interviewees also felt they had different perspectives depending on their relationship with the Scholar. For example, as a manager or workforce planner, the goal might be to retain the Scholar at the sponsoring facility. However, as a mentor the goal may be to have the Scholar flourish as a professional. Finally, one interviewee thought of retention as a spectrum where the farther away from the sponsoring facility the Scholar is, the less successful the retention thought it still may be considered a type of retention.

Some interviewees gave alternative definitions of retention including retention being within the branch associate with the sponsoring facility, the base where the sponsoring facility is located, all federal government (excluding contractors), and anywhere scholars contribute to the scientific workforce.

4. Cost Per Retention Years

In an attempt to quantify DoD's investment into SMART scholars, we estimated cost per scholar and divided that cost by the number of years phase II and phase III scholars were retained. We were unable to obtain tuition data from the SMART program office but instead modeled the cost of attendance for each SMART scholar using tuition data for graduates and undergraduates from the Integrated Postsecondary Education Data System (IPEDS) from the National Center for Education Statistics. Appendix C contains the methodology of how cost of attendance was calculated.

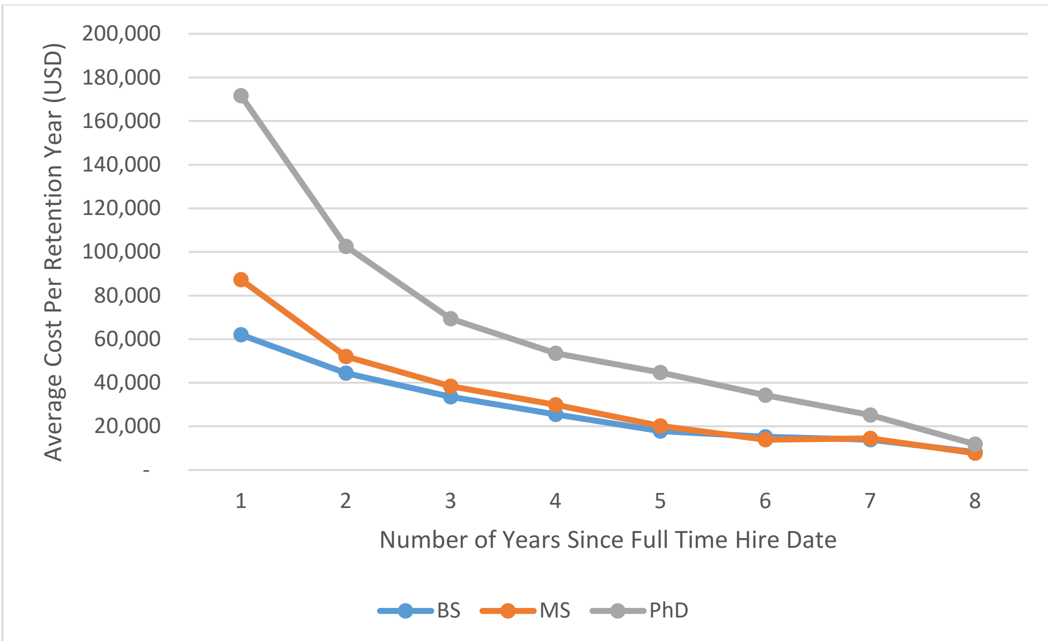
Figure 28 shows the average cost per scholar by degree level and service. Overall, the average award cost for SMART scholars is $135,000. The average cost for a doctoral degree is higher than for a master's or bachelor's degree likely because the stipend is higher and the median number of award years for a doctoral scholar is 3 whereas it is 2 for bachelor's and master's scholars. The average cost for a doctoral scholar is $211,000 whereas it is $98,000 and $114,000 for bachelor's and master's scholars respectively. The average award cost approximately the same for Army ($136,000) and Air Force ($135,000); it is higher for Additional DoD ($175,000) and slightly lower for Navy ($129,000). These distinctions are in large part because Additional DoD hires in more PhD scholars through SMART than other service.



Note: The cost of attendance is shown in 2017 dollars and includes tuition at a given institution, stipend, health insurance stipend, and miscellaneous fees.

Figure 28. Average Cost Per Scholar, by Degree Level and Service

Figure 29 shows the number of retention years versus the average cost per retention year. As expected, the investment in a given scholar decreases over time if they are retained. If an individual is only retained for one year, the average cost per retention year is $62,000 for scholars obtaining a bachelor's degree, $87,000 for scholars obtaining a master's degree and $171,000 for scholars obtaining a doctoral degree. After 8 years, the average cost per retention year appears to converge. That is, the yearly investment made in the scholars reduces to approximately $12k for doctoral scholars and $8k for bachelor's and master's scholars.



Note: The average cost per retention year is calculated by dividing the average award cost for all individuals that were hired in a given year by average number of retention years for all those individuals that were hired in a given year. On the x axis, 1 year represents all those hired in 2015 and 8 years represents all those hired in 2008.

Figure 29. Average Cost Per Year of Retention, by Degree Level

D. Overall Retention Findings

There are three overarching findings from this chapter. First, we found that SMART recruitment scholars leave at statistically significantly faster rates than their comparison group. This pattern is similar to other DoD scholarship incentive programs like ROTC. Second, SMART retention scholars are more likely to stay in DoD than their counterparts up to a point, but this trend changes over time. After retention scholars have likely worked at DoD for several years again after SMART, they are more likely to leave than their comparison group. However, several more years of data are needed to better understand retention scholars' likelihood to stay in DoD after their service commitment. Third, the majority of scholars that do separate from DoD civilian employment leave for the non-

DoD private sector (45 percent) or academia/further education (16 percent), and they reported leaving mostly for career growth and for more interesting jobs.

6. Academic Ties

Though not an explicit goal of the program, the DoD sponsor was interested in understanding spillover benefits to the SMART program. As a result, a research question related to understanding the extent to which the SMART program created or strengthened ties between PIs at academic departments and DoD facilities (particularly research facilities) was included.

We spoke to a select group of academic advisors to gather their insight on the SMART program and learn the extent to which they were contributing to new or improved DoD-academic research collaborations between scholars, academic institutions, and facilities. In the scholar survey, SMART scholars were asked several questions on the survey regarding academic ties with their institutions. In addition, we interviewed 18 academic advisors to better understand their perspectives of the SMART scholars and the scholarship fostering collaboration with the DoD. These 18 advisors are a subset of academic advisors and do not represent the overall experience of all academic advisors of SMART scholars. Appendix E provides more information on the academic advisor perspective including a brief literature review, interview analysis, and survey responses.

A. Benefits to SMART Program Participation

There are several benefits to building collaboration between DoD researchers and academic researchers including (1) building the talent pipeline in specialized research domains and applications and providing exciting opportunities for students to build their professional skills; (2) exposure to exciting mission specific problems and transition of research to application; and (3) enhanced research through access to specialized facilities, equipment, expertise, and funding (Gupta et al. 2014). In the context of the SMART program, these benefits are similar. Additionally, based on survey results, retention scholars are statistically significantly more likely to help form academic ties between their sponsoring facility and academic department than recruitment scholars. The academic advisor interviewees reported their motivations for participation in and perceptions of benefits from the SMART Program, particularly to scholars, their academic institution, their research, and the DoD or the Federal Government workforce. The benefits we observed fall into five key areas:

- **Connections to a wider network of experts**: Academic advisors noted that the SMART program may provide the opportunity for scholars, faculty members, and DoD research to collaborate with other experts who may be outside of their professional networks;

- **Attraction of high-quality students**: Academic advisors reported on the excellent quality of SMART scholars;
- **Access to state-of-the-art equipment**: Academic advisors appreciated that they had the ability to access state of the art DoD equipment and facilities;
- **Understanding of DoD mission and challenges as potential areas to expand research**: Academic advisors reported that the SMART program allows faculty members and scholars to work closely on unique research topics that offer in-depth knowledge into problem areas and needs facing the DoD research enterprise;
- **Future Funding Opportunities**: Academic advisors noted that the SMART scholarship provided scholars financial freedom and benefited their own research program as well.

B. Differences in DoD-Academic Collaborations between Recruitment and Retention Scholars

The SMART scholar survey evaluated the extent to which SMART scholars observed ties between their sponsoring facility and academic institution.[22] We compared retention and recruitment scholars' survey responses. Overall, the survey results showed that retention Scholars were statistically significantly more likely than recruitment scholars to agree that their advisors formed or reinforced ties with their DoD sponsoring facility.[23] PhD retention and PhD recruitment scholar responses are summarized in Figure 30 to display the breakdown of responses.

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22 The extent to which SMART Scholar respondents formed ties between their sponsoring facility and academic institution during Phase I was assessed with the survey question: "Members of my Sponsoring Facility formed new ties or strengthened old ties with the faculty at my academic institution through my participation in the SMART Program." This question was presented on a five-point Likert-type scale (strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, and strongly agree).

23 Statistical significance groups were detected for Scholar Type. Retention Scholars (M = 0.04 SD = 1.35, 36%) reported higher mean agreement with this survey item than Recruitment Scholars (M = -0.8 SD = 1.26, 16% agree).$t_{(972)} = -6.76$, *p* = < .001, *d* = 0.66.

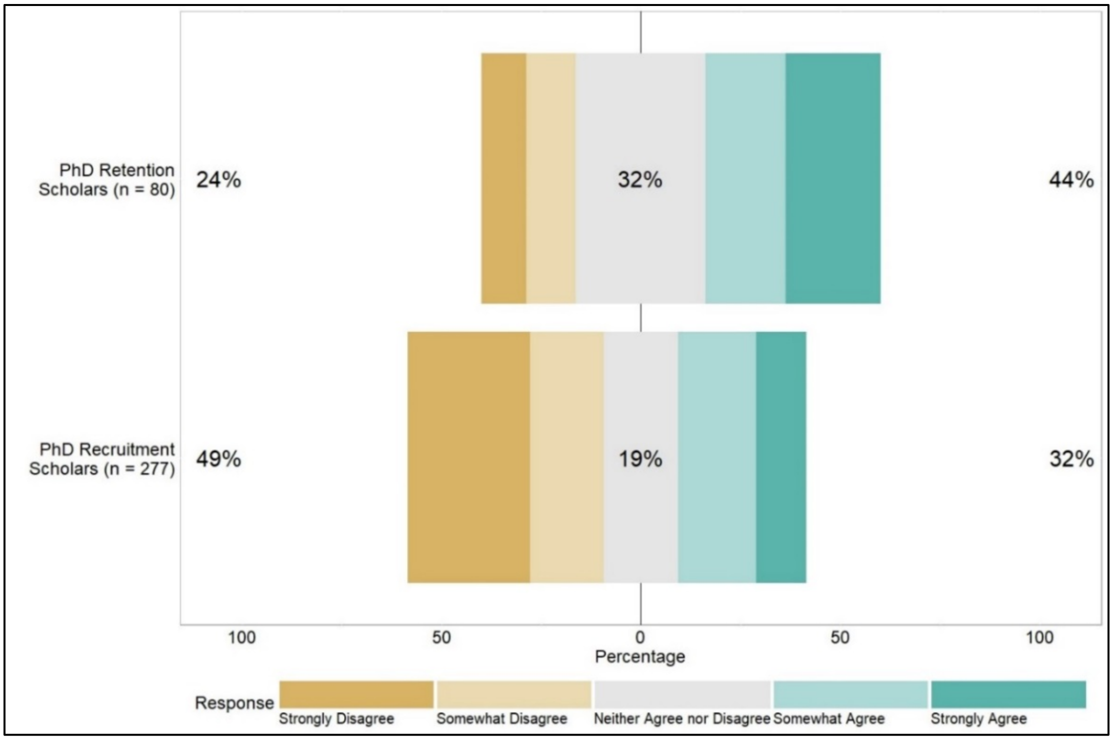

Figure 30. PhD SMART Scholar Survey Responses on Academic Ties Formation by Scholar Type

A noteworthy finding was that all advisors of recruitment scholars with prior DoD collaborations felt the SMART program contributed to reinforcing those relationships. Meanwhile, for retention scholars, the prior relationships were less effective in influencing further interactions with DoD researchers or the DoD sponsoring facility. Generally advisors with prior DoD collaborations noted that their relationship with the DoD sponsoring facility was present regardless of the SMART Program and the program did not change their level of interactions.

These results suggest that some advisors of recruitment scholars who had prior interaction with DoD researchers were able tap into the potential to use the SMART program to strengthen their relationships with DoD researchers—more so than those advising retention scholars. This is somewhat counterintuitive given that, in general, retention scholars reported having greater positive DoD-academic collaboration experiences in the survey.

C. Challenges with Establishing DoD-Academic Collaborations

Based on our interviews, IDA analyzed various challenges associated with developing or reinforcing DoD-academic collaborations through the SMART Program. These include:

- **Limited Bandwidth**: Academic advisor interviewees noted they have limited bandwidth and resources to support long-term, continued relationships with DoD researchers;
- **Need for Funding**: About half of the advisors interviewed said the collaborations with DoD researchers at the sponsoring facilities were not continued after SMART scholars graduated in part because funding ended. In other situations, additional funding from sponsoring facilities helped maintain and grow research collaborations;
- **Limited Understanding of DoD Challenges and Nature of Work**: Academic advisors noted a lack of awareness of the research problems and opportunities to impact DoD missions and that they encountered uninterested DoD researchers who did not fully understand how their academic work could aid DoD research;
- **Other Challenges Related to Participation in the SMART Program**: Interviewees discussed several challenges, including difficulty recruiting students for the SMART program based on a lack of knowledge, eligibility requirements, and concern from the service commitment.

D. Suggestions for Improving DoD-Academic Collaborations

1. Link to DoD Research Solicitations

Interviewees suggested the need for mechanisms to improve ongoing, continuous collaborations with DoD researchers. In particular, the SMART Program could partner with funding offices across the DoD (e.g., Air Force Office of Scientific Research, Office of Naval Research, and Army Research Office) to link the program with funding solicitations.[24] Two examples of DoD-sponsored programs that support research between DoD and academia are the Vannevar Bush Faculty Fellowship (VBFF) program and the Laboratory University Collaboration Initiative (LUCI). The VBFF program, sponsored by ASD(R&E) and managed by the Office of Naval Research, provides research awards to researchers from U.S. universities to conduct research of interest to DoD (Grants.gov 2018). The LUCI program, managed and sponsored by ASD(R&E), provides funding for government laboratories to conduct research with select VBFF program fellows (U.S. Department of Defense 2017).

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[24] Two examples of DoD sponsored programs that support research between DoD and academia are the Vannevar Bush Faculty Fellowship (VBFF) program and the Laboratory University Collaboration Initiative (LUCI). The VBFF program, sponsored by ASD R&E and managed by the Office of Naval Research, provides research awards to researchers from U.S. universities to conduct research of interest to DoD. The LUCI program, managed and sponsored by ASD R&E, provides funding for government laboratories to conduct research with select VBFF program fellows.

The creation of this new mechanism could leverage DoD's resources for research and incentivize joint DoD-academic collaborations. For instance, in responding to research grant solicitations, academics could identify graduate students as potential candidates for the SMART Program in their proposals. In this way, the SMART Program would be integrated as an option to fund graduate student researchers contributing to DoD research grants. This new mechanism could provide the following benefits:

1. Offset funding from DoD funding offices for research grants by leveraging SMART Program
2. Provide the SMART Program with a potential pool of scholar candidates that otherwise may not be identified
3. Provide opportunity for greater direction and, thus, contributions towards solving research problems relevant to DoD
4. Offer an opportunity for the scholar to further synergies with academic and DoD expertise and build capacity over several years in a focused research area directly relevant to DoD.

In addition, the SMART Program could further leverage resources by partnering with other DoD programs that provide resources for equipment and experimentation, such as the Defense University Research Instrumentation Program. Interviewees identified that in some cases, scholars require additional resources for their research, particularly experimental approaches that requires the development of instrumentation. The SMART Program could work with existent funding programs to create a mechanism that links the SMART Scholar's needs with their advisors, who can submit proposals to these programs. In this way, the academics and scholars could have access to funding that removes the burdens on academics to otherwise sponsor these needs.

2. Raise Awareness of DoD Capabilities and Challenges

Interviewees suggested several ways the SMART Program could raise awareness of DoD capabilities and challenges, including holding a symposium for past and present SMART scholars, academic advisors, and DoD sponsoring facility mentors. Interviewees recommended several options:

- Hosting symposia at several DoD SFs—This option could include SMART Program participants, locally or regionally, in close proximity to the SF. A local or regional symposium could reduce travel burdens for academics; however could also hinder incentives for academics to participate if not directly relevant to their research interests.
- Hosting symposia focused on research topics—This option could include hosting meetings that are topical, gathering stakeholders with interest in specific

fields and disciplines. Topical symposia could incentivize participation from academics but may require greater resources (than a local or regional option). To address this, some interviewees mentioned that symposia could be held in conjunction with professional scientific conferences, which are typically attended annually by advisors and DoD researchers alike. The SMART Program could target important scientific conferences to hold a topical symposia (or other meeting) and further identify ways to encourage SMART Scholars to attend (by leveraging professional development funding at SFs or via further coordination with research grant awardees).

A symposium could address the need for academics to better understand DoD's capabilities and problems across the research, development, test, and evaluation enterprise, and to share work, spur dialogue in specific problem areas, and stimulate interactions.

3. Expand Recruitment Outreach to Universities

The SMART Program could increase awareness of the program by focusing outreach, such as email blasts, to all SMART scholar advisors (past and current). Interviewees recommended that the SMART Program could also target outreach to the university's department chair rather than other offices, such as career services, with specific messaging that the SMART Program can and should be considered by "normal track" students (e.g., those with no prior DoD connection).

Based on the interview findings, the SMART Program could consider maximizing resources through coordination with DoD research funding programs and by targeting outreach to academics and universities:

- with preexisting relationships with DoD facilities and universities (e.g., via research grants), and
- who have shown interest in collaborating with DoD (e.g., via submitting proposals to research grants [whether they were awarded or not, such as award finalists]).

The SMART Program could also identify mechanisms, such as issuing guidance, to encourage DoD researchers, such as the Scholars' mentors, to improve engagement and communication with the Scholar's university—including participating in thesis committees and working towards joint-publications, as appropriate.

E. Overall Academic Ties Findings

We found that the SMART program had examples of academic ties that were a result of the SMART scholar, but the majority of scholars did not bridge research between their research advisors or their university and the sponsoring facility.

7. SMART Program Goals and Workforce Planning

We explored the SMART program goals and workforce planning thoroughly in the SMART Process Evaluation Report (Balakrishnan et. al., 2017). Many findings from that study are relevant in understanding the outcomes of the SMART program. This chapter reiterates some key findings from the process evaluation and lays out the importance for understanding the context of the program and the workforce needs the program is designed to meet.

The SMART program works with sponsoring facility POCs to gather the “demand” for SMART scholars by requesting the total number of scholars the sponsoring facility wishes to have in a coming year. This process requires the sponsoring facility leadership to assess what its workforce will look like in the future when scholars are ready to be hired. Each Component is given the flexibility to decide how it wants to allocate its scholarships, in terms of disciplines and degree level. For example, some Components have a higher demand for scholars with computational skills and are prioritizing hiring S&E workers with such skills through the SMART program. This approach relates directly to the legislative goal: “to provide financial assistance for education in science, mathematics, engineering, and technology skills and disciplines that, as determined by the Secretary, are critical to the national security functions of the Department of Defense and are needed in the Department of Defense workforce” (SMART Defense Education Program 2006).

A. SMART Program Goals

The stated goal can be parsed in a few different ways, and the SMART program design is based on interpreting which STEM skills and disciplines are “critical” and “needed” in the DoD. The program implements these aspects of the goal in the following ways:

- STEM disciplines are identified as 19 different STEM degree fields.
- STEM disciplines needed by the DoD are determined by asking the facilities within each of the Components to identify their own workforce needs and demands.

Given the stated goal in the legislation, we wanted to understand how the various stakeholders viewed the program goal. We asked the SMART program management, staff, CAOs, and S&E managers a set of questions about SMART program goals and what success means to them.

In general, descriptions of S&E managers' goals covered a broad array of themes, including scholar characteristics such as quality, exposing scholars to DoD, contributing to a strong workforce, and benefits to scholars. Managers tended to describe the program's goal as a way to attract people from a highly talented pool, whereas their own goals seemed more focused on using the SMART program strategically to hire people (STEM, underrepresented minorities, certain skills) and retain those people. Specifically, managers viewed SMART as a hiring mechanism to attract people at varying degree levels, as a means to increase diversity in the workforce and as a way to augment or build a strong S&E workforce. In terms of varying degree levels, responding managers most often mentioned recruiting entry-level or young students, and a few specifically mentioned gaining PhD students at their facilities as a goal. Others described the goal of SMART as improving student perspective to ensure that students are able to relate research and their classes to what they will do at the sponsoring facility and to provide the funding, experience, and other resources needed to help students through their academic careers.

Ultimately, we found that stakeholders have been interpreting legislative intent differently as there is no operational definition of "critical need" that the program uses/that facilities use (beyond "STEM" broadly).

B. Workforce Planning—Demand for SMART Scholars

Several stakeholders, including CAOs, sponsoring facility POCs, and sponsoring facility S&E managers, are involved in S&E workforce planning and the SMART scholar selection process. Depending on the Component, however, this approach may be bottom-up (where the S&E managers drive planning) or top-down (where CAOs drive the planning). The SMART service liaisons play a role assisting during this process by working primarily between the sponsoring facilities (via the sponsoring facility POC) and the SMART program office. CAOs are provided a yearly budget by the SMART program manager and must consider the "cost" of scholars against their overall budget.

Yearly, the sponsoring facilities participating in the SMART program determine SMART scholar requests/needs simultaneously with the scholar application process. The facilities submit their SMART scholar requirements to the SMART service liaisons by listing the number of scholars that the sponsoring facility is seeking and, for each scholar, the degree level and discipline that they are seeking to fill for that scholar position. The request is an initial "demand" signal to the SMART program and CAOs that indicates the level of interest and need that the sponsoring facilities have in SMART.

Often, the request is informed by the general S&E workforce planning conducted at the sponsoring facility. Independently of the SMART program, facility S&E managers identify and forecast workforce needs to manage their S&E personnel. S&E workforce planning varies from Component to Component and can also vary from sponsoring facility to sponsoring facility. Often, workforce planning is based on core capability needs. In some cases, a pivot to a certain discipline may occur, depending on new and emerging technical needs.

How a sponsoring facility is funded may also affect how workforce planning is executed. While some sponsoring facilities are mission funded (i.e., funding is directly appropriated to support a specific mission effort), other facilities are working-capital funded (i.e., funding is tied to operations and is funded on a project-by-project basis). Depending on the type of funding, sponsoring facilities may require more or less flexibility with their workforce or may be more or less equipped to make longer term projections about future workforce needs.

Some sponsoring facilities require S&E managers to participate in regular workforce assessments. These assessments look at retirement trends, technical needs, and how to create a pipeline of S&E personnel. In many cases, S&E managers use these assessments to inform SMART scholar selections. On the other hand, some S&E managers are given top-down instruction on the critical workforce needs from a Component perspective and on who will ultimately be hired. A few S&E managers said that the aging workforce with impending retirements is a significant factor in their workforce planning. Some of these managers said that they would like to hire young personnel in anticipation of a large portion of the workforce being eligible for retirement in the imminent future.

Many S&E managers said that the SMART program fit into a larger hiring strategy and viewed the program as one mechanism or hiring tool through which to recruit people. For instance, SMART can be one program used to plan for interns, another program to target specific disciplines, or even another program to hire entry-level personnel. SMART was one of many tools in workforce planning, but this tool filled a specific niche for entry-level S&Es, particularly in light of looming retirements. A few managers who work in facilities or divisions with a research focus targeted advanced-degree students with SMART to fulfill research needs. Some S&E managers had other DoD workforce programs such as the Navy's New Professionals program, the Air Force's PALACE Acquire Program, reassignment boards, or the Federal Government's Pathways Programs. Some S&E managers with whom we spoke preferred to use the SMART program because it offers a faster hiring process, even though it means waiting for the SMART scholar to complete school.

In other cases, SMART plays a much greater role in recruiting early career S&E workers, particularly given SMART's noncompetitive conversion authority, which allows the facility to convert SMART S&E civilians into permanent positions with ease. In some cases, due to hiring constraints, facilities have used the SMART program's competitive conversion authority as its sole hiring mechanism. This can be problematic in that these facilities may not be equipped to host scholars and ultimately may be in conflict with the overall goals of the SMART program.

Some patterns did emerge with regard to how Components tend to conduct workforce planning overall. For example, the Air Force and Navy tend to have a more top-down approach to workforce planning, where higher level officials within each Component estimate workforce priorities throughout their respective Services. The Army, on the other hand, has a more bottom-up approach, where workforce priorities are dictated more from the sponsoring facility level up through the Component.

As a result, scholars' experiences across SMART sponsoring facilities also vary insofar as the facility decides what type of work scholars do, what type of position scholars are hired into, what type of mentorship scholars are provided, and what, if any, professional development scholars are offered. In this sense, the SMART program is implemented from a bottom-up perspective versus top down from ASD(R&E).

C. SMART Application Review and Selection Process

1. Application Review Process

During the SMART award process, applicants are first ranked by the quality of their application by a review committee organized by the 19 STEM disciplines that SMART supports. The selection process starts with eligible applicants being evaluated and ranked by a review panel which is composed of members of academia and DoD civilian S&E managers. Applications are reviewed by discipline and scores encompass reviewers' assessment of the application as a whole: academic standing, letters of recommendation, personal statement, and so forth. Once all the applications have been reviewed, applications with scores in the top 50 percent of a given discipline are moved to the second round. If the demand for a certain discipline outweighs the supply (i.e., the number of applicants), at the program manager's discretion, more than the top 50 percent of scored applications can move on to the next round.

2. Selection

In the second round of selection, the top 50 percent of ranked applications are uploaded to an online portal that can be accessed by all the sponsoring facility POCs and S&E managers interested in participating in the SMART program. The SMART program gives the Components a yearly budget to spend on their selections. The portal also provides the CAOs and SMART service liaisons an estimated cost for each scholar applicant for the first year. The SMART contractor estimates this cost based on a model it has created that uses each university's tuition data as well as the expected stipend.

The adjudication of the "demand" for candidates with the "supply" of applicants is a complex process, given that all facilities and Components can review all applications and interview all applicants. In some cases, top ranked applicants are called by several facilities for interviews. Adjudication strategies vary by Component. For example, the Army takes a “bottom-up” approach. In other words, the CAO tries to accommodate the requests of the facilities to the best of their ability. The rationale is that the sponsoring facilities know their workforce needs most intimately and do not necessarily need additional direction. In contrast, the Navy, and in particular, the Air Force, take a “top-down” approach. In this case, the CAO prioritizes projects and SMART scholar selections, typically based on mission direction and mission pull. For example, if a particular technology area is growing, such as cybersecurity, the CAO may emphasize selections for sponsoring facilities and disciplines supporting this area of expertise. CAOs also make adjudications so that the facilities receive more equitable distributions of scholars. Any intra-Component selection conflicts are resolved in a meeting of all the Service liaisons (Air Force, Army, Navy, and other DoD agencies). They make decisions and negotiations with other Components on behalf of the CAOs.

D. Overall Workforce Planning, Selection, and Placement Findings

It is challenging to define or operationalize the stated program goal of recruiting S&E workers that have skills “critical to the national security functions of the Department of Defense and are needed in the Department of Defense workforce.” To meet this mandate, a full understanding of the DoD workforce needs is required. The program has been continuously improving their approach to fit SMART scholar applicants with facilities as this is one way to improve the satisfaction of a scholar and the likelihood that they may be retained.

8. Additional Findings

Scholars, S&T mentors, SMART sponsoring facility POCs and SMART program staff make up the majority of the stakeholders involved in the SMART program. Other key players include the Component Execution Office, which decides on the priorities for that component each year, and academic institutions and advisors who are educating and training the SMART scholars during the program. This section is focused on perspectives from the various stakeholders, particularly as their perspectives are relevant to the outcomes of the SMART program and the impact of the SMART program. Perspectives related to SMART program processes can be found in the Process Evaluation Report of the SMART Program (Balakrishnan et al. 2018).

A. Scholar Satisfaction

In the SMART scholar survey, four survey items as laid out in Figure 31 were designed to assess scholar satisfaction with the SMART program. These items were presented on a five-point Likert-type response scale (–2 = strongly disagree, +2 = strongly agree). The four items were averaged to obtain a mean satisfaction for each scholar because they demonstrate high internal consistency.[25]

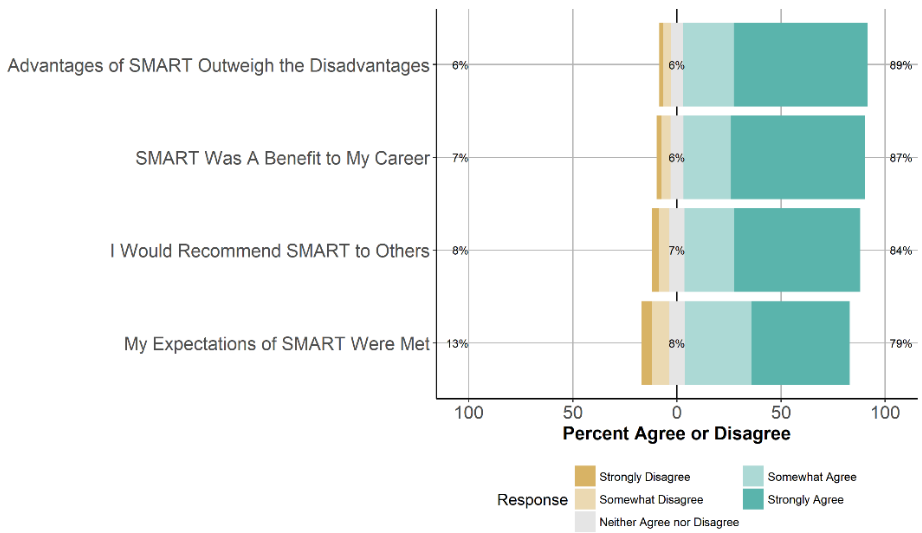

Figure 31. SMART Satisfaction Survey Items

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[25] Internal consistency between four survey items raw Cronbach's alpha = 0.91.

Overall, SMART scholar respondents reported high satisfaction with the SMART program.[26] We conducted multiple linear regression analyses to assess if various aspects of the SMART program explain variation in the outcome variable, scholars' mean satisfaction. Degree level, degree field, race, ethnicity, sex, cohort bin, scholar type (recruitment or retention), service, number of years funded through the SMART program, and the number of miles between the scholar's home address and sponsoring facility address are included in the model and are used to control for factors that might impact the outcome variable, mean satisfaction. In the linear regression, we found a few key characteristics of the scholars explained scholars' satisfaction:

- Scholars who were funded for more years were less satisfied[27]
- Scholars with doctoral degrees were less satisfied than scholars with bachelor's degrees[28]
- Scholars who did not enjoy working at their Sponsoring Facility were less satisfied than those who enjoyed their experience[29]
- Scholars who were less motivated to participate in the DoD mission were less satisfied[30]
- Scholars who worked at Sponsoring Facilities further away from their homes were less satisfied[31]

It is unsurprising that scholars who enjoyed working and were motivated to participate in the DoD mission were overall more satisfied. However, it is unexpected that scholars with doctoral degrees and those who were funded for more years were less satisfied. This may imply that the longer a scholar has to pay back service, the less happy he or she is, but there is really no causal relationship with the SMART scholarship.

B. Impact of Program on Scholar

We also relied on the SMART scholar survey to assess how the program affected the SMART recruitment scholar during the academic degree pursuit phase of the program (Figure 32). Seven survey items using a five-point Likert-type response scale (–2 = strongly disagree, +2 = strongly agree) were used. Statements ranging from how SMART funding

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[26] Full sample model, $M = 1.33$ $SD = 0.89$ ($N = 890$).

[27] Number of years funded, estimate:-.17, $p < .001$.

[28] Scholars with doctoral degrees compared to scholars with bachelor's degrees, estimate: -0.39, $p < 0.01$.

[29] Scholars who did not enjoy working at their Sponsoring Facility, estimate: -0.269, $p < 0.001$.

[30] Scholars who were less motivated to participate in the DoD mission, estimate: -0.120, $p < 0.05$.

[31] Distance between Sponsoring Facility and Home address (measured in miles divided by 100): -0.001, $p < 0.05$.

affected degree completion (e.g., *SMART funding made it possible for me to complete my degree more quickly*), to how SMART affected academic pursuit (e.g., *My experience with the SMART Program and scholarship was a motivating factor for me staying in my academic field*). One of these statements (*My experiences at my Sponsoring Facility positively affected my academic direction*) was selected to represent the impact that the SMART program had on scholars experiences during Phase I ("impact on scholar").

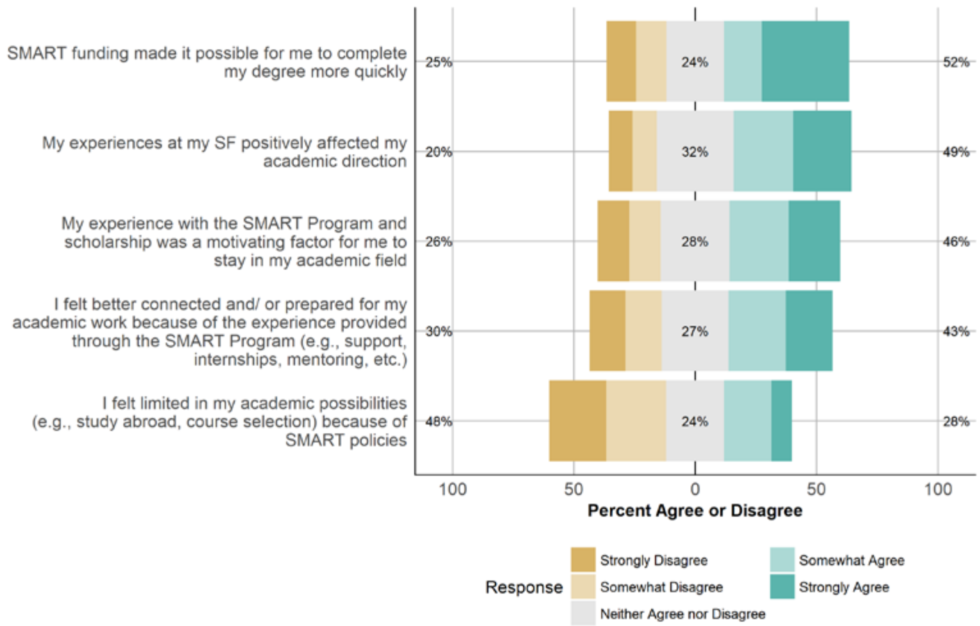

Figure 32. SMART Program's Impact on Scholar

About one-half of SMART scholar respondents reported that experiences at their Sponsoring Facility positively affected their academic direction.[32] We conducted a multiple linear regression analysis to assess if various aspects of the SMART Program explain variation in the SMART program's impact on recruitment scholars. We found that recruitment scholars who felt adequately mentored during their internship(s) and found their internship experience valuable reported a higher positive impact.[33] Additionally, scholars in the 2015 cohort reported higher positive impact compared to the other three cohorts (2006–2007, 2008–2012, and 2013–2014).[34] Recruitment scholars who preferred

32 $M = 0.43$ $SD = 1.23$, 49% agree.

33 Recruitment scholars who felt adequately mentored during their internship(s), estimate: 0.218, $p < 0.001$. Recruitment scholars who found their internship experience valuable, estimate: 0.418, $p < 0.001$.

34 2015 cohort compared to 2006-2007 cohort, estimate: 0.417, $p < 0.05$.

facilities where they had prior work experience during the application process also reported a higher positive impact.[35]

C. S&T Manager Perspectives

S&T managers interviewed were overall very satisfied with the SMART Program. We developed three statements to quantify levels of satisfaction based on a five-point Likert-type response scale. Figure 33 describes the S&T managers' overall satisfaction of the program based on 55 interviews.

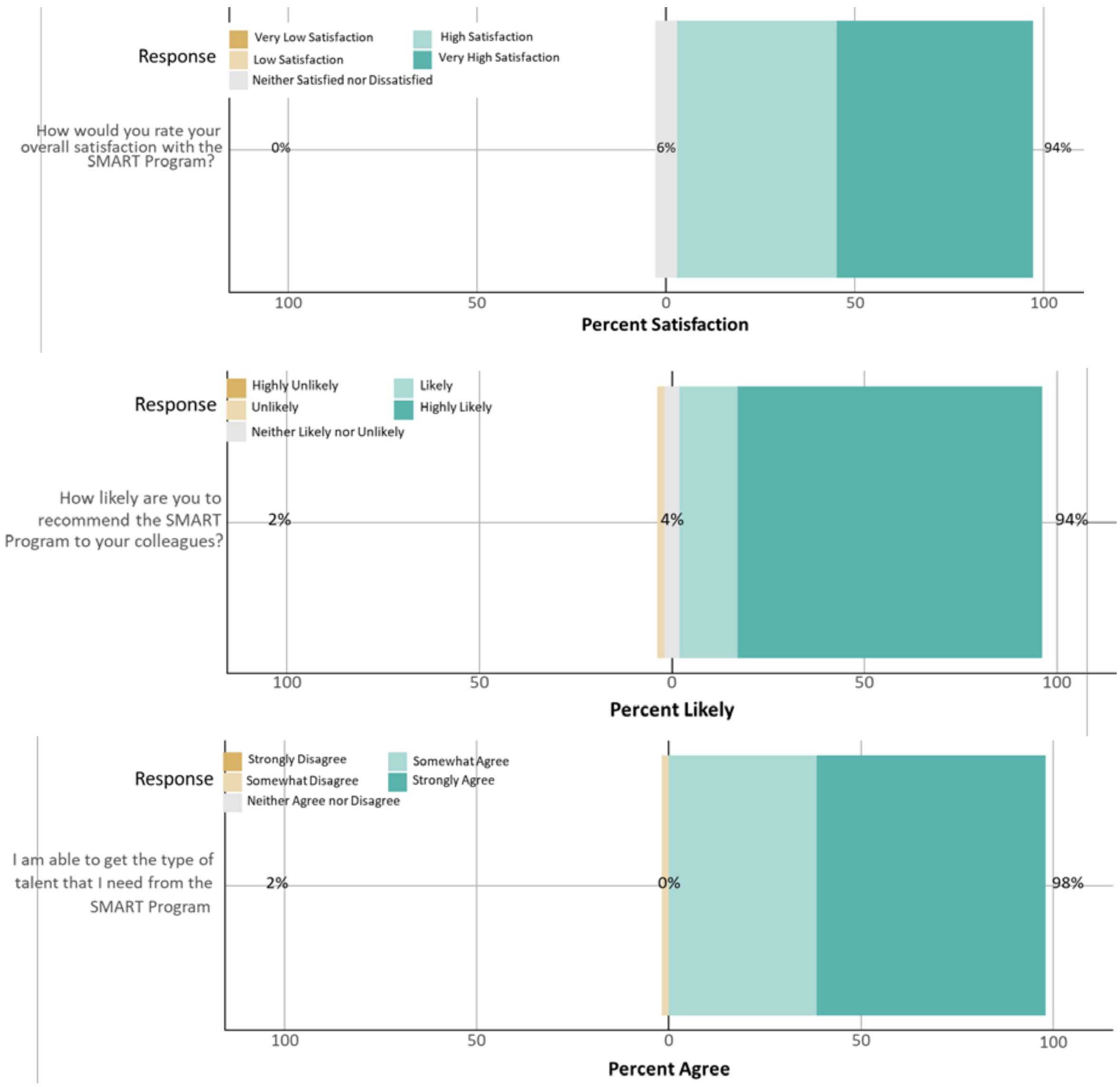

Figure 33. S&T Manager Satisfaction of SMART Scholarship Program

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35 Preference for facilities where they had prior work experience, estimate: 0.098, $p < 0.01$.

Ninety-four percent of respondents indicated high or very high satisfaction when asked how they would *Rate [their] overall satisfaction with the SMART Program*. The small minority who did not indicate high or very high satisfaction answered neutrally (they were neither satisfied nor dissatisfied). These respondents typically identified a specific part of the process with which they were unhappy (for example, if a security clearance was not handled efficiently or timely). Ninety-six percent of respondents said *they were likely or highly likely to recommend the SMART Program to colleagues*. Ninety-one percent of respondents indicated that they somewhat or strongly agree that *they are able to get the type of talent they need from the SMART Program*.

D. Scholar Perspectives on Hiring in Facilities

Scholar survey respondents who reported completing Phase I were asked a series of questions regarding their perceived level of support during the transition from Phase I to Phase II (e.g., *I Felt Supported by SMART Program Office During my Transition from Phase I to Phase II*) and their experiences during Phase II (e.g., *I Felt Adequately Mentored by Someone at my Sponsoring Facility during Phase II*). These survey items were presented on a 5-point Likert-type scale (–2 = strongly disagree, +2 = strongly agree).

Overall, SMART scholar respondents reported feeling supported and mentored by members of the sponsoring facility but were less likely to report feeling supported by the SMART program office during Phase II (see Figure 34 for more details). These survey results did not change significantly from cohort to cohort. One explanation for feeling less supported by the SMART program office during the transition to Phase II or during Phase II itself is that scholars do not typically view themselves as a SMART scholar after being hired by a sponsoring facility. Rather, they view themselves as sponsoring facility employees or S&E workers because there is no branding or community of SMART during Phase II. Like other SFS programs, the SMART program may want to consider building a community of SMART scholars at facilities or through virtual networks to maintain a SMART scholar identity. Providing more opportunities to build a network can offer benefits to both the scholars and the program. The scholars may learn about work being done at their sponsoring facility and at other facilities, and they may feel they have a sense of belonging at their sponsoring facility. Facilities in turn can rely more heavily on their hired SMART scholars to recruit for the SMART program and serve as mentors for new scholars. This is already being done in several facilities, but creating a program for SMART alumni may foster more networking.

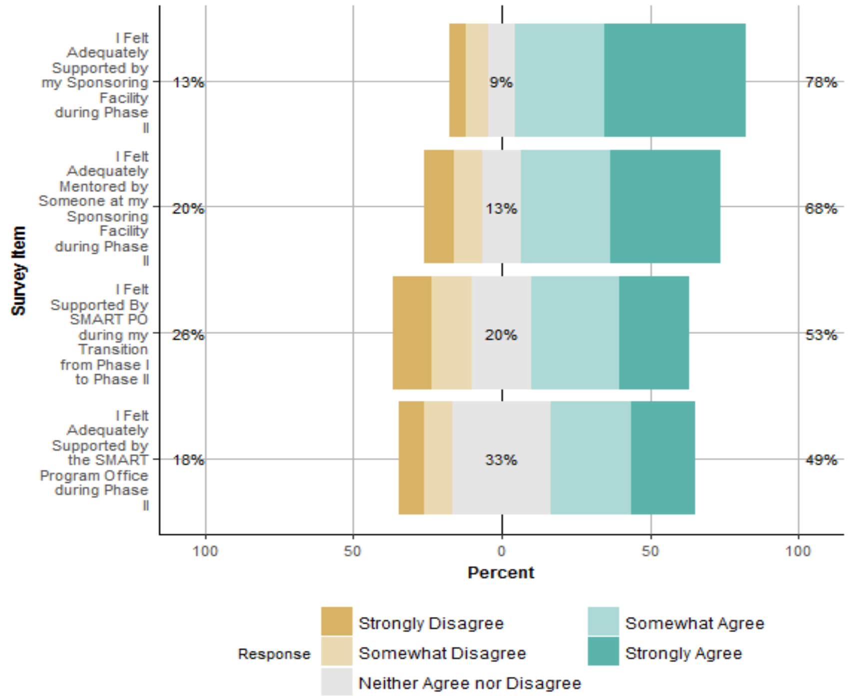


Figure 34. Perspectives on Hiring and Phase II

In 2015, NAVAIR's Patuxent River facility began hosting a SMART scholar symposium for their SMART scholars. The SMART program staff and the Patuxent River S&E leadership were invited to attend the event. Several SMART scholars, mostly in Phase II, presented their research through poster presentations to the colleagues, including other SMART scholars, S&E managers and supervisors, and the facility leadership. In 2017, the SMART program office expanded the SMART research symposium to include SMART scholars from all Components. Facilities were asked to nominate scholars to attend the event and present to DoD S&E leadership about their research. The event was held in July 2017 at Wright Patterson Air Force Base. Scholars were given tours of the sponsoring facility and the opportunity to network with each other and leaders in the DoD S&E enterprise. The SMART program should continue to promote such events and consider expanding them to more scholars. This event is an example of building in more identity for SMART scholars after they are hired and maintaining the SMART brand after they graduate.

E. Overall Stakeholder Perspective Findings

Overall SMART scholars and their S&E managers were satisfied with the SMART scholarship and would recommend the program others. However, scholars did identify some areas that could be improved like support during their transition from their degree pursuit to their service commitment phase. In addition, scholars were seeking more mentoring and professional development opportunities.

In terms of the program's impact on the scholar, one-half of SMART scholar respondents reported that experiences at their Sponsoring Facility positively affected their academic direction which when controlling for demographic variables was correlated with feeling adequately mentored during their internship.

9. Overarching Findings and Recommendations

This program evaluation encompassed understanding and analyzing many facets of the SMART program, from the vast array of stakeholders to the different processes and finally the outcomes of the scholars. The overarching findings are based on stakeholder interviews, a SMART scholar survey, site visits, analyses of administrative and workforce data and publication data.

Finding 1: SMART scholars are overall higher quality than counterparts

We considered several aspects of SMART scholar quality given that there is no single measure of worker quality. Our overall assessment is that the SMART scholar group is higher performing than those DoD civilian S&E workers hired through other mechanisms. Based on DoD S&E civilian personnel data from the DMDC, SMART recruitment scholars are promoted more rapidly and have faster salary increases than their counterparts. S&E managers that directly oversee the work of SMART scholars at their sponsoring facilities agreed, during structured interviews, that SMART scholars perform better when compared to traditional workers across several components of quality including technical capability and caliber of work produced.

We also investigated metrics relating to a SMART scholar and comparison group S&E worker background. There is evidence that the SMART program draws from a higher quality candidate pool than the one available to DoD generally in hiring S&E workers. Analyses of the type of research institutions by Carnegie Classification and R&D spending at doctoral institutions suggests that SMART doctoral scholars come from higher quality institutions than the DoD civilian S&E workers comparison group.

Across all education levels, we found that SMART recruitment scholars have lower starting salaries, controlling for age, sex, race, and occupation. This effect is more pronounced at the master's and doctoral levels. When scholars were asked about their perspectives on the salary offered at the DoD, 32 percent of scholars strongly or somewhat agreed that they were being paid comparable to other positions for which they were qualified (not necessarily in direct comparison with similar individuals at their facilities). In contrast, 55 percent disagreed with the statement indicating that SMART scholars felt underpaid for the type of work they did.

In 2014, the SMART program office made efforts to remedy the lower starting salaries of SMART scholars. Results of our analyses of starting salary by cohort are inclusive, in large part, because few individuals, especially few doctoral scholars, in the 2014 cohorts and after have started Phase II.

Finding 2: The SMART program attracted students who had not considered the DoD as an S&E employer

Thirty percent of scholars surveyed were not aware of S&E workforce opportunities at DoD prior to applying indicating that a number of scholars who join the DoD workforce through the SMART scholarship would not have otherwise come. The two types of scholars apply for the program for different reasons – retention scholars have already chosen to serve the DoD mission and want to gain more skills through receiving another degree viewing the SMART scholarship program as a professional development opportunity. In contrast, the recruitment scholars are new to the DoD and tend to be early career. They learn about their program through word of mouth, not necessarily through their universities or through advisors. Furthermore, for many recruitment scholars, the DoD facility employment is their first job. The SMART program office has implemented some activities such as site visits and the SMART scholar symposium to help scholars better understand the work at the facilities and to engage in activities that build their careers.

Finding 3: The SMART program has greater gender diversity, but less racial diversity, than the DoD S&E workforce

The SMART program has more women or greater gender diversity (26 percent of scholars hired into DoD) than the DoD S&E workforce (21 percent). The gender diversity of SMART scholars has been increasing since the start of the program. In contrast, SMART scholars are less racially diverse than both the pool of S&E applicants receiving STEM degrees and the overall DoD S&E workforce. Furthermore, racial diversity decreases at every step in the application process.

Finding 4: The SMART program appears not to contribute to the retention of SMART scholars at DoD sponsoring facilities post-service commitment

SMART recruitment scholars leave at statistically significantly faster rates than their comparison group. For example, the percentage of recruitment scholars retained at 3 years, and 5 years is 73 percent, and 55 percent respectively, and the percentage of their comparison group retained 3 years, and 5 years is 86 percent, and 78 percent. SMART scholars are leaving at statistically significantly faster rates because of low salaries (starting and in comparison to the private sector), frustration with the work culture and work experience, and working in locations far from their homes. This pattern is similar to other DoD scholarship incentive programs like ROTC, and there is evidence from the literature that paying above and beyond for students or workers does not necessarily result in them staying after their commitment is completed. Second, SMART retention scholars are more likely to stay in DoD than their counterparts up to a point, but this trend changes over time. After retention scholars have likely worked at DoD for several years again after SMART, they are more likely to leave than their comparison group. However, several more years of data are needed to better understand retention scholars' likelihood to stay in DoD after their service commitment.

There are two other germane retention findings. First, when scholars leave DoD, the majority of scholars leave for non-DoD private sector employment (45 percent) or academia/further education (16 percent). Scholars reported leaving mostly for career growth and for more interesting jobs.

Finding 5: While the legislative goal of the SMART program is to provide S&E talent to meet the needs of the DoD mission, the actual execution of the program indicates that there are multiple goals in operation

Through interviews, we understood that initially the program was created, in part, to address the needs of the aging S&E workforce, indicating that DoD was interested in recruiting **more** S&E workers. But in discussions, many stakeholders noted that the SMART program provided facilities access to **higher quality** talent. Some SMART S&E managers stated that increasing **diversity** was important, though not listed, is not an explicit goal under the legislative authority of the program. The program goals are implemented in multiple ways given that there are retention scholars who are already DoD civilian S&E workers and seeking to further their education, and recruitment scholars who are new talent who have never worked for the DoD and are in school at the time of application.

Having many stakeholders approaching the goals in multiple ways makes managing the SMART program more challenging. To that end, the SMART program office has implemented processes that address the legislative mandate of providing talent that have "STEM skills…as determined by the Secretary…needed in the DoD workforce. This is done by allowing the services to prioritize degree fields and degree levels that meet the service's critical mission area workforce needs each year. The services are then given the opportunity to determine the sponsoring facilities eligible to receive a SMART scholar. Each service approaches this opportunity differently, with Navy and Air Force taking a top-down approach and Army a bottom-up approach. This process uses degree fields and degree levels as a proxy for "skills" and could be refined to identify skills demand more effectively.

Some sponsoring facilities appear to be relying on the program because it recruits top talent and it offers non-competitive conversion hiring authority which is an attractive hiring tool. The S&E talent hired through the SMART program is very broad, across many disciplines and degree levels. A sponsoring facility may rely on the SMART program to hire bachelor's degree engineers, but they could perhaps meet that demand using other hiring mechanisms. Some sponsoring facilities indicated that they have a demand for graduate level degrees in certain fields that are hard to hire using their traditional hiring mechanisms and authorities. This latter type of demand appears to be more appropriate for the SMART program than hiring because the program has the mechanism to hire scholars easily. It may even be appropriate to look at the demand for scholars at certain types of facilities or laboratories where skills and degree fields for the DoD S&E workforce need to be more research oriented. Scholars are placed at sponsoring facilities across the laboratory and facility enterprise, with slightly more than 50 percent of scholars being placed at laboratories within the Defense Laboratory Enterprise structure, which focuses more on basic and applied R&D.

Finding 6: Many SMART scholars are satisfied with the program

Eighty-seven percent of scholars surveyed stated that the SMART program was a benefit to their career and 84 percent indicated they would recommend the program to others. Scholars who are more satisfied with the program are more likely to be retained. Furthermore, scholars that are more satisfied are more interested in serving the DoD mission. Scholars noted that satisfaction with their work and the topics they are working on are very important as well. Matching the scholars to the facility that best suits their interests and meets the DoD workforce needs is challenging, and can lead to some dissatisfaction. Unsurprisingly, those who were less satisfied with the program were more likely to leave DoD civilian employment than those who were more satisfied with the SMART program.

Overall, retention scholars had a higher approval of the SMART program and generally higher retention rates than recruitment scholars.

Recommendations

The SMART program office asked IDA to identify a set of recommendations to improve the outcomes of the SMART program.

Though the legislative goal of the program has been generally followed, there has been a lot of focus on metrics of retention for SMART scholars, and less on metrics for quality. Retention of SMART scholars and recruitment of quality scholars are two different aspects of the program, and the SMART program office has much more influence over the recruitment of quality SMART scholars rather than the retention of scholars. Retention is the responsibility of the sponsoring facilities. That said, the program office has some levers it can use to help influence retention.

Recommendation 1: The SMART program office could focus on continuing to recruit high quality scholars and improve the applicant pool.

If the goal is to increase quality of the underlying people then the focus should be on improving the pool of candidates, both recruitment and retention scholars at the recruitment and application stages.

Recruitment of High Quality Scholars

Recommendation 1.1. Build a SMART brand within DoD and outside of DoD that attract high quality students through using SMART alumni from facilities to recruit new SMART scholars.

Recommendation 1.2. Educate faculty and university career offices to better understand the SMART scholarship program.

Recommendation 1.3. Create a pilot program with top higher education institutions to provide SMART scholars' academic advisors research support to conduct research of critical importance to the DoD mission while also training SMART scholars. This approach could lead to stronger ties between academia and DoD research priorities.

Recommendation 1.4. Create programming to help bring SMART scholars together to build networks of scholars at facilities and rely on these networks for recruitment.

Recommendation 2: The SMART program office could also focus on improving retention of scholars.

If the goal is to train SMART scholars to be better DoD S&E employees who are interested in staying employed at the DoD, then the focus should be on influencing the internship experience to prepare scholars more effectively.

Retention of Scholars

Recommendation 2.1. Ensure that sponsoring facilities meet a standard of excellence regarding providing scholars effective mentorship and training, and provide scholars work experiences commensurate with their skills and interests.

Recommendation 2.2. Consider making revisions to the scholarship application to more effectively test scholars' interest in serving the DoD mission.

Recommendation 2.3. Create a pilot program to build more flexibility regarding scholar placement between scholar and facility, perhaps allowing scholars to rotate between commands or services.

Recommendation 2.4. Implement more experiences like the SMART scholars symposium to recognize SMART scholars and highlight their accomplishments while they are working at their sponsoring facilities.

Recommendation 2.5. Reconsider relying on percentage of scholars retained as a metric by which to evaluate the SMART scholarship program.

Recommendation 3: Investigate differences in starting salaries and work with DoD facilities to understand the salary disparities

Starting salaries for SMART scholars are statistically significantly lower than their comparison group: DoD civilian S&E workers. Over the past 4 years, the SMART program office has worked to address this issue, but the timeframe of this evaluation analysis would not capture any SMART scholar policy changes that occurred after 2014.

Recommendation 3.1. Sponsoring facilities needs to investigate hiring processes to ensure equity in the SMART scholar hiring process

Recommendation 3.2. Sponsoring facilities should monitor starting salaries and ensure SMART scholars are paid commensurate with their peers at all facilities

Recommendation 4: To increase diversity, continue to recruit female scholars while expanding efforts to increase representation of URM

Recommendation 4.1. Investigate why so many URMs drop out during the application process and if the process is losing top talent. Consider piloting a mentoring effort during the application process to a group of URMs to see if efforts will increase application success

Recommendation 4.2. Explore focusing more recruiting on scholars from Hispanic Serving Institutions and large academic institutions with a large number of URMs.

Recommendation 5: Conduct a workforce "demand" analysis for components and facilities to determine and prioritize the sponsoring facility/laboratory need for SMART scholars including degree field, degree level and skill level

Recommendation 5.1. Given the changing landscape of S&T priorities within the services, such as Artificial Intelligence or Quantum Computing, the SMART program could target certain disciplines and skill levels each year to meet the DoD S&E workforce demand, particularly in areas of science and technology where the Department is challenged in finding qualified workers. Furthermore, a workforce demand analysis could determine that certain degree field and degree levels may not be necessary to include in the SMART program because the Department is able to find these S&E workers through other hiring mechanisms.

Recommendation 5.2. The SMART program could consider relying on a workforce demand analysis to determine the degree to which the SMART program should expand.

Appendix A.
Study Questions

SMART Program Impacts

1. To what extent did the SMART program impact (financially, economically, academically, etc.) SMART scholars?
    a. To what extent did the SMART program benefit SMART scholars who would not have normally worked at DoD facilities?
    b. To what extent did the SMART program benefit SMART scholars who had previous DoD work experience?
2. To what extent did the SMART program attract a more diverse set of S&E workers to the DoD as compared to the broader DoD S&E workforce?
3. To what extent did the SMART program attract S&Es who would not have normally worked at DoD?
4. To what extent did the SMART attract S&Es to who had previous DoD work experience to continue working at DoD?
5. To what extent are various stakeholders satisfied with facility placement particularly with regard to fit? (e.g. support/mentorship/professional development opportunities provided to the scholar by the facility)
6. To what extent does the SMART program contribute to the retention of SMART scholars at the facilities post-service commitment
    a. To what extent does the SMART program contribute to the retention of SMART scholars with previous DoD facility work experience at the facilities post-service commitment?
    b. To what extent does the SMART program contribute to the retention of SMART scholars with no previous DoD facility work experience at the facilities post-service commitment?
    c. To what extent is SMART scholar retention (post-service commitment) depend on the Sponsoring Facility? (with prior DoD experience)
    d. To what extent is SMART scholar retention (post-service commitment) depend on the Sponsoring Facility? (without prior DoD experience)

7. To what extent did the SMART program improve the quality of the civilian S&T workforce? (e.g. outputs such as publications, presentations, research, honors/recognition, patents, community service)

SMART Program Spillover Benefits

1. To what extent did the SMART program create or strengthen ties between PIs at academic departments and DoD facilities (particularly research facilities)?
2. To what extent do SMART scholars who leave DoD facilities join organizations that serve DoD interests (DoD contractors, FFRDC, etc.)

Appendix B. Logic Model

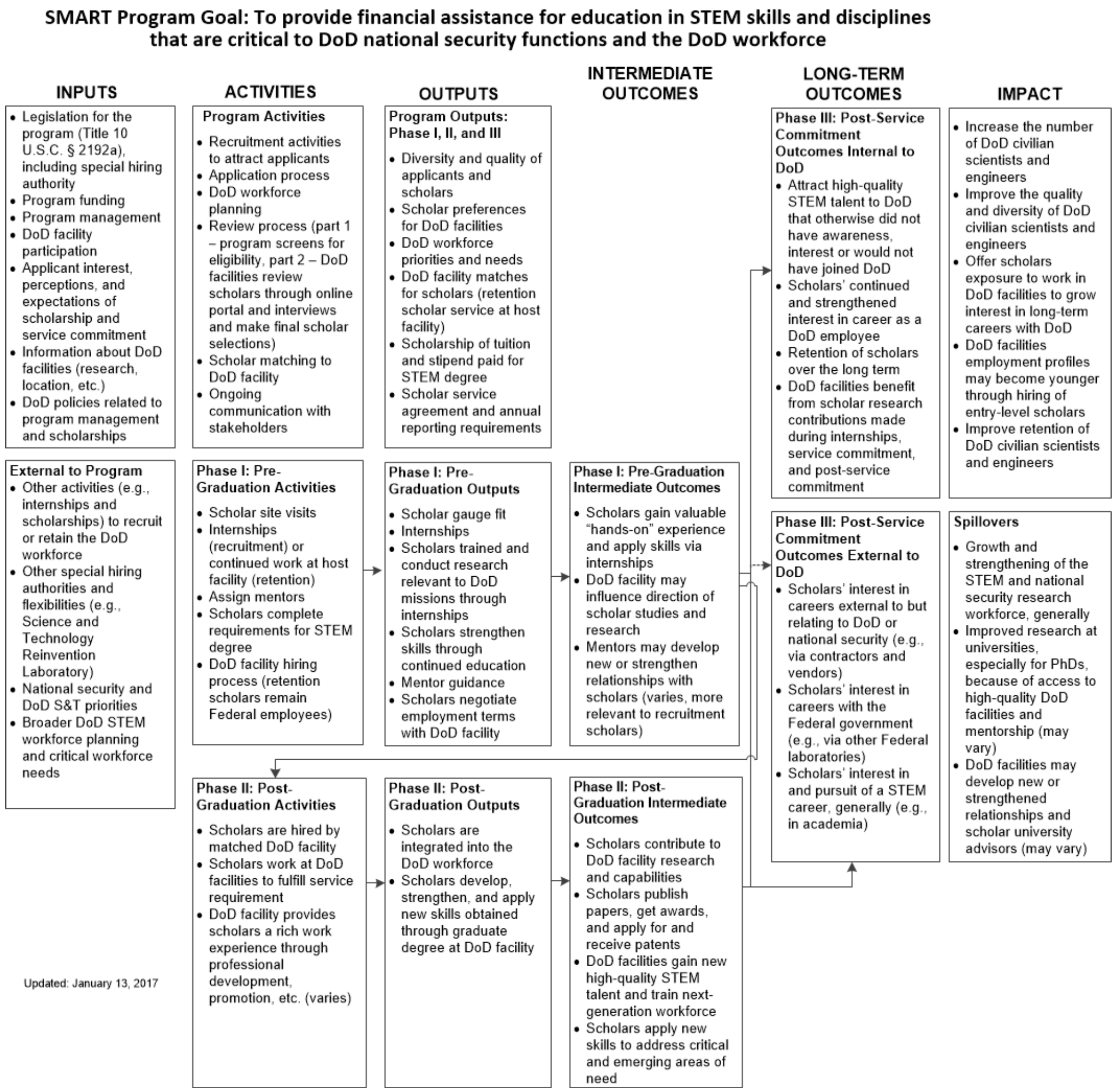


Figure 35. SMART Program Logic Model

This model described in Figure 35 is broken out into six categories: inputs, activities, outputs, intermediate outcomes, long-term outcomes, and impact.

1. Inputs are essential elements of the program. For the SMART scholarship, these inputs include the defining legislation, program management, appropriated funding, interested scholars, and sponsoring facilities.
2. Activities can be broken out into the following:
   a. Program activities, such as application reviews, facility placement and coordination, scholar remuneration, and tuition payments
   b. Scholar activities in the various phases of the scholarship, including degree pursuit, internship, and service commitment.
3. Outputs are the near-term results of activities and can include the number of STEM degrees supported, the number of internship years supported, and the number of scholars employed at DoD sponsoring facilities.
4. Intermediate outcomes are aspirational and near-term results of outputs, and can include experiences gained through exposure to DoD S&E work or connections made between sponsoring facilities and academics.
5. Long-term outcomes are cumulative results of intermediate outcomes that demonstrate the promise that these outcomes will make an impact. For example, these long-term outcomes could include scholars having a continued interest in working for DoD or, in general, within the mission of national security.
6. Impact is the realized benefits of the investment on either the worker, the facility, or the institution. For example, improving the growth of the S&E workforce within the DoD.

In Phase I, the scholars are enrolled in an academic degree program and receive the scholarship. For scholars who have multiple year length awards, during the summers in between their semesters, they participate in internships at their sponsoring facility. In Phase II, the scholars repay their commitment by working as a government employee at a DoD facility. In Phase III, scholars have fulfilled their commitment and may continue to work at the DoD facility or may leave.

Appendix C.
Methodology

The evaluation used several approaches to gather qualitative and quantitative data, including program documentation, interviews, a survey of the SMART Scholars, reviews of other Federal scholarship-for-service programs, bibliometric review, and data analysis using program data, as well as data from the Defense Manpower Data Center (DMDC). For details about the study questions, see Appendix A of this report.

Program Documentation

The SMART program office provided some literature about the program, and IDA identified some additional relevant literature. Overall, this literature included the SMART legislation, the SMART participant handbook, the SMART scholarship application, ASD(R&E) budget requests for SMART that were submitted to Congress, the SMART program website, and other materials provided by the SMART program contractor or the SMART service liaisons (U.S. Congress 2004, U.S. Department of Defense 2018). We derived a basic understanding of the program process through these documents.

Interviews

The IDA team conducted several rounds of interviews to target various stakeholders involved in the program. For each round of interviews, we identified the target group of interviewees or sponsoring facilities, developed interview protocols, and interviewed several stakeholders from the program and selected sponsoring facilities. Stakeholders were divided into groups: SMART program staff including the program management and liaisons with the components, SMART Component Execution Leads, DoD sponsoring facilities staff (HR, SMART POCs and S&E managers), select academic PhD thesis advisors and SMART scholars. The research team began the process evaluation interviews with a set of stakeholders who work full time to operate and manage the SMART program. These stakeholders include the SMART program manager, SMART service liaisons, and other SMART staff who provide program support.

Across the two rounds, we interviewed personnel at 29 sponsoring facilities (19 sponsoring facilities visited in person) in 23 locations (16 locations visited in person) that were spread across 16 States. At the sponsoring facilities, we interviewed SMART POCs, HR personnel, S&E managers, and scholars. Forty percent of SMART scholars placed between 2006 and 2016 were at one of these sponsoring facilities. Table 15 shows the number of interviewees in each of the stakeholder groups.

Table 15. SMART Interviewee List

Group	Number of Interviews
SMART program staff (program manager, contractor support staff)	5
SMART service liaisons (Air Force, Army, Navy and Other DoD)	4
Component Administrating Officers (CAOs) (Air Force, Army, Navy)	3
Scholars	59
Phase I*	16
Phase II	21
Phase III	22
Facility S&E Mentors and Managers	99*
SMART POCs	33*
HR personnel	17
Academic Advisors	18
Other	2
Total	**232**

* Two Phase I scholars had been awarded the SMART scholarship and were on their site visits when interviewed. Among the S&E managers interviewed, eight were also SMART POCs, so they are counted in both categories but only counted once for the total

Round 1—POCs, Liaisons, Contract Support and S&T Managers

The interviews with stakeholders were conducted in two rounds. Round 1 interviews were initiated at the early stages of the evaluation to understand the program goals and processes, and took place from September 2015 to January 2016. Initial interviews with contract support such as Service Liaisons and Cohort Administrators were focused on getting a firm understanding of how the program works and the program's stated goals. Interviews with component execution leads, S&E managers, SMART POCs and HR managers. Sponsoring facilities targeted for interviews were selected based on the number of Scholars at those facilities. Selections were also made such there was an equal representation across Components with a diversity of facility type (e.g. research laboratory, acquisition facility, life cycle management center).

A protocol was developed for interviews with sponsoring facility stakeholders, which included:

- Benefits of using the SMART Program and working with SMART Scholars
- Challenges of using the SMART Program and working with SMART Scholars
- Connections with academia
- Perceived goals of the SMART Program and personal goals for using the SMART Program; definition of success
- How the SMART Program is used as a hiring tool, other workforce programs used, workforce planning, and recruitment techniques for SMART and traditional hiring

- Importance of, meaning of, and factors influencing retention
- Mentorship of SMART scholars
- Performance of the SMART scholar
- Suggestions for improvement

After interviews were completed, NVivo software was used to code the interview responses. NVivo is an analysis software that aggregates and manages qualitative data. A codebook was used to standardize how responses were labelled or “coded” in NVivo. After interview responses were coded, analysis on the data was conducted to determine if there were trends or general agreement across interviewees.

Round 2—SMART Scholars

The Round 2 interviews took place from June 2016 to October 2016 and focused more on SMART scholars, though some S&E managers were included. Scholars interviewed were in all Phases (I, II, and III), though all interviewees were retained or progressing at their Sponsoring Facility.

A protocol was developed for Scholar interviews that included questions in areas such as:

- SMART program and DoD awareness (how they heard about the SMART program, if they were aware of S&E career opportunities within the DoD prior to SMART)
- Motivation for applying to the SMART program
- Other scholarships applied for/considered
- SMART sponsoring facility selection
- Expectations of the SMART program
- Internship and mentorship experience
- Advantages and disadvantages to being a SMART Scholar
- Suggestions for change
- Overall satisfaction
- Likelihood to recommend the SMART program to others

Data from the interviewees with SMART Scholars were used to develop the SMART Scholar survey.

Round 3—S&T Managers and Mentor

Round 3 focused on conducting structured interviews with S&T mentors, supervisors, SMART POCs, and workforce planners to collect information about Scholar attitudes and performance, work assignments, definition of retention, and how the SMART program fits into overall workforce planning. An interview protocol was developed to standardize the interviews across interviewees. The protocol was organized into the following sections: Role of interviewee; Interactions with Scholars; Overall satisfaction; Applicant comparisons; Scholar performance; Scholar work assignment; Academic ties; Retention; and Workforce planning and recruitment strategy.

IDA identified facilities to participate in the interviews based on the number of scholars and having equal representation across services. The first criteria were to look at facilities with at least four scholars in Phase I and at least four scholars in Phases II and III. Facilities that were included in the preliminary interviews at the beginning of the study were excluded.[36] Additional down selection was made to ensure equal facility representation across Services and geographic diversity. In all, 17 facilities were included and 55 people were interviewed. Interviewees were asked questions that pertained to their interactions with SMART scholars and the SMART program, as well as their experience in workforce planning. For each question asked, we report the number of interviewees who responded to the question. Not all interviewees were asked all questions on the interview protocol. For example, if an interviewee was a workforce planner at their facility and did not work directly with SMART Scholars, they were not asked questions about mentoring or supervising SMART Scholars. Consequently, different questions will report having different numbers of respondents.

Of the facilities included, four were associated with the Air Force, six with Army, six with Navy, and one with DoD other. Nineteen interviewees (35 percent) were associated with the Air Force, 16 interviewees (29 percent) were associated with the Army, 19 interviewees (35 percent) were associated with the Navy, and one (2 percent) was associated with DoD other (Figure 36).

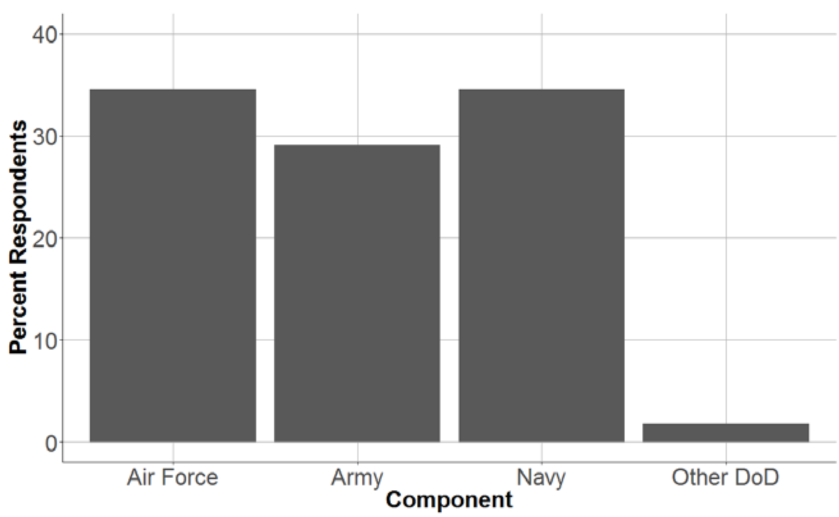


Figure 36. Percent of Interviewees by Component

36 See the Interim Evaluation Report for SMART Scholarship Program for information on the results of the preliminary interviews.

Demographics/Roles of Interviewees and Interactions with Scholars

Interviewees were provided with definitions of sponsoring facility roles associated with the SMART Program. Definitions included:

> SMART mentors—the facility staff that directly mentor SMART Scholars. These staff may include project leads, branch chiefs, or any other person who provides direct and continued mentorship in a formal or informal capacity.
>
> SMART supervisors—the facility staff that directly or indirectly supervise SMART mentors. These staff may include division chiefs, technical directors, or otherwise.

Additionally, interviewees were asked if they were their facility's appointed SMART POC and if they engage in workforce planning activities. Interviewees were allowed to indicate as many of the roles (SMART mentor, SMART supervisor, SMART POC, or workforce planner) as they identified with (Table 16).

Table 16. Roles of Interviewees

Role	Number of Interviewees
SMART Mentor	36
SMART Supervisor	31
SMART POC	6
Workforce Planner	45

Note: Interviewees were allowed to indicate all roles that applied (i.e. more than one selection)

Forty-five of the 55 interviewees indicated they participate in workforce planning. Of these interviewees, approximately equal numbers of mentors, supervisors, and those who indicated being both mentors and supervisors engaged in workforce planning. Additionally, all six SMART POCs interviewed engaged in workforce planning and one person interviewed only participated in workforce planning—in other words, had no other relation to the SMART Program (Table 17).

Table 17. Workforce Planner Roles

Role	Number of Interviewees
Mentor	11
Supervisor	13
Mentor and Supervisor	14
SMART POC	6
Only workforce planner	1

The 50 interviewees who indicated mentoring or supervising SMART Scholars and their mentors were asked how many SMART Scholars they worked with over the course of their careers.

The median number of SMART Scholars mentored or supervised by interviews is 3, however the mode was 2 and range was 1 to 17 (Figure 37).

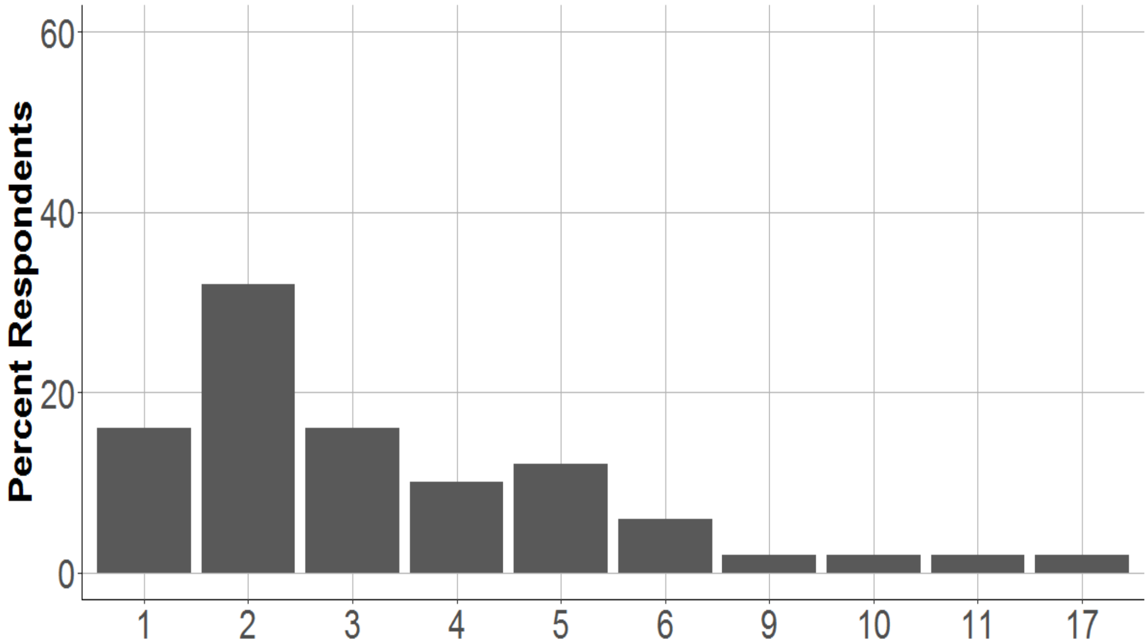


Figure 37. Number of Scholars Mentored or Supervised

Interviewees were asked how frequently they interacted with their SMART Scholar(s), to which the majority answered on a daily basis (Figure 38).

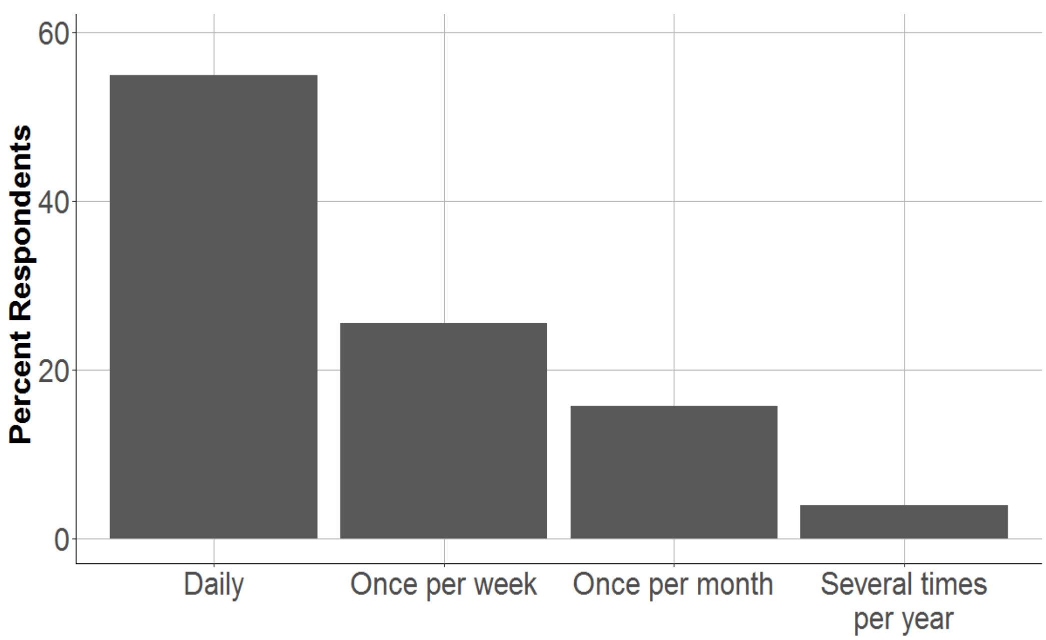


Figure 38. Average Interactions with Scholars

In some instances, supervisors and mentors had connections to SMART Scholars prior to their participation in the SMART Program. Interviewees indicated that in some cases, they use other programs or mechanisms—such as summer internship programs or university collaborations—to identify strong candidates who they refer and encourage to apply for the SMART Program. Of the 51 interviewees asked if they had prior connections with their SMART Scholar(s), 19 responded in the affirmative (37 percent). Of those who had prior connections with SMART Scholars, eight were with Navy, six were with Air Force, and five were with Army (none was with Other DoD). Types of previous interactions included summer interns (10), retention scholars (5), academic or other research collaborations (3), and personal references (2).

Round 4—Faculty Interviews

IDA conducted a series of interviews with past and present academic advisors of SMART scholars to better understand how the SMART Program contributed to forming or reinforcing collaborative relationships between sponsoring facilities and universities, and how the program could improve the opportunities through understanding best practices for improved DoD-university collaborations. Eighteen university faculty members who served as academic advisors for SMART scholars were interviewed.

IDA developed a semi-structured interview guide to ask the advisors about their awareness of the SMART Program, the perceived benefits and challenges with the program, any interactions with the scholar's SF, and suggestions for successful relationship building with SFs. Using information derived from interviews, IDA identified common themes in advisor experiences, a collection of factors that may lead to successful relationships between academic advisors and DoD researchers, and suggestions on how the SMART Program could be revised to improve opportunities for collaboration between academia and DoD. This study is not comprehensive or exhaustive—the intention was to identify effective mechanisms that can be shared with S&T managers and academic advisors on how to foster and strengthen ties between the DoD facilities and academic departments via the scholars.

IDA developed (1) a methodology for selecting academic advisors and (2) a discussion protocol to the guide semi-structured interviews.

Selection of Interviewees

IDA selected the advisors to be contacted for interview requests by analyzing information from the SMART Program administrative database, which provided contact information for academic advisors for each scholar, and results from the SMART scholar survey administered by IDA. Information regarding the interviewed academic advisors and their respective SMART scholars is shown in Table 18.

Table 18. Interviewees and their Respective SMART Scholar's University, Degree Type, and Scholar Cohort Year

Service	Sponsoring Facility	Scholar's University	Scholar's Degree Type	Scholar's Cohort Year
Air Force	Air Force Materiel Command-Air Armament Center	University of Michigan-Ann Arbor	Aerospace Engineering	2008
	Air Force Materiel Command-Air Armament Center	University of Florida	Aeronautical and Astronautical Engineering	2009
	Air Force Research Laboratory-Munitions Directorate	Auburn University Main Campus	Aeronautical and Astronautical Engineering	2008
	Air Force Research Laboratory-Sensors Directorate-Wright Patterson	Naval Postgraduate School	Aeronautical and Astronautical Engineering	2010
	Air Force Research Laboratory-Sensors Directorate-Wright Patterson	North Carolina State University at Raleigh	Electrical Engineering	2012
Army	U.S. Army Aviation-Missile Research Development And Engineering Center	The University of Texas at Austin	Aeronautical and Astronautical Engineering	2011
	U.S. Army Aviation-Missile Research Development And Engineering Center	Duke University	Chemistry	2010
	U.S. Army Communications-Electronics Research Development Center	University of Maryland-College Park	Materials Science and Engineering	2011
	U.S. Army Natick Research, Development and Engineering Center	Michigan State University	Biosciences	2008
	U.S. Army Research Lab - Sensors and Electron Devices Directorate	North Carolina State University at Raleigh	Chemical Engineering	2010
	U.S. Army Research Lab - Weapons and Materials Research Directorate	Georgia Institute of Technology-Main Campus	Mechanical Engineering	2011
Navy	Naval Air Warfare Center-Patuxent River	Pennsylvania State University-Main Campus	Aeronautical and Astronautical Engineering	2011
	Naval Air Warfare Center-Patuxent River	North Carolina State University at Raleigh	Electrical Engineering	2008
	Naval Undersea Warfare Center-Division Newport	University of Rhode Island	Electrical Engineering	2011
	Space and Naval Warfare Systems Center Pacific	University of California-San Diego	Electrical Engineering	2007
	Space and Naval Warfare Systems Center Pacific	University of Washington-Seattle Campus	Electrical Engineering	2006
Other DoD	Defense Microelectronics Activity	Naval Postgraduate School	Electrical Engineering	2009
	Defense Microelectronics Activity	University of California-Davis	Electrical Engineering	2010

Development of the Discussion Guide

IDA developed a discussion guide with a series of questions to provide guidance for semi-structured interviews. The questions targeted information of interest related to the potential roles the scholar and SMART Program played in influencing DoD-university collaborations, while also providing the interviewee the flexibility to shape their response and discuss their unique experiences. Discussion topics and questions included:

- Background questions to identify ways academic stakeholders hear about SMART
- Questions to describe the academic advisor's role, their opinions about the SMART Program, and their interactions with DoD researchers
- Benefits of SMART program, comparison to other STEM scholarships, and overall views of the SMART program
- How did SMART scholar funding impact your time/resources?
- Current relationship with the SMART scholar
- Types of interactions with DoD researchers at the SMART scholar's facility
- Potential ways to improve interactions between the SMART program office or DoD facilities with academic faculty

SMART Scholar Survey

The SMART scholar survey was designed to assess SMART scholars' attitudes and perspectives towards the SMART program, to understand factors that may affect retention, and to collect demographic information. Specific survey items related to the process evaluation include:

- Overall level of satisfaction with the SMART Program and scholarship experience
- SMART application, selection, and acceptance processes
- Perspectives during Phase I: Academic Degree Pursuit
- Perspectives during Phase II: Service Commitment
- Perspectives during Phase III: Post-Service Commitment
- Background information

The survey was organized around the different phases of the SMART program and respondents were presented with only those portions of the survey relevant to their scholar type (recruit versus retention), program phase, follow-on status, and whether or not they transferred sponsoring facilities during the academic pursuit phase (Phase I) or the service commitment phase (Phase II).

IDA obtained both demographic and contact information, including primary and secondary email addresses and phone numbers, for the comprehensive population of 1,723 current and former

SMART scholars from the 2006–2015 cohorts.[37,38] SMART scholars were contacted using a multi-modal approach including via email participation requests from the SMART program office and IDA, as well as via phone contact. First, the SMART program office emailed an informational message to SMART scholars on February 17, 2017 to inform them of the SMART Scholar survey. Second, IDA staff emailed two participation requests to primary email addresses on February 24, 2017, March 2, 2017, and to secondary email addresses on March 8, 2017. Third, IDA staff called non-responsive SMART scholars the week of March 15, 2017 to inform them of survey and to acquire a current email address. Overall, this methodology yielded a 64 percent response rate (1,112 out of 1,723 total SMART scholars). More details about the SMART scholars survey can be found in the SMART Process Evaluation Report (Balakrishnan et. al. 2017).

Review of Other Federal scholarship-for-service Programs

The research team also conducted a parallel study of other SFS and service payback programs to inform this evaluation (Peña et al. 2016). We identified 35 SFS programs (not including SMART) supported by Federal and non-Federal organizations. We identified these programs through public literature and online program document searches.

Our criteria for inclusion in this review included Federal and non-Federal programs that

1. Funded scholarships at the undergraduate and graduate (master's and doctoral) levels, including health professional degrees, such as those in dentistry, nursing, and medicine;
2. Ranged in service lengths or minimum service commitments; and
3. Ranged in flexibility regarding the type of organizations in which the service commitment could be met, among other program features.

In the parallel study, we selected 10 Federal programs to further explore their processes. These programs were selected for diversity across the three characteristics outlined above and included STEM-focused and non-STEM programs. We researched these programs in depth and conducted interviews with staff from each SFS program to inform the development of case studies and to understand each program's history, policies, design, administration and management, and hiring processes. This review helped to inform the process evaluation in that SFS programs are designed differently based on the different outcomes sought. Best practices from the other models of SFS programs were provided to the SMART program in the separate report, which outlined

[37] 2016 cohort data is included in much of the analysis, but they were not included in the survey as they would not have effectively started internships in the SMART program until after the survey was complete. Because of the nature and process of the program in 2005, the pilot year, responses from the 2005 cohort were removed from survey analysis.

[38] 1723 scholars represented 1782 scholarships awarded from 2006–2015. 55 scholars were awarded two or more scholarships from 2006 to 2015. Two additional scholars who received multiple awards (one of which occurred during 2015) were removed from analysis.

possible opportunities for improvement. These best practices were integrated into the process evaluation findings in this report.

SMART Program Office Data

The SMART program office provided the research team detailed information about scholars. This information included cohort year, degree field, degree type, STEM discipline, scholarship status, facility assignment, and educational institution. Descriptive statistics and analyses of characteristics of scholars, sponsoring facilities, and higher education institutions are presented in Chapter 2.

Defense Manpower Data Center Database

Introduction

We received personnel data on civilians employed from October 2006 to October 2016 from the Defense Manpower Data Center (DMDC). We obtained quarterly data beginning in 2008; prior to 2008, we obtained only annual data in October. For each individual, we received information on demographics, education, position, and location (Table 19). The data we received contained information on 1.3 million individuals; in 2006 there were approximately 680,000 civilians and in 2016 there were approximately 755,000 civilians. We processed and analyzed all data containing personally identifiable information in a secure facility.

Table 19. Data Fields Obtained from DMDC

Category	Field
Personal Information	Name Social Security Number
Demographics	Race Sex Ethnicity
Education	Degree Level Degree Field Graduation Date Occupation Code Position Title
Salary/Promotion	Annual Base Pay Work Schedule Grade Step or Rate

Category	Field
Location	Base ID Base Zip Code Unit Identification Code
Dates	Hire Date (entry point in data) Departure Date (exit point in data) Federal Service Compute Date Birth Date

SMART Scholars, Comparison Group, and S&E Civilian Population

We ran a one sample Z test of proportion with continuity correction comparing SMART scholars to the S&E population. The subsequent section of this Appendix describes of our use of propensity score matching to identify a comparison group. SMART scholars are generally more diverse in terms of sex and less diverse in terms of race. Additionally, compared to the S&E population the percentage of PhD SMART scholars is greater (20 percent vs. 6 percent), and there is a higher percentage of SMART scholars in the Air Force (33 percent vs. 19 percent) and a lower percentage of SMART scholars in the Navy (32 percent vs. 38 percent). The comparison group was selected from the S&E Civilian Population. Overall, the comparison group is more representative of SMART scholars.

Identifying SMART scholars

To match DMDC records with SMART scholars, IDA first used social security numbers of SMART Scholars that were provided by the SMART program office. There were 1,216 unique SSNs available. From these values, IDA obtained was able to match 1,150 scholars out of 1,383 scholars (unique people) in Phase II or Phase III, indicating an 83 percent flag rate.

Second, IDA used first name, last name, middle initial, service, and position (whether the individual had an S&E job) to select all individuals that could match that scholar. We flagged individuals as SMART scholars if for every SMART scholar there was only one DoD civilian match. This accounted for multiple DoD civilians working in the same service, in an S&E position, and with the same first name, middle initial, and last name. IDA researchers also assessed each of the additional entries to determine if they were, in fact, SMART scholars based on additional criteria (education level, graduation year, and position title). IDA researchers used the additional information in the following manner:

If the graduation year and education level match, and position title makes sense with the degree discipline given by SMART (i.e. someone that studied Mechanical Engineering becomes a Mechanical Engineer), these are all flagged as SMART scholars. This case represented the majority of cases. If there was a discrepancy between graduation and/or education level, we identified them as a SMART scholar if they were a retention scholar and/or if the position title made sense given the degree discipline. We removed approximately 50 of these individuals because we believed they were incorrectly identified.

Overall, IDA flagged 1,267 scholars as SMART scholars, indicating a 92 percent flag rate.

Propensity Score Matching

We used propensity score matching to identify a comparison group for SMART scholars from the DMDC data. Propensity score matching is a technique to estimate the treatment effects of a given intervention when performing a randomized control trial is not possible.

Variable Selection

We included the following variables in the propensity score calculation and matching process: unit identification code (UIC), degree level, occupation, race, sex, ethnicity, hire date, birth year, and Federal credible service compute date. UIC is an indicator of their work location—it is generally more granular than base or command. The Federal credible service compute date is a constructed date used to calculate retirement benefits; it is generally a proxy for hire date though it is calculated differently across different agencies. However, because we are matching on UIC, it is fine to use this date in a comparison. For recruitment scholars, we consider their hire date to be at the beginning of Phase II; this is different for retention scholars. The hire date for retention scholars is considered prior to the SMART program.

Based on previous findings from the survey, interviews, and the process evaluation report, we exact matched on UIC, degree level, and occupation. In other words, for any given SMART scholar, their counterpart will have the same UIC, degree level, and occupation. All other variables are considered in the process but on the aggregate; the distributions for any given variable will likely be similar (Table 20).

Table 20 Select DMDC Variable Count and Percentages

	Category	All SMART Scholars (*N* = 1,244, %)	Comparison Group 3 to 1 (*N* = 2,926, %)	S&E Civilian Population (*N*= 188,904, %)
Degree Level	Bachelor's	679 (55%)	1,646 (56%)	108,243 (57%)
	Master's	311 (25%)	764 (26%)	43,645 (23%)
	PhD***	254 (20%)	516 (18%)	10,626 (6%)
	Other***	-	-	26,390 (14%)
Ethnicity	Hispanic**	32 (3%)	99 (3%)	7,863 (4%)
	Not Hispanic***	1,195 (96%)	2,750 (94%)	177,069 (94%)
	Unknown	17 (1%)	77 (3%)	3,972 (2%)
Occupation	Biological Sciences***	19 (2%)	43 (1%)	6,395 (3%)
	Engineering and Architecture***	868 (70%)	2,052 (70%)	97,439 (52%)

	Category	All SMART Scholars (*N* = 1,244, %)	Comparison Group 3 to 1 (*N* = 2,926, %)	S&E Civilian Population (*N*= 188,904, %)
	Information Technology***	17 (1%)	50 (2%)	50,978 (27%)
	Mathematical Sciences***	196 (16%)	422 (14%)	14,849 (8%)
	Physical Sciences***	103 (8%)	262 (9%)	10,589 (6%)
	Social Science and Psychology***	26 (2%)	61 (2%)	8,654 5%)
	Other	15 (1%)	36 (1%)	-
Race	African American or Black***	40 (3%)	116 (4%)	14,617 (8%)
	American Indian or Alaskan Native	10 (1%)	29 (1%)	1,604 (1%)
	Asian	45 (4%)	110 (4%)	8,534 (5%)
	Multiracial*	19 (2%)	45 (2%)	1,769 (1%)
	Native Hawaiian or Pacific Islander	3 (<1%)	9 (<1%)	782 (<1%)
	Unknown Race***	35 (3%)	156 (5%)	17,283 (9%)
	White***	1,130 (91%)	2,553 (87%)	148,116 (78%)
Service	Army	421 (34%)	949 (32%)	64,876 (34%)
	Air Force***	413 (33%)	893 (31%)	36,174 (19%)
	Navy***	401 (32%)	1,060 (36%)	71,770 (38%)
	Additional DoD***	9 (1%)	24 (1%)	16,084 (9%)
Sex	Female***	323 (26%)	671 (23%)	40,605 (21%)
	Male***	921(74%)	2,255 (77%)	148,292 (79%)
	Unknown	-	-	7 (<1%)

Source: DMDC dataset.

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***. Individuals that are multiracial are represented in the table more than once, thus the percentages do not add up to 100%. Other degree level includes high school and associate's degrees. Other occupation includes technicians and medical/dental professions. All statistics are based on a one sample Z test of proportion with continuity correction comparing SMART scholars to the S&E population. Significant test results are as follows: PhD (Z = 22.58, p < .001), Degree-Other (Z = 20.32, p < 0.001), Hispanic (Z = 2.74, p = 0.0062), Not Hispanic (Z = 3.33, p < 0.001), Biological Sciences (Z = 3.55, p < .001), Engineering and Architecture (Z = 12.81, p = < .001), Information Technology (Z = 20.32, p < .001), Mathematical Sciences (Z = 10.92, p < .001), Physical Sciences (Z = 4.04, p < .001), Social Science and Psychology (Z = 4.13, p < .001), African American or Black (Z = 5.92, p < .001), Multiracial (Z = 2.02, p = .044), Unknown Race (Z = 7.70, p < .001), White (Z = 10.62, p < .001), Air Force (Z = 12.56, p < .001), Navy (Z = 4.16, p < .001), Additional DoD (Z = 9.79, p < .001), Female (Z = 3.80, p < .001), Male (Z = 3.80, p < .001).

Propensity Score Calculation

We calculated propensity scores using a logistic regression. Propensity scores represent the likelihood or "propensity" that an individual will receive a given treatment, in this case the SMART scholarship. Computationally, propensity scores are defined as the log-odds of being in the SMART program for each individual. Given a set of variables $(x_1, \ldots, x_k)$ to match on, the propensity score is calculated assuming the following model:

$$Log\left(\frac{\Pr(SMART)}{1 - \Pr(SMART)}\right) = \beta_0 + \beta_1 x_1 + \cdots + \beta_k x_k$$

Propensity scores for the potential comparison group and SMART scholars can be found in Figure 39. The potential comparison group includes individuals that have the same UIC, degree level (bachelor's, master's, PhD), and occupation bin as SMART scholars. Because the sample size of the potential comparison group is much larger than the number of SMART scholars, there are a large number of individuals that have similar propensity scores to SMART scholars.

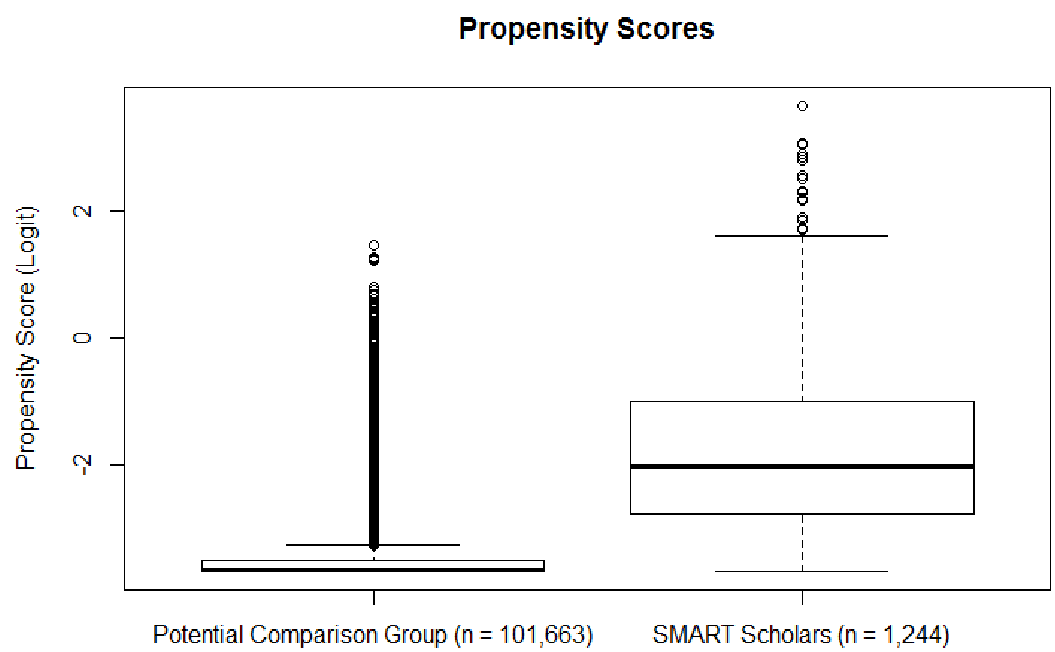
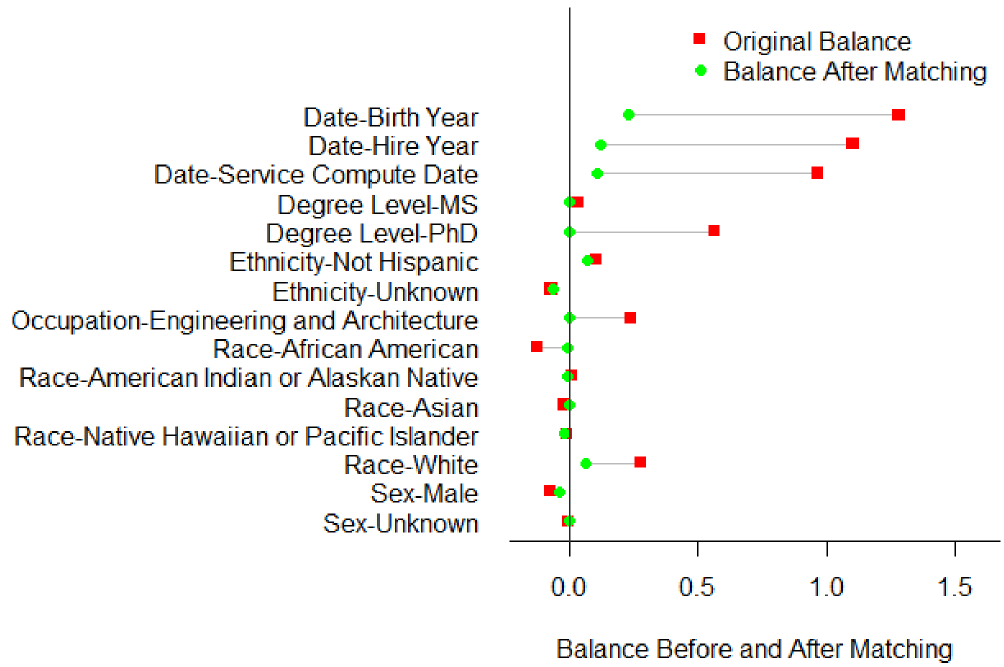


Figure 39. Propensity Score Calculation for SMART Scholars and the Potential Comparison Group

Comparison Group Selection

We used the R package optmatch to select optimal full matches (CRAN 2018). We ran this process twice to obtain one-to-one matches (one person in the comparison group for every SMART scholar) and three-to-one matches (three people in the comparison group for every SMART scholar). In both cases, we were able to match a given SMART scholar with a match approximately 95 percent of the time. In three-to-one matching, 80 percent of SMART scholars were matched with three counterparts, 6 percent of SMART scholars were matched with two counterparts, and 14 percent of SMART scholars were matched with one SMART scholar.

Figure 40 shows the balance before and after the matching process; it shows how different two populations are before and after matching. For the fields in which we exact matched (degree level and occupation bin), the balance is 0 after matching—in other words, there is no difference between the treatment and control populations. For the other cases, balance after matching is close to 0. For example, the average age for the S&E population is 51 while it is 32 for SMART scholars. The average age of the comparison group is 35. The balance for birth year is close to 0. If the balance after matching is less than .5, it is considered fine to move on (Stuart and Rubin 2008). Figure 40 describes the population of SMART scholars, the S&E population, and their comparison group.



Note: UIC and all occupations other than Engineering are omitted from this figure to avoid overcrowding. In these cases, the balance is 0 after matching.

Figure 40. Balance Plot before and after Matching

Bibliometric Review

A bibliometric review was used as one proxy for determining the quality and productivity of PhD SMART Scholars. Two metrics were used in this effort: number and impact of publications during the time in which the SMART Scholar was pursuing their PhD and number and impact of lifetime publications. A comparison group was established using DMDC data in which S&E workers were identified using a one-to-one propensity score match (See previous section on Defense Manpower Data Center Database). For the review, we looked at publication history for the 240 SMART Scholars who earned PhDs and who were found in the DMDC.

Of the 240 SMART Scholars and 240 comparison group S&E workers initially identified, publications were found for 215 SMART Scholars and 206 of the comparison group workers. Two types of papers will extracted for each group:

1. **Publications during PhD.** This was used as a proxy for productivity in graduate school. Data from the SMART Program was used to estimate the time and duration of SMART Scholars' PhD programs. Start date data from DMDC was used to estimate the time of the comparison group workers' PhD programs.
2. **Lifetime publications.** This included all publications ever authored or co-authored by the SMART Scholar or comparison group worker at any affiliation.

Two different types of analyses were conducted on each of these datasets. The first was a mean field-weighted citation impact (FWCI). The FWCI related the number of citations received by a given publication with the expected number of citations received by similar publications. FWCI is used as a measure of citation impact of a publication. The second analysis conducted looked at the number of top 10 percent highly cited papers based on FWCI. These analyses and datasets were used to answer two different research questions (Table 21).

Table 21. Bibliometric Research Questions and Data/Analyses Used

Research Question	Dataset and Analyses Used
Is the SMART Program Office recruiting a higher quality worker than traditional mechanisms of recruitment and hiring?	Number of publications during PhD
	FWCI on publications during PhD
	Number of top 10 percent publications based on FWCI for PhD publications
Are SMART Scholars of higher overall academic quality as compared to traditional workers?	Number of lifetime publications
	FWCI on all publications
	Number of top 10 percent publications based on FWCI for all publications

Cost Per Scholar Model

Introduction and Rationale

The research team modeled the total cost based per student on tuition data available from the Integrated Postsecondary Education Data System from National Center for Education Statistics, which can be accessed here: http://nces.ed.gov/ipeds/Home/UseTheData. We downloaded tuition and fee data from 2005–2016 for 308 institutions.[39] IPEDS data included the following categories useful in analysis: in-state tuition for undergraduates, in-state tuition for graduates, out-of-state tuition for undergraduates, and out-of-state tuition for graduates. IPEDS provides the distinction for in-state and out-of-state for both public and private institutions though for private institutions there was little distinction.

[39] SMART scholars attended 309 different institutions. There was no data for download available for the Uniformed Services University of the Health Sciences.

Methodology

We used the following model to calculate the tuition for each student.

Variables:

- T_X, the tuition for a given student at a given year in their award, so T_1 is the tuition for the first year of the program, T_2 the tuition for the second year in the program. See assumptions 1, 5, 6, and 7 for more information.
- *Y*, the number of years they requested and are supported by SMART. See Assumption 2 for more information.
- *S*, the stipend that SMART will pay. This also includes health insurance and miscellaneous fees. See assumptions 2 and 3 for more information.

  We calculated the cost, C, spent on each student as follows:

$$C = (T1+\ldots+TY) + SY$$

Assumptions

Assumptions for data provided by SMART:

1. **Home state**: The home state and institution state category provided in the master data set is an indication of whether the SMART program will pay in-state or out-of-state tuition. If the *home state* was not listed (123 instances), IDA researchers replaced this value with the scholar's residence state.
2. **Years requested**: IDA researchers took the *current years requested* category. When the current years requested category did not exist (28 instances), IDA researchers used the *original years requested* category.
3. **Stipend, Health Insurance, and Miscellaneous Fees**: IDA researchers assumed a stipend breakdown of $25,000 and $33,000 for Bachelor's and Master's students over all years. For PhD students, IDA researchers assumed a $41,800 stipend until 2012, and a $38,000 stipend thereafter. For health insurance and miscellaneous fees, IDA researchers assumed SMART paid scholars an additional $1,200 and $1,000 for all years. In reality, these additional allowances became consistent in for all years. In reality, the health insurance became consistent ~2011 and the stipends became consistent in ~2008. In years prior to that, based on American Society for Engineering Education data, there was variation in these data.
4. **5 years**: If a student receives an award for a half year, or a half year in addition to other years, IDA researchers assumed that SMART would pay half of the annual tuition for the remaining year and half of the stipend, health insurance allowance, and miscellaneous allowance.

5. **Fee data**: IPEDS also provides fee data; however, IDA researchers did not use fee data because the tuition disbursement provided on the portal for scholars seemed to match the tuition number only, not the tuition and fees combined. Additionally, the fee data from IPEDS appeared to be less reliable. For example, fee data is not listed for all universities, and oftentimes certain years were missing.
6. **Missing data**: The IPEDS data was complete. However, for 32 scholars at nine institutions, there was missing data and for 19 scholars at 2 institutions, there was no IPEDS data available.[40] There were several instances where there was no data for a particular category (e.g., no in-state tuition listed). If this was the case, IDA researchers used the alternative category (e.g., out-of-state). However, the majority of institutions with missing data had data listed for certain years (e.g., for years 2005–2009) years in all categories. IDA researchers extrapolated remaining years by calculating the Cumulative Average Growth Rate (CAGR) for the years listed, then estimating tuition for years before or after present data using available data and the CAGR. The Naval Postgraduate School and Uniformed Services University of the Health Sciences were the two institutions in which no data for any of the four categories was present. There are 18 scholars who the Naval Postgraduate School and one scholar who attended the Uniformed Services University of the Health Sciences; their data is left out of the tuition model.

Potential Limitations

The evaluation is bounded in three dimensions: time, extent of activities, and stakeholders.

Overall Limitations

Time

The SMART program began as a pilot activity in 2005 and became a permanent program in 2006. The data from 2005 is sparse, and given that it was a pilot year, we eliminate it from our study timeframe. This outcome evaluation will cover activities from the 2006–2007 to the 2016–2017 academic year. Also, minor and substantial changes to the process have taken place over this 11-year period and were considered in the evaluation.

Extent of Activities

Program components assessed include everything from the SMART scholar recruitment and selection process to the placement of SMART scholars at DoD sponsoring facilities for internships (Phase I), their payback period by working in the civilian service after completing their education

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[40] The one student from Uniformed Services University of the Health Sciences is excluded from these calculations.

(Phase II), and scholars satisfying post-education service commitment (Phase III). We developed a preliminary schematic (logic model) to show the logical progression (chronologically) of the program's activities through three phases.

Stakeholders

The SMART program stakeholders were identified through discussions with representatives of the SMART program office. The program stakeholders included in the evaluation are the Assistant Secretary of Defense for Research and Engineering, SMART program office, SMART program support, SMART component administrating offices (CAOs), SMART service liaisons, facility points of contact (POCs), facility human resources (HR) staff, facility S&E managers, and SMART scholars. Some potential stakeholder groups, such as the DoD contractors and academic institutions educating SMART scholars, have been excluded from the stakeholder list because these groups are not directly involved in the SMART program process, although they may benefit indirectly from it. In addition, these groups are outside the oversight of the SMART program and have limited influence on its success.

Limitations with the DMDC Dataset

In a dataset this large and complex, it is common to have several limitations. There are several limitations in the DMDC set.

Hire Date and Exit Date

We were not able to obtain an individual's exact hire date or exit date. Therefore, we used an individual's first/last appearance in the dataset to estimate these dates. For retention scholars who started prior to 2006, their first instance in the dataset is a less accurate proxy for hire date. However, the Federal Credible Service Compute Date (Service Compute Date) can also be used as a proxy for hire date. This date is used to calculate benefits for Federal service and can be used as a proxy for start date. While different agencies calculate this date differently, among individuals are the same UIC, the date can serve as a rough comparison for hire date.

Identifying Interns

In identifying the comparison group, it was important not to match SMART scholars with interns in the comparison group. However, the dataset did not classify interns. For SMART scholars, we used the program administrative data's graduation date—if a SMART scholar had not yet graduated and appeared in the dataset, we considered them in intern. For other civilians, we used six criteria for identifying interns. We classified a non-SMART scholar as an intern if they met one of the following characteristics:

- Their occupation code was one of 26 codes that contained the word "trainee"

- Their position title included one of the following titles: “STUDENT,” “TRAINEE,” “INTERN,” “TRNE,” “AID,” “TECHNICIAN,” “CLERK,” “Technician,” “ENGINEERING TECH,” “PHYSICAL SCIENCE TECH”
- They had the “student educational employment program pay schedule” pay basis code
- They had the “student educational employment program pay schedule” or “apprentices and shop trainees” pay plan
- Their education level was between two degrees, for example, “one year of a bachelor’s degree”
- Their salary was less than that of the GS Grade 1, Step 1 in any given year

Race multicollinearity

The definition of race changes throughout the years in the DMDC database. In 2006, there was no way for an individual to be marked as more than one race. Therefore, individuals who did not have a reported race for that year could actually be either multiracial or did not wish to report their race. It is currently not possible to disambiguate the two. After 2006, an individual could list more than one race, and these race categories are disambiguated to be individual binary variables for each race category (African American or Black, American Indian or Alaskan native, Asian, native Hawaiian or Pacific Islander, and White). Additionally, multicollinearity arises when including all the non-mutually exclusive race categories in a regression. Multicollinearity occurs when an independent variable can be linearly predicted with other independent variables to a high degree of accuracy. In the case of race, most individuals in our data are not multiracial, which means that knowing the value of one race variable is guaranteed to predict the values of the other race variables (i.e. if someone is marked as African American, then the other variables are most likely going to be unmarked). As a result, the coefficient estimates for the race variables are biased, with the effect of each individual race variable difficult to disambiguate. However, the other non-race variables are unaffected.

Multicollinearity can be empirically tested with the generalized variance inflation factor (GVIF) (Fox and Monette 1992). When including all the race variables in our regressions, we found high values of GVIF. We can remedy this issue with combined mutually exclusive race categories, i.e. White, multiracial, and unknown are all together as one category, with each individual therefore only marked as one category. This reduced the GVIF for race variables to acceptable levels, but left us with a difficult to interpret model (especially given the ambiguous definitions of race from 2006). Therefore, we left the multicollinear race variables in our regressions with DMDC data, and chose not to interpret their impact. Other variables are unaffected by this choice. We hope that in the future we are able to resolve this issue and analyze race more thoroughly in a regression setting with the DMDC database.

Appendix D.
Academic Advisor Perspectives

Through its core activities to support scholars, the SMART program was interested in understanding the extent to which they were also contributing to new or improved DoD-academic research collaborations between scholars, academic institutions, and facilities. While forming academic ties is not an explicit goal of the SMART program, it is an important spillover benefit that is fostered by the SMART scholars. The IDA research team identified three main study questions to investigate the motivations, benefits, and challenges with developing and maintaining academic ties.

- To what extent does the SMART Program contribute to creating or reinforcing university-DoD collaborations?
- What is the role of the SMART Scholar in creating or reinforcing DoD-academic research collaborations?
- How could the SMART Program improve opportunities for DoD-academic research collaborations?

SMART scholars were asked several questions on the survey regarding academic ties with their institutions. In addition, we interviewed 18 academic advisors to better understand their perspectives of SMART scholars and the scholarship fostering collaboration with the DoD.

A 2014 IDA study examining the benefits from academics collaborating with DoD researchers found that the motivations for academics in engaging in research collaborations with DoD included: (1) building the talent pipeline in specialized research domains and applications and providing exciting opportunities for students to build their professional skills; (2) exposure to exciting mission specific problems and transition of research to application; and (3) enhanced research through access to specialized facilities, equipment, expertise, and funding (Gupta et al. 2014). Additionally, other literature on broader academic research motivations mentioned several other dimensions that may influence the development of research collaborations, including resources and distribution of work, geographic proximity, and career advancement (Bozeman et al. 2004, Bozeman et al. 2014, Abramovsky et al. 2008).

Benefits to SMART Program Participation

The interviewees reported their motivations for participation in and perceptions of benefits from the SMART Program, particularly to scholars, their academic institution, their research, and the DoD or the Federal Government workforce. We categorized these benefits into five areas—(1) connections to a wider network of experts, (2) attraction of high-quality students, (3) access to state-of-the-art equipment, (4) understanding of DoD mission and challenges as potential areas to expand research, and (5) access to funding.

Connection to a Wide Network of Experts

The SMART program may provide the opportunity for scholars, faculty members, and DoD researchers to share knowledge and collaborate with other experts in the field who they would not be able to otherwise connect.

From the perspective of a faculty member, the SMART program provided the possibility to open up doors for collaboration with researchers at DoD facilities. The majority of advisors noted that the SMART program allowed them to interact with DoD researchers who had expertise in an area of mutual interest. Some advisors stressed that the SMART program served as a catalyst for future collaboration by forming new ties or reinforcing old ties with DoD researchers. One advisor noted,

> The SMART Program is a lifeline that connects universities to DoD facilities—it's up to advisors to pursue those connections. I do what I can to exploit the [SMART scholar's] new position. We have formed formal collaborations with the [Sponsoring Service] as a consequence of the SMART Program. This has helped my career.

Another advisor reported that prior to advising the SMART scholar, they had frequent interactions with a specific group at the DoD facility. The scholar's participation in the SMART program introduced the advisor to researchers who were part of a different group at the sponsoring facility and do not work frequently with universities because of the classified nature of the work. The scholar's ability to work closely with DoD researchers within this group was reported by the advisor as a unique experience.

From the perspective of the scholar, the SMART Program provided freedom to engage in collaboration with both faculty members (who were not their primary advisor) and DoD researchers at the sponsoring facility. One advisor reported that after their scholar met with DoD researchers, the scholar knew exactly what was needed to successfully complete the research and was highly motivated to find the right people and resources on campus to accomplish the task. The scholar explored and sought academic collaborations not necessarily through the primary advisor. The advisor reported that the SMART program provided scholars with the freedom to establish useful collaborations and explore innovative research ideas with other academics at the university. This situation was possible because neither the advisor nor the scholar worried about the need to confine their research within a scope specified by a traditional research grant, which would have otherwise funded the scholar's research.

Some advisors reported that the SMART program was beneficial to DoD in its ability support civilians in their graduate studies and subsequently bring them into the DoD workforce. Similarly, advisors noted that DoD benefited when their civilian S&E employees received the SMART scholarship because the retention scholars were able to establish connections with academic experts. When returning to DoD, these retention scholars maintained their academic connections as a resource for potential future collaborations.

Access to and Development of High-Quality Students

Generally, advisors reported on the excellent quality of SMART scholars and how the quality of the scholars served as a benefit to both the university and DoD workforce. We asked about characteristics that the advisors would identify in students prior to recommending the SMART scholarship, and the majority of advisors reported academic excellence as a priority. One advisor noted,

> I would look for a high level of independence and creativity with their own ideas. They don't need to be advised too closely, can take their ideas and run, and collaborate with other people…Must be self-motived, organized, and strong computationally. [SMART Scholar name] was all of these things.

Another advisor stressed that the major benefit received from the SMART program was "the satisfaction of educating and training a student who will be productive in the machinery of the national defense research infrastructure." They perceived the SMART program as a way to support a strong student in continuing their education and assist the student's development into careers supporting national defense.

Access to State-of-the-Art Equipment and Facilities

Advisors stressed that the ability for SMART scholars to utilize DoD's state-of-the-art equipment and facilities is a key benefit of the program. One advisor stated that their department at the university received funding from the scholar's facility to purchase new instrumentation and equipment and update the department's facility. This advisor reported that the updates allowed the scholar to better conduct the necessary experimental research, and that the sponsoring facility was happy to provide the funding because it allowed the scholar to develop a unique expertise in a distinct problem area specific to DoD, benefitting all parties involved.

Some advisors noted that the scholar received access to DoD facilities and equipment during the scholar's internship period. During the internship, the scholar was able to diligently excel on research related to their dissertation and dramatically improve their technical development. Other advisors commented that the scholar gained free access to DoD facilities throughout the entirety of their research—not just during the internship period. Access to DoD equipment and facilities enabled the scholars to perform research at a higher level than other students and complete their work faster than they would otherwise.

Opportunities to Explore New Research Areas and Understand DoD Research Enterprise Challenges

Advisors reported that one of the main benefits of the SMART program is that it allows the faculty members and scholars to work closely on unique research topics that offer in-depth knowledge into problem areas and needs facing the DoD research enterprise. Several advisors noted that they were introduced to a completely new area of research or that their department at the university was able to expand upon the scholar's research after the scholar graduated. Advisors also expressed that interacting with DoD researchers through the SMART program kept their research relevant to DoD needs, and that the work would not have necessarily been available through other channels. One advisor reported that it was rewarding to collaborate closely with DoD researchers because it informed them of why they were doing the research and what made it important. This advisor noted that through the SMART Program, they offered a higher level of contribution to their field of work than if they had not participated in the program.

Future Funding Opportunities

Some advisors referenced the SMART scholarship funding as valuable to both their own research program and the scholar's career. One advisor noted,

> In terms of advancing my own research, the biggest impact was having the [SMART Scholar] on the scholarship because we didn't need to worry about funding year-to-year or semester-to-semester. Instead of jumping around from project to project, the [scholar] could lay out their research goals and work towards them persistently and consistently throughout their graduate program.

Generally, interviewees emphasized that the SMART scholarship provided the scholars with financial freedom. The scholarship funding allows scholars to work on their research with no distractions or other obligations, such as working as a teaching assistant or holding an outside job. One advisor reported that the SMART scholarship funding contributed to degree completion, noting that a primary reason students quit their graduate study was to seek employment to appease their financial needs. The SMART program offered scholars greater financial stability than other scholarships.

Differences in DoD-Academic Collaborations between Recruitment and Retention Scholars

The SMART scholar survey evaluated the extent to which SMART scholars observed ties between their facility and academic institution.[41] We compared retention and recruitment scholars' survey responses. Overall, the survey results showed that retention scholars were statistically significantly more likely than recruitment scholars to agree that their advisors formed or reinforced ties with their DoD facility.[42] PhD retention and PhD recruitment scholar responses are summarized in Figure 41.

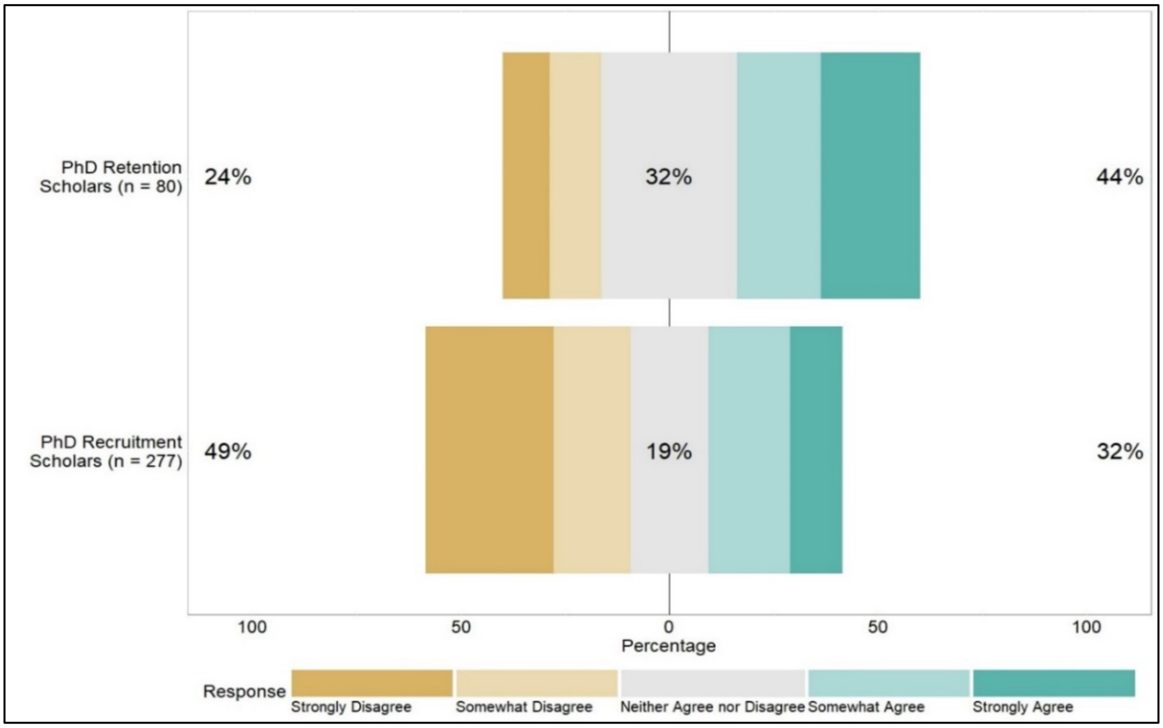

Figure 41. PhD SMART Scholar Survey Responses on Academic Ties Formation by Scholar Type

A noteworthy finding was that all advisors of recruitment scholars with prior DoD collaborations felt the SMART program contributed to reinforcing those relationships. Meanwhile, for retention scholars, the prior relationships were less effective in influencing

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41 The extent to which SMART Scholar respondents formed ties between their sponsoring facility and academic institution during Phase I was assessed with the survey question: "Members of my sponsoring facility formed new ties or strengthened old ties with the faculty at my academic institution through my participation in the SMART Program." This question was presented on a five-point Likert-type scale (strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, and strongly agree).

42 Statistical significance groups were detected for Scholar Type. Retention Scholars (M=0.04 SD=1.35, 36%) reported higher mean agreement with this survey item than Recruitment Scholars (M=-0.8 SD=1.26, 16% agree).$t_{(972)} = -6.76$, p = < .001, d = 0.66.

further interactions with DoD researchers or the DoD facility. Generally, advisors with prior DoD collaborations noted that their relationship with the DoD facility was present regardless of the SMART Program and the program did not change their level of interactions.

These results suggest that some advisors of recruitment scholars who had prior interaction with DoD researchers were able tap into the potential to use the SMART program to strengthen their relationships with DoD researchers—more so than those advising retention scholars. This is somewhat counterintuitive given that, in general, retention scholars reported having greater positive DoD-academic collaboration experiences in the survey.

Challenges with Establishing DoD-Academic Collaborations

Based on our interviews, IDA analyzed various challenges associated with developing or reinforcing DoD-academic collaborations through the SMART Program.

Limited Bandwidth

Perhaps the most prominent challenge was that academics have limited bandwidth and resources to support long-term, continued relationships with DoD researchers. The SMART Program, although generally viewed as a beneficial vehicle for scholars over the short-term, does not and is not designed to support continued, long-term engagement between academics and DoD researchers after the scholar graduates. For example, the connections among academic and DoD researchers may abruptly end when a scholar leaves the university.

Need for Funding

About half of the advisors interviewed said the collaborations with DoD researchers at the sponsoring facility were not continued. In various interviews, advisors noted that additional funding from the sponsoring facility could have enabled a continued working relationship. In fact, we observed that that this situation did occur and helped maintain and grow research collaborations.

A few academics also noted the potential need for additional resources that the SMART Program does not cover depending on the nature of the scholar's research. For example, one advisor mentioned the scholar needed to build instrumentation capabilities to perform experiments. Working with the DoD sponsoring facility, they obtained additional funding to accommodate this need. In some cases, senior academics were able to leverage funding from other research grants to cover other materials and supplies for the scholar's research that were not funded through the SMART Program. However, they denoted that junior faculty may not have as much flexibility. These needs can impose burdens to junior faculty that they cannot afford, hindering the scholar's research and their ability to maximally address DoD's research needs, which potentially negatively impacts collaborative opportunities with DoD.

Limited Understanding of DoD Challenges and Nature of Work

Three other factors impeded an advisor's ability to take full advantage of the bridge for DoD collaborations offered via the scholar:

1. A lack of awareness of the research problems and opportunities to impact DoD missions—In some instances, interviewees described how Retention Scholars played a role in offering meaningful research ideas of interest to both parties.
2. Uninterested DoD researchers at the sponsoring facility that do not fully understand how the academic and scholar's research could help solve relevant research problems—One advisor remarked, from their experience, that "laboratories will not go out of their way to form new collaborations." Effective communication is required to help academics and DoD researchers come to mutual understanding of research problems and solutions.
3. The inability to access and share research due to the classified nature of the work at DoD sponsoring facility—One advisor commented that their scholar would largely work at the lab given the classified nature of the data or specialized equipment needed to conduct the research. Working with classified research can undermine the advisor's ability to build collaborative relationships with DoD researchers.

Other Challenges Related to Participation in the SMART Program

In addition, interviewees discussed general challenges related to recruiting students for the SMART Program. They explained there was a lack of awareness about the SMART Program across their university or department. They also stated their concerns regarding the limited pool of students interested and eligible to qualify for the SMART Program, particularly given the U.S. citizen and service requirements. One advisor commented that they did not know the program was open to all students and not restricted to current DoD employees (i.e., limited knowledge of the difference between Recruitment and Retention Scholars). Some interviewees commented that they did not receive sufficient information about the SMART Program, including eligibility requirements and the variety of missions, research, and capabilities across DoD's research, development, test, and evaluation enterprise.

Appendix E.
Statistics Appendix

This appendix describes the methodology, assumptions, findings, and model diagnostics for four pieces outlined in the report: satisfaction, scholar impact, retention, and quality. Each section includes several models, and in many cases, we include results from similar models on different subgroups (i.e. those who completed the survey versus those that did not). To start, we describe linear regression because this technique is used throughout our analysis. In this appendix, all references to the "comparison group" refer to DoD S&E civilian matches obtained through propensity score matching (Appendix C).

Linear Regression

Because we use linear regressions in multiple analyses, we define it here. Linear regression models the impact of several independent variables on a dependent (outcome) variable. Five assumptions must be met to obtain unbiased and consistent estimates of an independent variable's effect on a dependent variable.

- **Linearity of data**: The relationship between each independent variable and the dependent variable is linear.
- **Normality of residuals**: The residuals are assumed to be normally distributed.
- **Homoscedasticity**: The residuals have constant variance.
- **Exogeneity**: The residuals are independent of any independent variable.
- **No multicollinearity**: No independent variables can be linearly predicted by other independent variables.

For any continuous variables in our data, we examined their relationship with the dependent variable and found a form that defines the most linear relationship (e.g., log, square-root, exponential). Normality of residuals are examined with a normal quantile-quantile (q-q) plot, which compares the distribution of the residuals to the standard normal distribution. The assumption of homoscedasticity can be relaxed in most situations. When heteroscedasticity (its natural opposite) is present, one can use robust standard errors to obtain unbiased hypothesis test results on any of the effects estimated (assuming our coefficients are unbiased) (White 1980). Endogeneity, the issue when the assumption of exogeneity is not satisfied, often arises when a variable that is related to the dependent and independent variables is not controlled for, causing the estimated effect of the independent variable on the dependent variable to be biased. This is often the case in our analyses. It is difficult and sometimes impossible to measure every single important variable that influences overall satisfaction, retention, salary, and other outcomes of interest. However, we mitigate bias through the matching process controlling for independent variables (Appendix C). Multicollinearity can be quantified, and its main consequence in our analyses is described in Appendix C.

Overall Satisfaction

The subsections below describe the methodology and findings related to SMART scholars' overall satisfaction with the program, using survey data, and supports the main findings in the report.

Assumptions and Sample

All scholar survey respondents who had completed Phase I were asked a series of four survey items related to scholar satisfaction with the SMART program (890 of 898 possible scholar survey respondents answered at least one of these survey items). These items were presented on a 5-point Likert-type response scale (–2 = strongly disagree, +2 = strongly agree). The four items attempted to measure whether scholars were satisfied with the program (1. *Overall, the SMART Program has been a benefit to my career*, 2. *Overall, the advantages of the SMART Program outweigh the disadvantages*, 3. *Overall, my expectations of the SMART Program were met*, 4. *I would recommend the SMART Program to others*). We checked the internal consistency of the four survey items by computing Cronbach's alpha and found it to be 0.91, indicating that scholars who rated one item positively also rated other items positively with high reliability. Due to the high internal consistency, we averaged the four survey items for each scholar to obtain scholars' mean satisfaction (Cortina 1993).

We modeled mean satisfaction using a linear regression to determine if various aspects of the SMART program explain variation in the response. We modeled the linear regression in two ways: (1) capture as many scholars as possible in the model by only including demographic variables ("full sample model"), and (2) include additional categorical and Likert-type variables that might impact mean satisfaction but limit the sample in the model ("Likert model").

A subset of the SMART scholars (N = 856) are included in the full sample model. Degree level, degree field, race, ethnicity, sex, cohort bin, scholar type (recruitment or retention), service, number of years funded through the SMART program, and the number of miles between the scholar's home address and sponsoring facility address are included in the model and are used to control for factors that might impact the outcome variable, mean satisfaction.[43]

[43] Cohort bin is based on a scholar's cohort (i.e. the fall in which they started the program). The bins are 2006–2007, 2008–2012, 2013–2014, 2015 and are based on program changes and program management changes provided by the SMART program office.

Table 22. Full Sample Satisfaction Model Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Mean Satisfaction	1.33	0.88	-2	1	1.75	2	2
Years Funded	2.27	1.07	0.5	1.5	2	3	6
Miles between home & Sponsoring Facility (in Hundreds)	3.67	7.43	0	0.095	0.25	3.27	55.66

Table 23. Full Sample Satisfaction Model Categorical Variable Summary

Variable	Value	% of Sample
Sex	Female	28%
	Male	70%
	Do not wish to respond	2%
Race	White	83%
	Black or African American	3%
	I do not wish to respond	8%
	Asian	5%
	American Indian or Alaska Native	1%
Degree Binned	Master’s	3%
	Bachelor’s	43%
	PhD	29%
Ethnicity	Not Hispanic or Latino	89%
	Hispanic or Latino	4%
	I do not wish to respond	8%
Degree Field	Physical Science	7%
	Computer Science	14%
	Engineering	64%
	Mathematical Science	7%
	Biosciences	3%
	Earth Science	2%
	Psychology	3%
Cohort Bin	2008–2012	72%
	2015	4%
	2006–2007	9%
	2013–2014	15%

Variable	Value	% of Sample
Service	Army	34%
	Navy	31%
	Air Force	32%
	Additional DoD	4%
Scholar Type	Recruitment	88%
	Retention	12%

A smaller subset of the SMART scholars (*N* = 523) are included in the limited model. The model includes all variables in the full model and additional scholar perspectives captured through a 5-point Likert-type response scale. These Likert-type responses included four items measuring scholars' perspectives on Sponsoring Facility research/work (1. *I do cutting-edge research/work at my Sponsoring Facility*, 2. *I do important research/work at my Sponsoring Facility*, 3. *I do enjoyable research/work at my Sponsoring Facility*, 4. *My research/work matches my skillset*), three items measuring perspectives on other features of scholar experience at the sponsoring facility (1. *I enjoyed working at my Sponsoring Facility*, 2. *I enjoyed living in the region where my Sponsoring Facility is located*, 3. *I was motivated to participate in the DoD mission*), and two items measuring perspectives towards a scholars' SMART internship(s) (1. *Overall, my internship experience was valuable*, 2. *I felt adequately mentored during my internship(s)*). The model also included scholars' starting (or in the case of retention scholars, 2006) salary. Comparing the variable summaries of both samples (Table 22, Table 23, Table 24, Table 25), almost every variable has a similar distribution in both regressions, with the only marked change being an increase in the proportion of recruitment scholars (88% compared to 93%) for the smaller sample.

Table 24. Likert Model Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Mean Satisfaction	1.25	0.96	-2	1	1.5	2	2
Likert-Internship experience was valuable	0.86	1.27	-2	0	1	2	2
Likert-During internship, felt adequately mentored	0.52	1.34	-2	-1	1	2	2
Mean Work Satisfaction	0.58	1.23	-2	-0.25	1	1.75	2

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Miles between home & sponsoring facility (in Hundreds)	3.6	7.73	0	0.093	0.25	2.33	55.66
Likert-Motivation for DoD Mission	1.08	1.12	-2	1	1	2	2
Likert-Enjoyed working at sponsoring facility	0.81	1.28	-2	0	1	2	2
Likert-Enjoyed sponsoring facility region	0.6	1.4	-2	-0.5	1	2	2
First salary in data (in Thousands)	52.22	14.79	18.94	40.84	50.43	62.12	114.13
Years Funded	2.62	0.91	0.5	2	2	3	6

Table 25. Likert Model Categorical Variable Summary

Variable	Value	% of Sample
Sex	Female	25%
	Male	73%
	Do not wish to respond	2%
Race	White	84%
	I do not wish to respond	8%
	Asian	4%
	Black or African American	3%
	American Indian or Alaska Native	1%
Degree Binned	Master’s	24%
	Bachelor’s	45%
	PhD	31%
Ethnicity	Not Hispanic or Latino	88%
	I do not wish to respond	8%
	Hispanic or Latino	4%
Degree Field	Physical Science	7%
	Computer Science	15%
	Engineering	65%

Variable	Value	% of Sample
	Biosciences	3%
	Mathematical Science	6%
	Psychology	2%
	Earth Science	2%
Cohort Bin	2008–2012	80%
	2006–2007	9%
	2013–2014	11%
	2015	< 1%
Service	Army	35%
	Navy	31%
	Air Force	33%
	Additional DoD	2%
Scholar Type	Recruitment	93%
	Retention	7%

Findings

The regression results for the full model indicate that SMART scholars who receive SMART program funding for more years and work farther away from their home address report lower mean satisfaction, controlling for other variables (Table 26). However, it should be noted that the magnitude of effect for an increase in a hundred miles between sponsoring facility and scholar home address is small and does not change mean satisfaction in a meaningful way. Additionally, Hispanic or Latino SMART scholars report higher mean satisfaction compared to non-Hispanic or Latino SMART scholars, and scholars who are employed for the Navy report higher mean satisfaction compared to scholars who work for the Army, controlling for other variables.

After adding scholar perspectives and changing the sample accordingly in the Likert model, *years funded*, *miles between home & sponsoring facility (in Hundreds)*, and the *Hispanic or Latino* variables are still significant indicators of mean satisfaction (albeit with smaller magnitudes) (Table 26). The variable indicating employment for the Navy is no longer significant, suggesting that most of the impact of the *Navy* variable in the full regression is accounted for by scholar perspectives. Additionally, six other variables were found to be statistically significant. The following variables are associated with lower mean satisfaction when controlling for everything else:

- Scholars with PhD degrees
- Scholars who were less motivated to participate in the DoD mission
- Scholars who did not enjoy working at the Sponsoring Facility
- Male scholars compared to scholars who did not report sex

Table 26. Satisfaction Regression Results

Coefficient (Std. Error)	Full Sample Model	Likert Model
Constant	1.52*** (0.25)	0.75 (0.52)
Sex-Female	0.05 (0.07)	0.11 (0.09)
Sex-Do not wish to respond	0.16 (0.21)	0.54** (0.22)
Race-Asian	0.04 (0.13)	-0.01 (0.15)
Race-Black or African American	0.01 (0.20)	-0.10 (0.21)
Race-American Indian or Alaska Native	0.36*** (0.10)	0.27 (0.23)
Race-I do not wish to respond	-0.13 (0.31)	-0.12 (0.31)
Degree Binned-Master's	0.02 (0.07)	-0.15 (0.09)
Degree Binned-PhD	-0.12 (0.09)	-0.39** (0.13)
Ethnicity-Hispanic or Latino	0.31* (0.12)	0.21 (0.11)
Ethnicity-I do not wish to respond	0.04 (0.28)	0.09 (0.27)
Degree Field-Computer Science	0.01 (0.24)	-0.18 (0.38)
Degree Field-Earth Science	0.41 (0.26)	0.17 (0.42)
Degree Field-Engineering	0.21 (0.23)	0.02 (0.38)
Degree Field-Mathematical Science	0.09 (0.24)	0.001 (0.39)
Degree Field-Physical Science	-0.03 (0.25)	-0.02 (0.39)
Degree Field-Psychology	0.41 (0.29)	0.13 (0.48)
Cohort Bin-2006–2007	0.10 (0.15)	0.41 (0.26)
Cohort Bin-2008–2012	0.06 (0.11)	0.36 (0.23)
Cohort Bin-2013–2014	-0.14 (0.14)	0.23 (0.26)
Years Funded	-0.17*** (0.04)	-0.10* (0.05)
Service-Navy	0.15* (0.07)	0.07 (0.09)
Service-Air Force	0.001 (0.08)	-0.01 (0.08)
Service-Additional DoD	-0.02 (0.17)	-0.18 (0.63)
Miles between home & sponsoring facility (in Hundreds)	-0.01*** (0.004)	-0.01* (0.004)
Scholar Type-Retention	0.15 (0.10)	0.17 (0.14)
Mean Work Satisfaction		0.09 (0.06)
Likert-Motivation for DoD Mission		0.12* (0.05)
Likert-Enjoyed working at sponsoring facility		0.27*** (0.06)
Likert-Enjoyed sponsoring facility region		0.01 (0.03)
Likert-Internship experience was valuable		0.04 (0.04)
Likert-During internship, felt adequately mentored		0.06 (0.04)
First salary in data (in Thousands)		0.002 (0.004)
Observations	856	523
R^2	0.09	0.49
Adjusted R^2	0.07	0.46
Residual Std. Error	0.85 (df = 833)	0.70 (df = 493)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

The regression diagnostics for both regressions are very similar and indicate that there is room for improvement in terms of model specification; however, we performed additional sensitivity analyses that support our methodology and results (Figure 42, Figure 43). The residuals are not normally distributed, and there is a pattern in the residuals plots, indicating that we did not accurately model the shape of our outcome. This is likely due to the originally ordinal nature of the Likert-type questions our mean satisfaction variable is derived from. Another approach to modelling ordinal data is ordinal logistic regression, where there is no assumption of homoscedasticity. However, the interpretation of these models is more complex, and there are additional assumptions to consider, such as the assumption of proportional odds. IDA conducted a sensitivity analysis to assess the extent to which results varied between linear regression and ordinal logistic regression. This preliminary analysis suggests that no significant coefficient (except years funded in the full sample model, albeit with a small magnitude) changes sign in the ordinal regression. This supports our results.

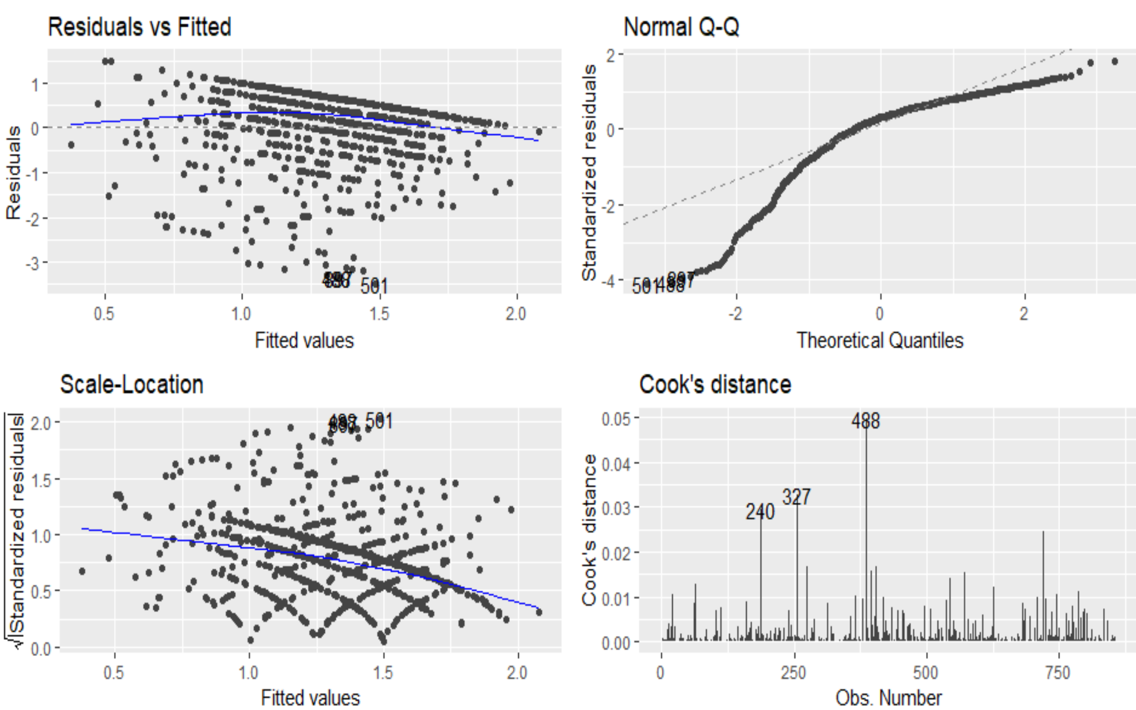


Figure 42. Full Sample Model Regression Diagnostics

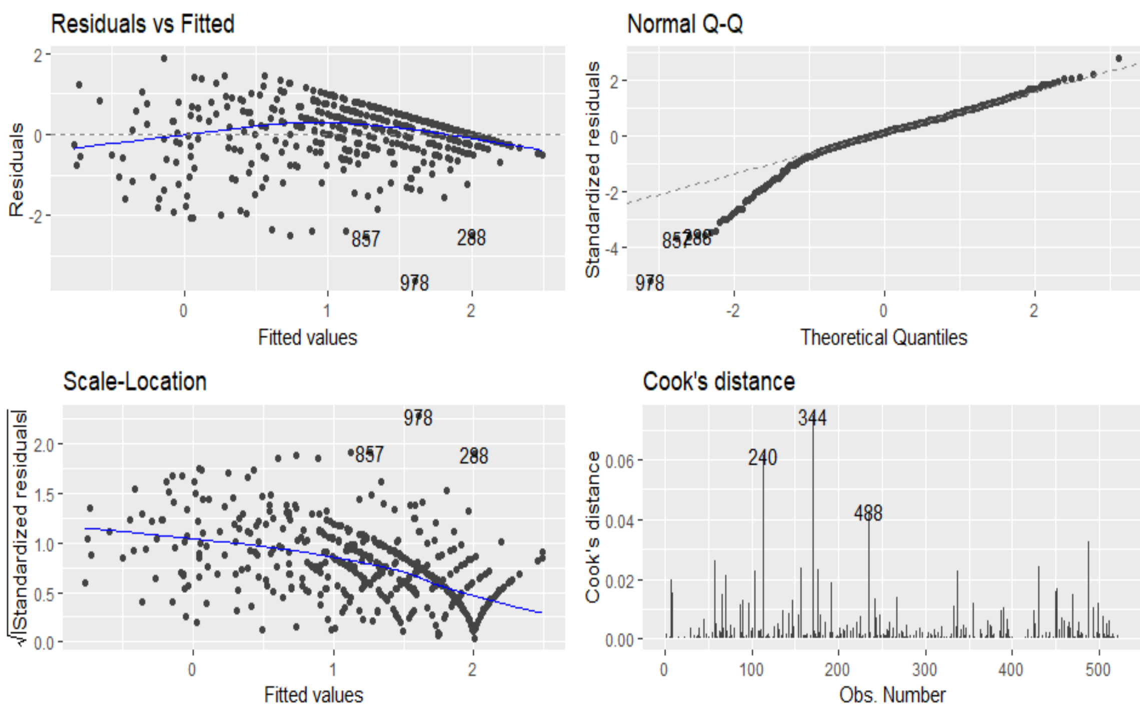


Figure 43. Likert Model Regression Diagnostics

Scholar Impact

The subsections below describe the methodology and findings related to the SMART program's impact on SMART scholars' academic directions using survey data.

Assumptions and Sample

We used SMART scholar survey data together with administrative data to learn more about which factors impact a SMART scholar's academic direction. We modeled scholars' perspectives on the statement *My experiences at my sponsoring facility positively affected my academic direction* to understand the impact that the SMART program had on scholars. To do so, we used a linear regression to determine if various aspects of the SMART program explain variation in the response. A subset of SMART scholars (N = 659) are included in the model.

The model included both descriptive scholar features (degree level, degree field, race, ethnicity, sex, service, cohort, grade point average, Carnegie Classification of the scholar's university) and scholar perspectives captured through a 5-point Likert-type response scale. These Likert-type items included three items measuring scholars' perspectives on internships and during Phase II (1. *I felt adequately mentored during my internship*, 2. *Overall, my internship experience was valuable*, 3. *I felt adequately mentored by someone at my Sponsoring Facility during Phase II*) and five items measuring recruitment scholars' preferences in sponsoring facility placement (1. *I preferred Sponsoring Facilities that were close to family/friends*, 2. *I preferred Sponsoring Facilities in a specific region of the country (West Coast, Midwest, etc.)*, 3. *I preferred Sponsoring*

Facilities affiliated with specific Service (Army, Navy, Air Force, other DoD), 4. *I preferred Sponsoring Facilities where I had prior work experience*, 5. *I preferred Sponsoring Facilities aligned with my academic/research interests*). The model also included a binary question of whether the Sponsoring Facility offered the scholar professional development opportunities (e.g., poster presentation sessions, luncheons, field trips, social events) during the scholar's internship(s) (Table 27, Table 28).

Table 27. Impact Regression Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Likert-Impact on scholar's academic direction	0.32	1.29	-2	0	0	1	2
Likert-Internship experience was valuable	0.91	1.27	-2	1	1	2	2
Likert-During internship, felt adequately mentored	0.6	1.34	-2	0	1	2	2
GPA	3.73	0.24	2.91	3.58	3.8	3.92	4
Likert-During Phase II, felt adequately mentored	0.82	1.29	-2	0	1	2	2
Likert-Preference for facilities aligned with academic interest	1.24	1.01	-2	1	2	2	2
Likert-Preference to be near family or friends	0.73	1.28	-2	0	1	2	2
Likert-Preference for prior work experience at facility	-0.45	1.32	-2	-2	0	0	2
Likert-Preference for specific facility	0.72	1.28	-2	0	1	2	2
Likert-Preference for specific service	-0.27	1.28	-2	-1	0	1	2
Years Funded	2.56	0.87	0.5	2	2	3	6

Table 28. Impact Regression Categorical Variable Summary

Variable	Value	% of Sample
Sex	Female	27%
	Male	71%
	Do not wish to respond	2%
Race	White	85%
	Black or African American	3%
	Asian	4%
	I do not wish to respond	8%
	American Indian or Alaska Native	< 1%
I was offered professional development opportunities	No, I was not offered professional development opportunities	36%
	Yes, I was offered professional development opportunities	64%
Degree Binned	Master's	24%
	Bachelor's	46%
	PhD	30%
Ethnicity	Not Hispanic or Latino	88%
	Hispanic or Latino	4%
	I do not wish to respond	7%
Degree Field	Physical Science	8%
	Computer Science	15%
	Engineering	65%
	Biosciences	2%
	Mathematical Science	5%
	Psychology	2%
	Earth Science	2%
Cohort Bin	2008–2012	76%
	2015	1%
	2006–2007	9%
	2013–2014	14%
Service	Army	34%
	Air Force	32%
	Navy	30%
	Additional DoD	4%
Carnegie Class	Doctoral Universities: Highest Research Activity	61%
	Doctoral Universities: Moderate Research Activity	5%
	Doctoral Universities: Higher Research Activity	21%
	Master's Colleges & Universities: Small Programs	1%
	Master's Colleges & Universities: Medium Programs	2%

Variable	Value	% of Sample
	Special Focus Four-Year: Engineering Schools	2%
	Master's Colleges & Universities: Larger Programs	4%
	Baccalaureate Colleges: Arts & Sciences Focus	1%
	Baccalaureate Colleges: Diverse Fields	2%
	Special Focus Four-Year: Medical Schools & Centers	< 1%

Findings

Three variables significantly impact scholars (Table 29). The following variables are associated with higher impact on scholars when controlling for everything else:

- Scholars who felt adequately mentored during their internship(s).
- Scholars who felt adequately mentored during Phase II.
- Scholars who found their internship experience valuable.

Table 29. Scholar Impact Regression Results

	Coefficient (Std. Error)
Constant	-0.36 (0.99)
Sex-Female	0.06 (0.11)
Sex-Do not wish to respond	-0.07 (0.41)
Race-Asian	-0.21 (0.30)
Race-Black or African American	-0.17 (0.25)
Race-American Indian or Alaska Native	-0.32 (0.45)
Race-I do not wish to respond	0.46 (0.31)
I was offered professional development opportunities	0.02 (0.11)
Degree Binned-Master’s	0.004 (0.13)
Degree Binned-PhD	0.04 (0.15)
Ethnicity-Hispanic or Latino	-0.14 (0.26)
Ethnicity-I do not wish to respond	-0.23 (0.32)
Degree Field-Computer Science	-0.14 (0.29)
Degree Field-Earth Science	0.22 (0.35)
Degree Field-Engineering	-0.17 (0.25)
Degree Field-Mathematical Science	-0.49 (0.32)
Degree Field-Physical Science	-0.35 (0.28)
Degree Field-Psychology	-0.34 (0.51)
Cohort Bin-2006–2007	-0.44 (0.47)
Cohort Bin-2008–2012	-0.38 (0.43)

	Coefficient (Std. Error)
Cohort Bin-2013–2014	-0.60 (0.44)
Years Funded	0.04 (0.07)
Service-Navy	0.07 (0.12)
Service-Air Force	-0.15 (0.13)
Service-Additional DoD	-0.15 (0.35)
GPA	-0.0003 (0.20)
Baccalaureate Colleges: Diverse Fields	0.99 (0.54)
Doctoral Universities: Higher Research Activity	0.72 (0.46)
Doctoral Universities: Highest Research Activity	0.53 (0.44)
Doctoral Universities: Moderate Research Activity	0.74 (0.51)
Master's Colleges & Universities: Larger Programs	0.76 (0.49)
Master's Colleges & Universities: Medium Programs	0.83 (0.54)
Master’s Colleges & Universities: Small Programs	0.27 (0.52)
Special Focus Four-Year: Engineering Schools	0.72 (0.50)
Special Focus Four-Year: Medical Schools & Centers	0.26 (1.07)
Likert-Internship experience was valuable	0.42*** (0.06)
Likert-During internship, felt adequately mentored	0.16* (0.07)
Likert-During Phase II, felt adequately mentored	0.10* (0.05)
Likert-Preference to be near family or friends	0.004 (0.06)
Likert-Preference for specific facility	-0.05 (0.05)
Likert-Preference for specific service	0.07 (0.04)
Likert-Preference for prior work experience at facility	0.08 (0.04)
Likert-Preference for facilities aligned with academic interest	0.08 (0.05)
Observations	503
R^2	0.42
Adjusted R^2	0.37
Residual Std. Error	1.02 (df = 460)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

The regression diagnostics for the impact regression have the same issues as the overall satisfaction regressions (Figure 44). As with the overall satisfaction regressions, we conducted a sensitivity analysis to assess the extent to which results varied between linear regression and ordinal logistic regression. This preliminary analysis suggests that no significant coefficient changes sign in the ordinal regression and supports our methodology. A deeper analysis of the ordinal regression results are suggested for further work.

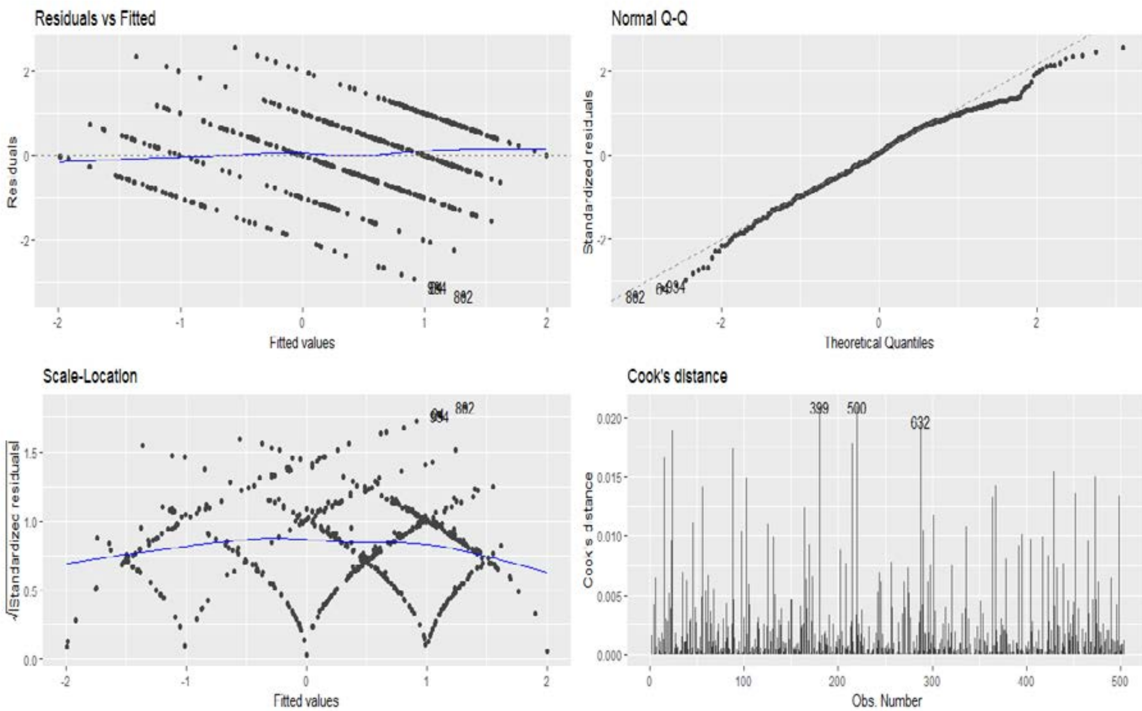


Figure 44. Scholar Impact Regression Diagnostics

Retention Analyses

The subsections below describe the methodology and findings for the comparison group (recruitment scholars and retention scholars) and scholars-only using the survey data. Analyses for recruitment and retention scholars are done separately because they were matched with their comparison group differently: recruitment scholars were matched after they finished phase I and retention scholars were matched at the first occurrence in the data. Additionally, we describe the Cox proportional hazards model, the regression technique used in the retention analyses. We also include several additional retention plots by degree level and service.

Cox Proportional Hazards Model

The Cox proportional hazards model is a regression technique that models the impact of a set of independent variables on the hazard (the rate of failure at a specific time, given the individual has succeeded up to that time) for a sample (Cox 1972). In the case of our analyses, failure is determined if someone leaves DoD. The sample can be right-censored (a failure is not observed for some observations) and in our analyses, an individual that is still employed as of October 2016 is right-censored. To correctly estimate the impact of these variables, the Cox model relies on a few assumptions about relationships in the dataset.

- **Proportional hazards**: The effect of an independent variable on the hazard does not change over time.

- **Non-informative censoring**: Censoring times do not relate to survival times and vice versa.
- **Independent censoring**: Conditional on the values of independent variables, individuals are not more or less at risk during any given time period if they are censored.

We tested the proportional hazards assumption, and it was met in each model (Grambsch et al. 1994). Additionally, transformations of any continuous variable are examined to ensure that the most linear relationship between the variable and the hazard is included in the model (Therneau et al. 1990). We are not aware of an empirical method for testing the censoring assumptions. However, one can make a case that for our matched dataset, the assumptions are satisfied. We have no reason to believe that individuals who are still in the dataset as of October 2016 are inherently more or less likely to be retained.

Recruitment Scholars and Comparison Group

Assumptions and Sample

We tested whether SMART recruitment scholars are leaving at faster rates than their comparison group using a Cox proportional hazards model. The model included recruitment scholars located in DMDC (N = 1,047) and their comparison group (3 to 1 matches) (N = 2,523). The survival model leveraged the matching structure of the dataset and used the matched groups as strata in estimating hazard ratios. Additionally, other variables include those that were used in the matching process, but not as exact matching criteria, were also included as controls, along with starting salary (in thousands). The proportional hazards assumption was tested and met.

Findings

We found that the hazard of leaving the DoD for SMART scholars is 1.66 times higher than their counterparts, indicating that SMART scholars are likely to leave at faster rates than their counterparts, controlling for the matching structure, race, ethnicity, sex, starting salary, and birth year. Additionally, a one percent increase in the starting salary (in thousands) decreases the hazard for leaving by 40 percent for both SMART scholars and their comparison group, controlling for everything else (Table 30). Figure 45 shows the estimated cumulative probability of retention for SMART scholars and their counterparts and is an additional way of viewing retention that is not shown in the main body of the report.

Table 30. Recruitment Scholar and Comparison Group Retention Cox Proportional Hazard Model Results

	Hazard Ratio (Std. Error)
SMART Scholar	1.66*** (0.28)
Log Starting Salary (in Thousands)	0.40** (0.05)
Race-Asian	1.11 (0.51)
Ethnicity-Not Hispanic	1.72 (1.14)
Ethnicity-Unknown	1.96 (2.04)
Sex-M	1.10 (0.16)
Race-White	1.15 (0.41)
Race-African American	0.78 (0.24)
Race-Native Hawaiian	2.41 (5.69)
Race-American Indian	1.10 (0.56)
Birth Year	0.99 (0.01)
Observations	3,570
R^2	0.02
Max. Possible R^2	0.32
Log Likelihood	-651.10
Wald Test	58.01*** (df = 11)
LR Test	60.41*** (df = 11)
Score (Logrank) Test	61.37*** (df = 11)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

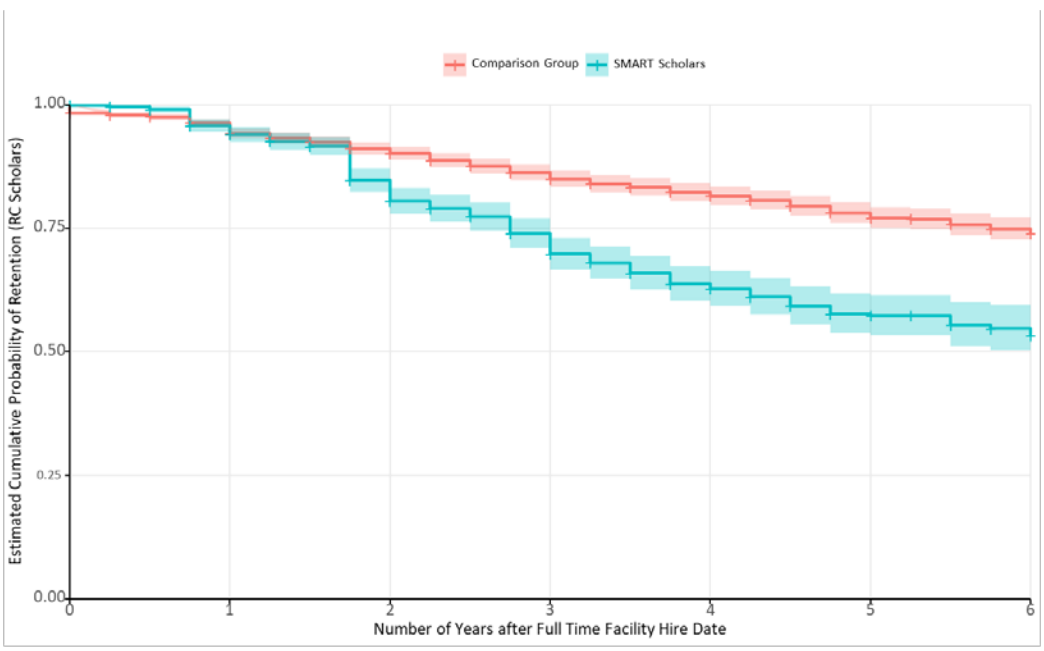


Figure 45. Estimated Cumulative Probability of Retention for Recruitment Scholars and Comparison Group

In addition to a Cox proportional hazards model, we ran four other models for each year of data, with a binary outcome related to retention in the year:

- Conditional logistic regression conditioned upon the matched group and controlling for race (White and Asian), birth year, hire date, service compute date, and sex (Breslow et al. 1978)
- Conditional logistic regression conditioned upon the matched group with no control variables
- Logistic regression controlling for matched group, birth year, hire date, service compute date, race (White and Asian), and sex (Walker and Douglas 1967)
- Logistic regression with no control variables

In all cases, SMART recruitment scholars are leaving at faster rates than their counterparts at statistically significantly higher rates after year two. In other words, our results concerning SMART recruitment scholars are agnostic to model specifications; the results do not change with the presence or absence of control variables.

Model Diagnostics

Examining the deviance residuals of the Cox regression, we can better understand how our model's errors are distributed (Figure 46). Residuals for Recruitment Scholar and Comparison Group Retention Regression positive deviance residual for an individual indicates that the person left sooner than expected according to the model, while negative values indicate that the person stayed longer than expected according to the model. It appears that there is a slightly higher density of negative deviance residuals. Therefore, it seems to predict that individuals in our dataset leave more than they actually do.

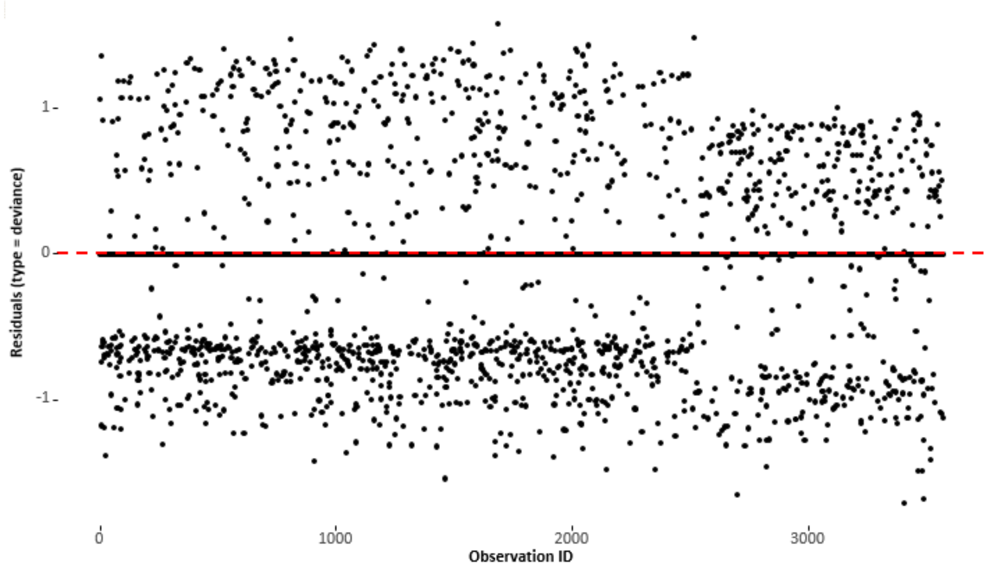


Figure 46. Residuals for Recruitment Scholar and Comparison Group Retention Regression

Retention Scholars and Comparison Group

Assumptions and Sample

We analyzed the retention rate for SMART retention Scholars and their comparison group using a Cox proportional hazards model. The model included retention scholars located in DMDC ($N = 146$) and their comparison group (3 to 1 matches) ($N = 403$). The survival model leveraged the matched structure of the data by stratifying along matched groups. Additionally, the variables that were used in the matching process, but not as exact matching criteria, were also included as controls. In order to meet the proportional hazards assumption for the SMART scholar indicator variable, we used a time transformation function that allows the variable's effect to change over time.

The matching process is slightly different for retention scholars and will thus affect how the retention rate for these scholars can be analyzed. Retention scholars are matched with counterparts based on their hire date before they received the SMART scholarship. Therefore, the time in which retention scholars are in the degree completion phase (Phase I), will be counted towards the amount of time they are retained. In order to understand how retention scholars' career progression factors into the SMART program, it is important to consider counterparts prior to the SMART program. Further, had we matched retention scholars based on the hire date after the SMART program, the matching process would not take prior Federal service into account.

Hire date is based upon the quarter when they first entered the data. Thus, if retention scholars started prior to 2006, their first instance in the dataset is a less accurate proxy for hire date. However, the Federal Credible Service Compute Date (Service Compute Date) can also be used as a proxy for hire date. This date is used to calculate benefits for Federal service and can be used as a proxy for start date. While different agencies calculate this date differently, among individuals at the same UIC, the date can serve as a rough comparison for hire date.

Because retention scholars are matched to counterparts before they received the SMART scholarship, the degree level considered is the degree level they had before they were awarded the SMART Scholarship. Therefore, there are very few retention scholars that would be identified as PhD scholars in the DMDC data.

Findings

We can see that during the first 7 years after their full time hire date, retention scholars have a lower hazard rate of leaving DoD employment compared to their comparison group, controlling for other variables (Figure 47). However, after year 7, retention scholars have a higher hazard rate of leaving DoD employment compared to their comparison group, controlling for other variables (Figure 47). Hazard Ratio over Time for SMART Scholars shows the change in this hazard ratio over time. On average, retention scholars are in the dataset for 3 years prior to receiving the

SMART scholarship and have an average service commitment of 2 years; therefore, on average retention scholars will be finishing Phase II around year 7.

We use a time transformed SMART scholar variable because in a regression without a time transformed SMART scholar variable, we found that our model violated the proportional hazards assumption in that the hazard for SMART scholar status changed over time (Figure 48). The shape of the relationship between SMART scholar status and the number of years since full time hire date led us to use a linear interaction between time and the SMART scholar variable to account for the changing effect (Figure 49). The two resulting variables from this time transformation (the intercept and slope of the time varying effect respectively) have residuals indicating the proportionality assumption is met (Figure 50).

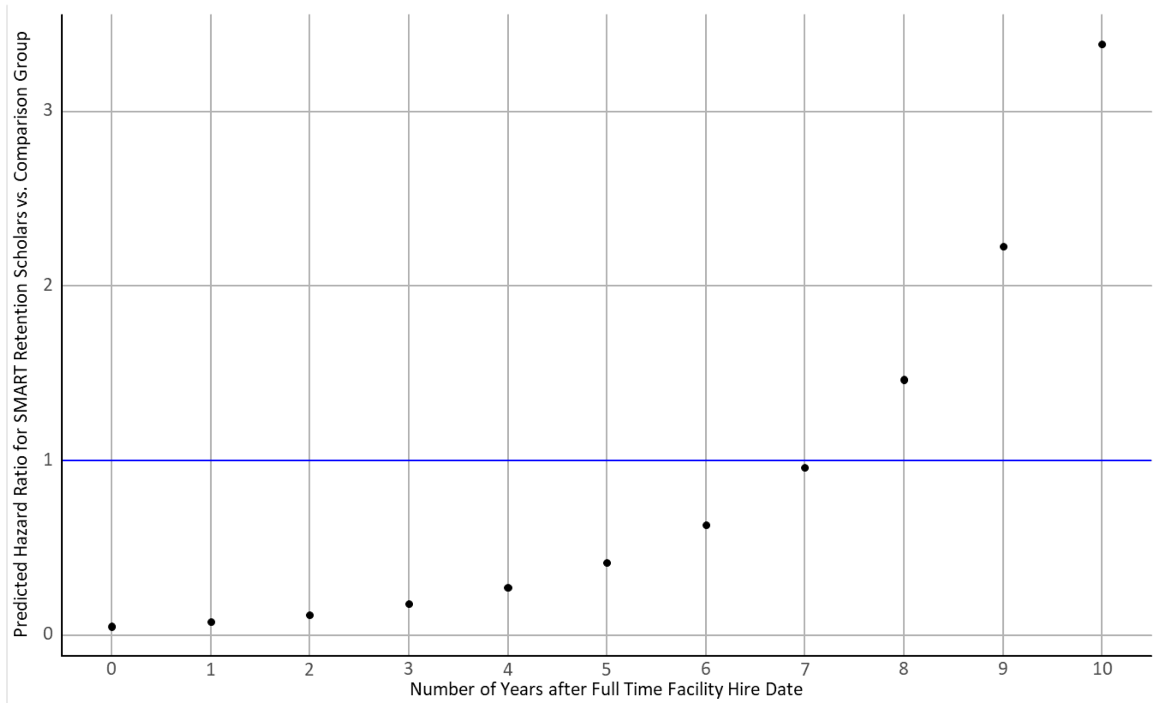


Figure 47. Hazard Ratio over Time for SMART Scholars

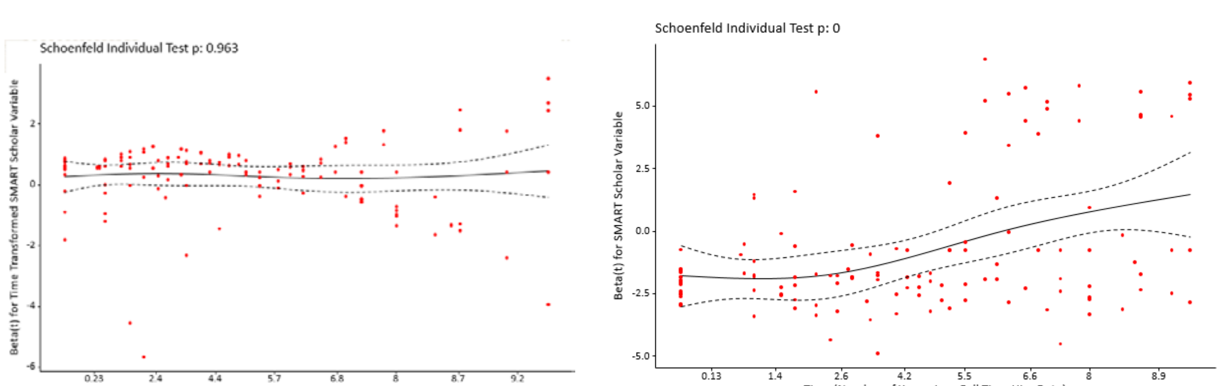


Figure 48. Proportionality Assumption before Time Transform

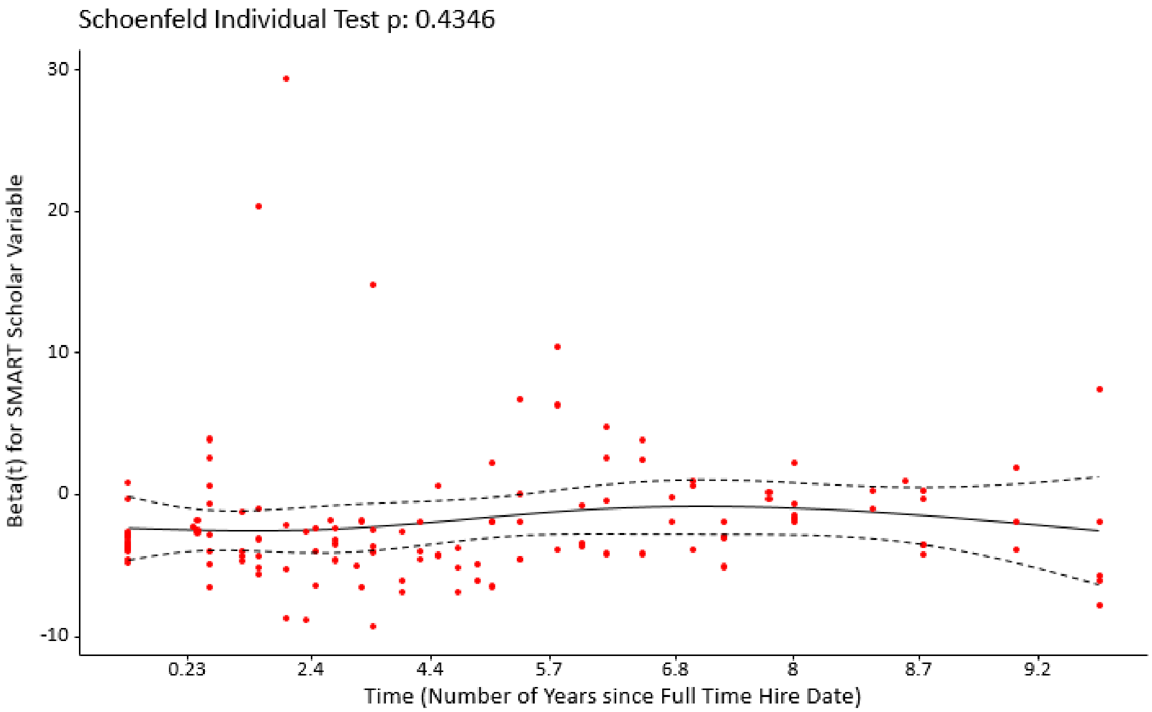


Figure 49. Proportionality Assumption after Time Transform for SMART Scholar Variable

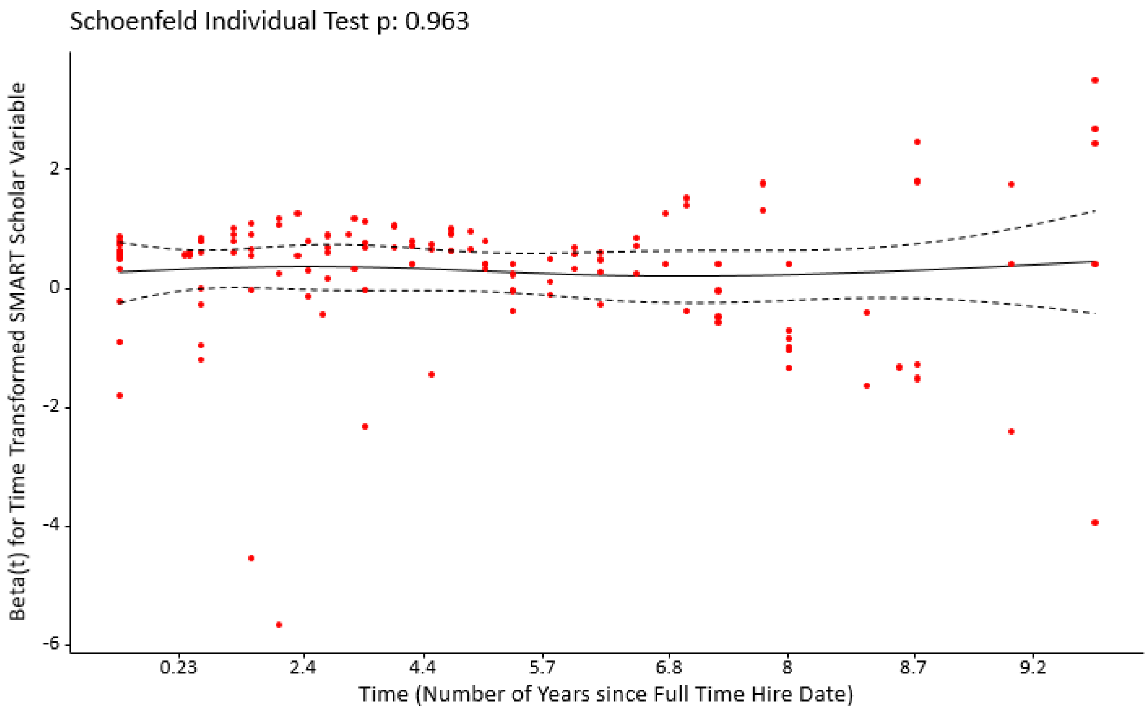


Figure 50. Proportionality Assumption after Time Transform for Time Transform SMART Scholar Variable

In addition to a Cox proportional hazards model (Table 31), we ran four other models for each year of data, with a binary outcome related to retention in the year:

- Conditional logistic regression conditioned upon the matched group and controlling for race (White and Asian), birth year, hire date, service compute date, and sex
- Conditional logistic regression conditioned upon the matched group with no control variables
- Logistic regression controlling for matched group, birth year, hire date, service compute date, race (White and Asian), and sex
- Logistic regression with no control variables

In all cases, SMART retention scholars are shown to have a significantly lower retention rate than their counterpart from years 2 to 9. These results do not account for the probability of leaving and just show the retention rate; therefore, there is no way to observe at what point retention scholars may be more likely to leave (see Figure 51).

Table 31. Retention Scholar and Comparison Group Retention Cox Proportional Hazard Model Results

	Hazard Ratio (Std. Error)
SMART Scholar	0.15*** (0.01)
Time Varying SMART Scholar	1.52*** (0.25)
Ethnicity-Not Hispanic	1.49 (2.13)
Ethnicity-Unknown	0.97 (0.89)
Sex-M	0.98 (0.30)
Race-White	0.45 (0.12)
Race-Asian	2.35 (4.90)
Race-African American	1.53 (2.03)
Race-Native Hawaiian	0.55 (0.41)
Race-American Indian	0.39 (0.18)
Birth Year	1.00 (0.04)
Starting Salary (in Thousands)	1.00 (0.01)
Observations	549
R^2	0.07
Max. Possible R^2	0.41
Log Likelihood	-122.38
Wald Test	24.70* (df = 12)
LR Test	41.13*** (df = 12)
Score (Logrank) Test	32.09** (df = 12)

Note: p < 0.05 *; p < 0.01 **; p < 0.001 ***

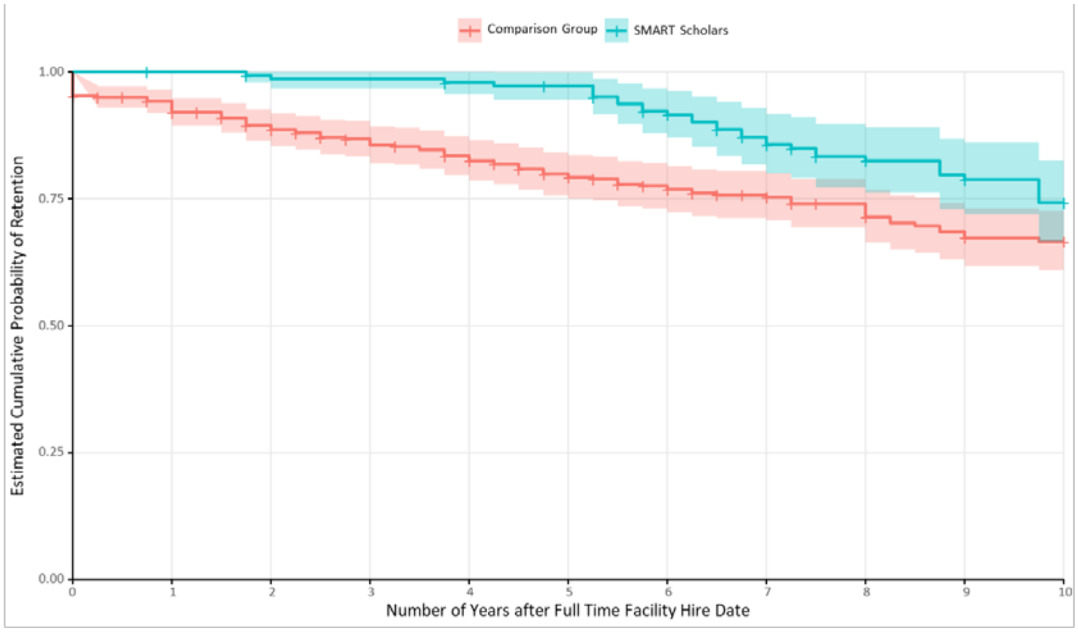


Figure 51. Estimated Survival Curves for Retention Scholars and Comparison Group

Model Diagnostics

As described with recruitment scholars, examining the deviance residuals of the Cox regression (Figure 52) we can better understand how our model's errors are distributed. A positive deviance residual for an individual indicates that the person left sooner than expected according to the model, while negative values indicate that the person stayed longer than expected according to the model. Similar to recruitment scholars, it seems that there is a slightly higher density of negative deviance residuals, and therefore, our model seems to predict that individuals in our dataset leave more than they actually do.

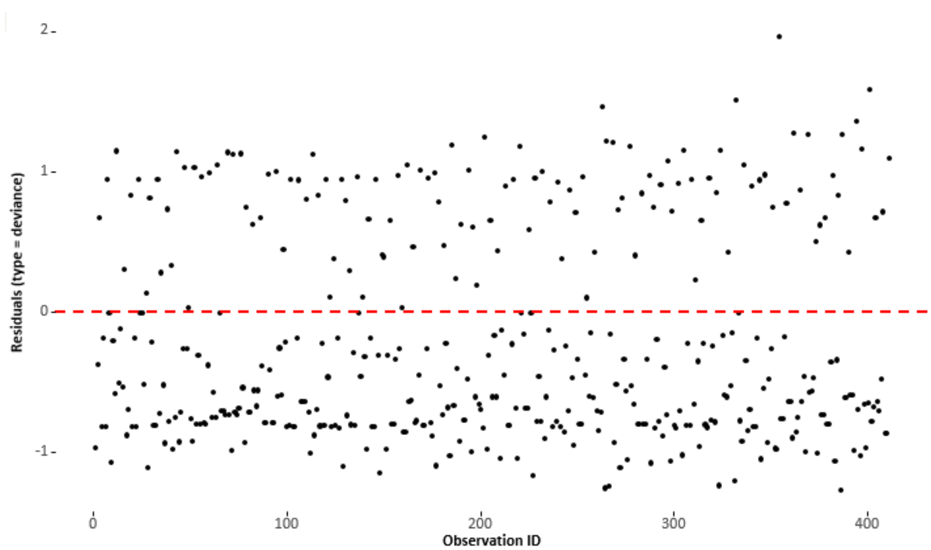


Figure 52. Residuals for Retention Scholar and Comparison Group Retention Regression

Survey Retention Model

Assumptions and Sample

We tested what factors, if any, impact retention using a Cox proportional hazards model. The model included recruitment scholars located in DMDC; who took the survey; were in Army, Navy, or Air Force; and answered the three survey items that we tested. The variables that were used in the matching process, but not as exact matching criteria, were also included as controls, along with starting salary (in thousands) and three items from the survey. The items included from the survey include Mean Satisfaction, Mean Work Satisfaction, and those that answered the question *I was motivated to participate in the DoD mission* [at their Sponsoring Facility]. The proportional hazards assumption was tested and met. We ran two models for retention: the first uses the number of years retained after Phase II (N = 746) and the second uses the number of years retained after Phase III (N = 456). Results are reported using the first model (after Phase II). Including the number of service commitment years violated the proportional hazards assumption, so we ran the second model to test whether the length of service commitment affects retention. The variable summaries used in the regression indicate a similar distribution for the sample included in the model compared to the full survey dataset (Table 32, Table 33).

Table 32. SMART Scholar Survey Retention Cox Proportional Hazard Model Numerical Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
First salary in data	52,171.45	14,749.16	18,940	40,993.68	50,399	62,107.07	116,198.81
Mean Satisfaction	1.33	0.88	-2	1	1.75	2	2
Mean Work Satisfaction	0.62	1.19	-2	-0.25	1	1.75	2
Miles between home & Sponsoring Facility (in Hundreds)	3.64	7.65	0	0.092	0.25	2.6	62.67
Number of retention years after Phase II	2.87	1.79	0	1.5	2.75	4.25	8
Likert-Workplace Culture	0.54	1.3	-2	0	1	2	2
Years Requested	2.29	1.07	0	1.5	2	3	6

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Likert-DoD Mission	1.11	1.07	-2	1	1	2	2

Table 33. SMART Scholar Survey Retention Cox Proportional Hazard Model Categorical Variable Summary

Variable	Value	% of Sample
Scholar Type	Retention	13%
	Recruitment	87%
Degree Level	Bachelor's	53%
	PhD	21%
	Master's	26%
	Engineering	73%
Degree Field	Mathematics	4%
	CS and IT	9%
	Other	6%
	Physical Science	7%
	Psychology	1%
Service	Navy	34%
	Army	37%
	Air Force	29%
Sex	Male	73%
	Female	27%
Ethnicity	Not Hispanic or Latino	96%
	I do not wish to respond	2%
	Hispanic or Latino	3%
Race	African American	3%
	American Indian	1%
	Native-Hawaiian	0%
	Asian	0%
	White	91%
	I do not wish to respond	5%

Findings

There are several factors that impact retention among SMART scholars. The SMART scholars that are more satisfied and more likely to stay in DoD are in the Navy over the Air Force, and work closer to their home address (Tables 34–35). Between the two models, the same factors are significant; however, the magnitude of the hazard changes slightly. The hazards from the first model (after Phase II) are described below:

- The hazard for SMART scholars that are more satisfied is .64 times lower than those that are less satisfied ($p < .001$)
- The hazard for SMART scholars in Air Force is 1.85 times less than SMART scholars in Navy ($p < .001$)
- The hazard for SMART scholars that are employed at facilities close to their home address are 1.26 times more likely to leave ($p < .01$)

While retention scholars appear from this model to not leave at faster from recruitment scholars, retention scholars are also more satisfied (Section E-6). Further, from earlier models we know that when satisfaction is removed from this model, retention scholars are likely to leave at faster rates. Additionally, the number of service commitment years does not affect retention.

Table 34. SMART Scholar Survey Retention Cox Proportional Hazard Model Results

	Hazard Ratio (Std. Error)
Mean Satisfaction	0.64*** (0.04)
Mean Work Satisfaction	0.92 (0.07)
DoD Mission	0.93 (0.07)
Workplace Culture	0.90 (0.06)
Scholar Type	0.64 (0.12)
Degree Level-Master’s	0.93 (0.17)
Degree Level-PhD	0.81 (0.23)
Degree Field-Engineering	0.91 (0.22)
Degree Field-Mathematics	1.29 (0.72)
Degree Field-Other	1.03 (0.45)
Degree Field-Physical Science	1.16 (0.58)
Degree Field-Psychology	2.59 (4.46)
Service-Army	1.44 (0.46)
Service-Air Force	1.85** (0.73)
Starting Salary (in Thousands)	1.00 (0.01)
Square Root (Distance)	1.26*** (0.07)
Sex-M	1.05 (0.20)
Ethnicity-Not Hispanic	0.42 (0.12)

Hazard Ratio (Std. Error)	
Ethnicity-Unknown	1.04 (1.11)
Race-African American	0.28 (0.09)
Race-American Indian	3.84 (10.39)
Race-Asian	1.58 (1.74)
Race-White	1.28 (1.06)
Observations	746
R^2	0.15
Max. Possible R^2	0.88
Log Likelihood	-739.09
Wald Test	130.28*** (df = 23)
LR Test	124.94*** (df = 23)
Score (Logrank) Test	153.27*** (df = 23)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Table 35. SMART Scholar Retention Cox Proportional Hazard Model Results, after Phase III

Hazard Ratio (Std. Error)	
Service Commitment Years	0.84 (0.10)
Mean Satisfaction	0.69* (0.07)
Mean Work Satisfaction	0.85 (0.08)
Workplace Culture	0.98 (0.10)
DoD Mission	0.85 (0.08)
Scholar Type	0.81 (0.21)
Degree Level-Master's	1.03 (0.26)
Degree Level-PhD	0.97 (0.42)
Degree Field-Engineering	0.80 (0.22)
Degree Field-Mathematics	1.25 (0.83)
Degree Field-Other	1.33 (0.89)
Degree Field-Physical Science	0.84 (0.40)
Degree Field-Psychology	1.08 (1.27)
Service-Army	1.15 (0.36)
Service-Air Force	1.70* (0.77)
Starting Salary (in Thousands)	0.99 (0.01)
Square Root (Distance)	1.24*** (0.08)
Sex-M	0.96 (0.21)
Ethnicity-Not Hispanic	1.02 (1.29)
Ethnicity-Unknown	0.31 (0.14)
Race-African American	0.06* (0.005)
Race-American Indian	0.55 (0.40)

Hazard Ratio (Std. Error)	
Race-Asian	0.29 (0.08)
Race-White	0.22 (0.04)
Observations	456
R^2	0.14
Max. Possible R^2	0.94
Log Likelihood	-612.99
Wald Test	78.70*** (df = 24)
LR Test	69.79*** (df = 24)
Score (Logrank) Test	84.86*** (df = 24)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

As described in the comparison group analyses, examining the deviance residuals of the Cox regression (Figures 53, Figure 54), we can better understand how our model's errors are distributed. A positive deviance residual for an individual indicates that the person left sooner than expected according to the model, while negative values indicate that the person stayed longer than expected according to the model. Similar to the comparison group regressions, it seems that there is a slightly higher density of negative deviance residuals, and therefore, our models seem to predict that individuals leave more in our dataset than they actually do.

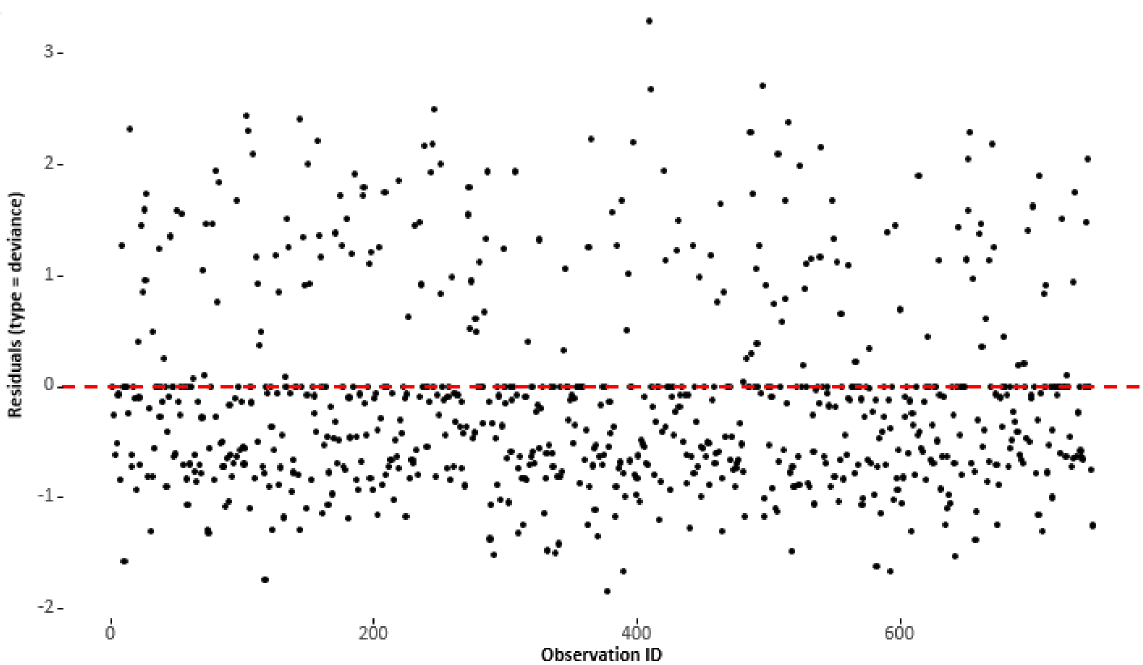


Figure 53. Residuals for SMART Scholar Survey Retention Regression

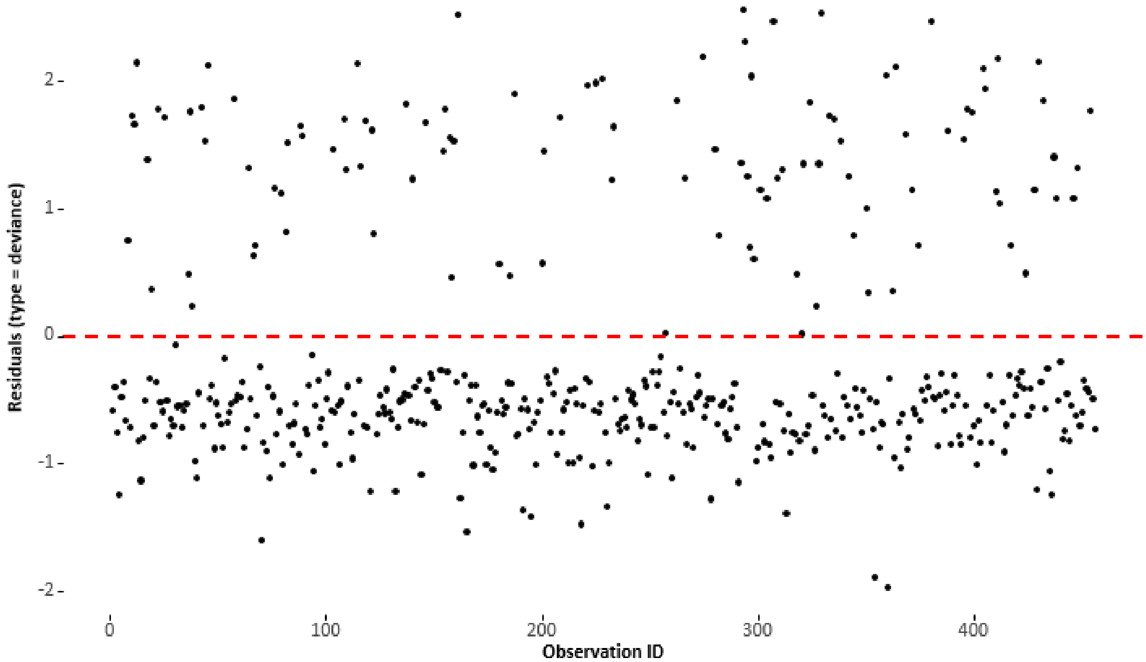
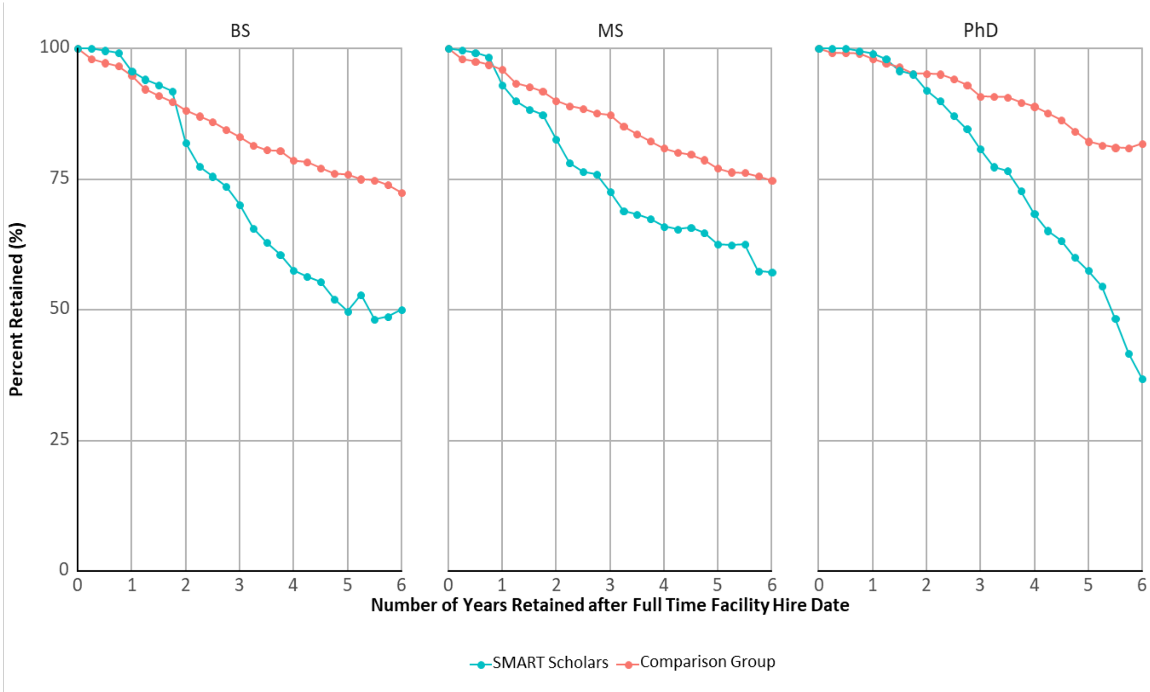


Figure 54. Residuals for SMART Scholar Survey Retention Regression (Shifted)

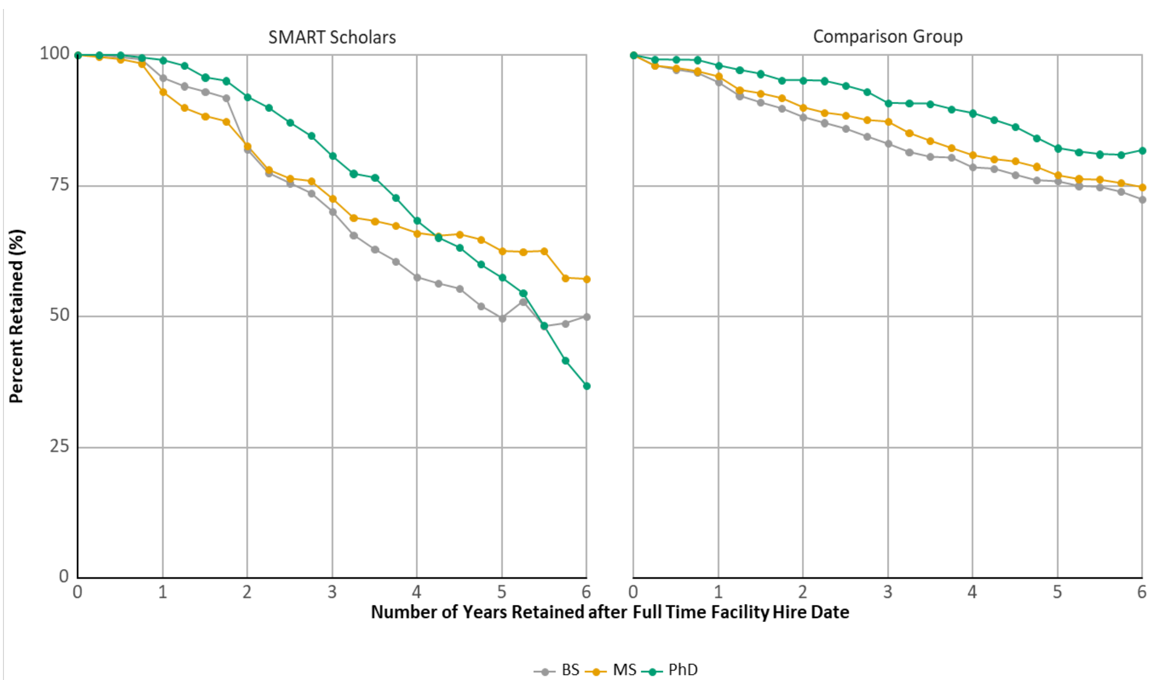
Additional Retention Rate Figures

The retention rate broken down by service and degree level for both recruitment and retention scholars are shown below (Figures 55–62). As described on page E-27, the only significant factor among degree level and service is that scholars in the Navy are significantly more likely to be retained than those in Air Force.



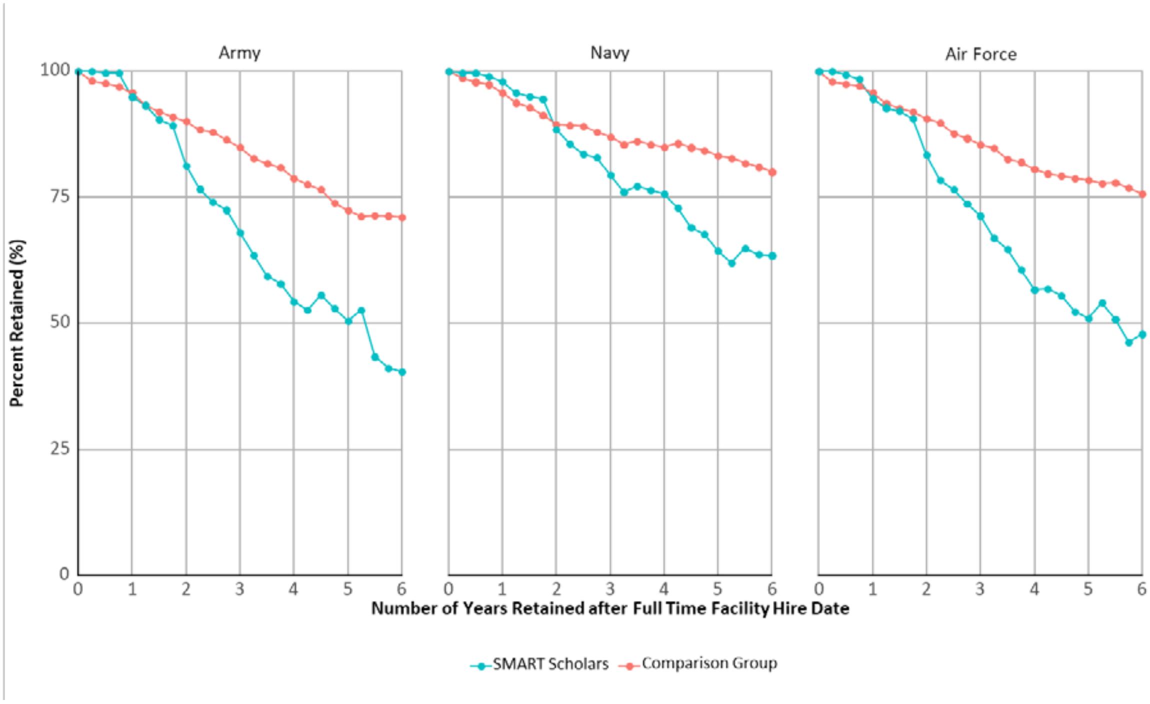
Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 55. Retention Rate among Recruitment Scholars and their Comparison Group, by Degree Level



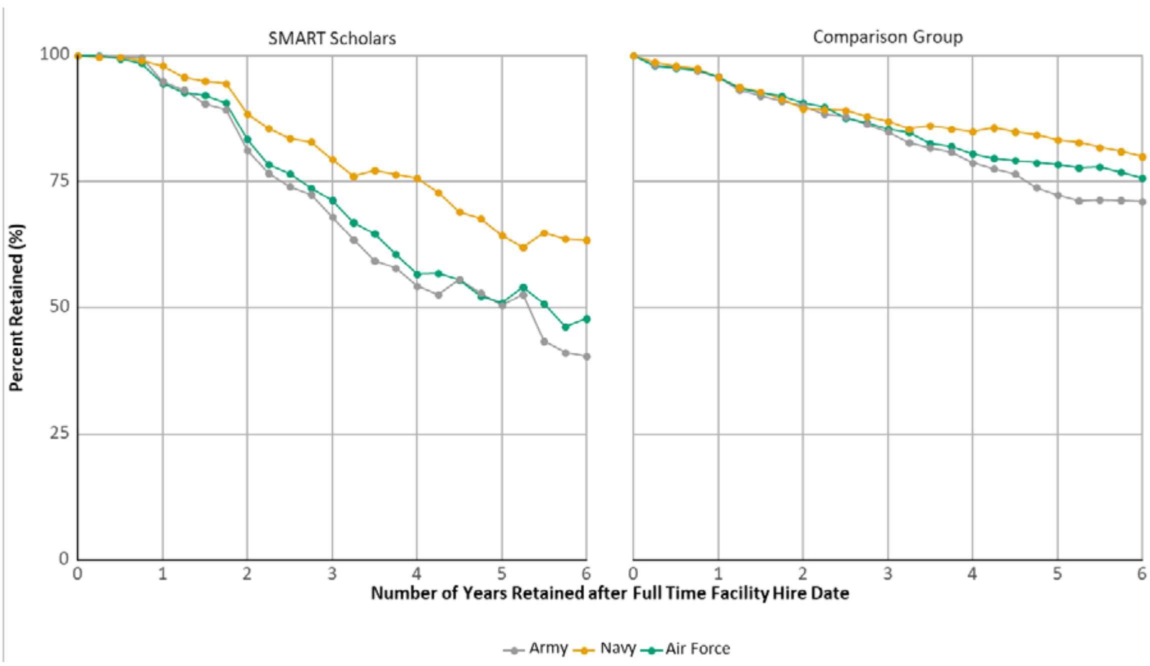
Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 56. Retention Rate among Recruitment Scholars and their Comparison Group, by Degree Level



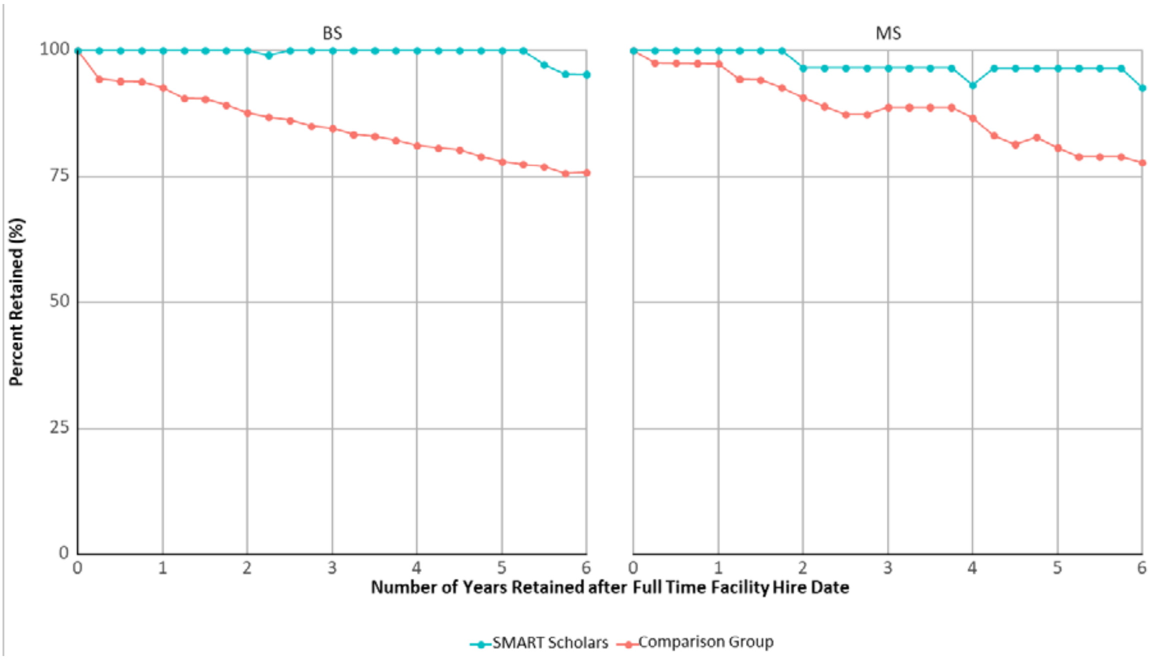
Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 57. Retention Rate among Recruitment Scholars and their Comparison Group, by Service



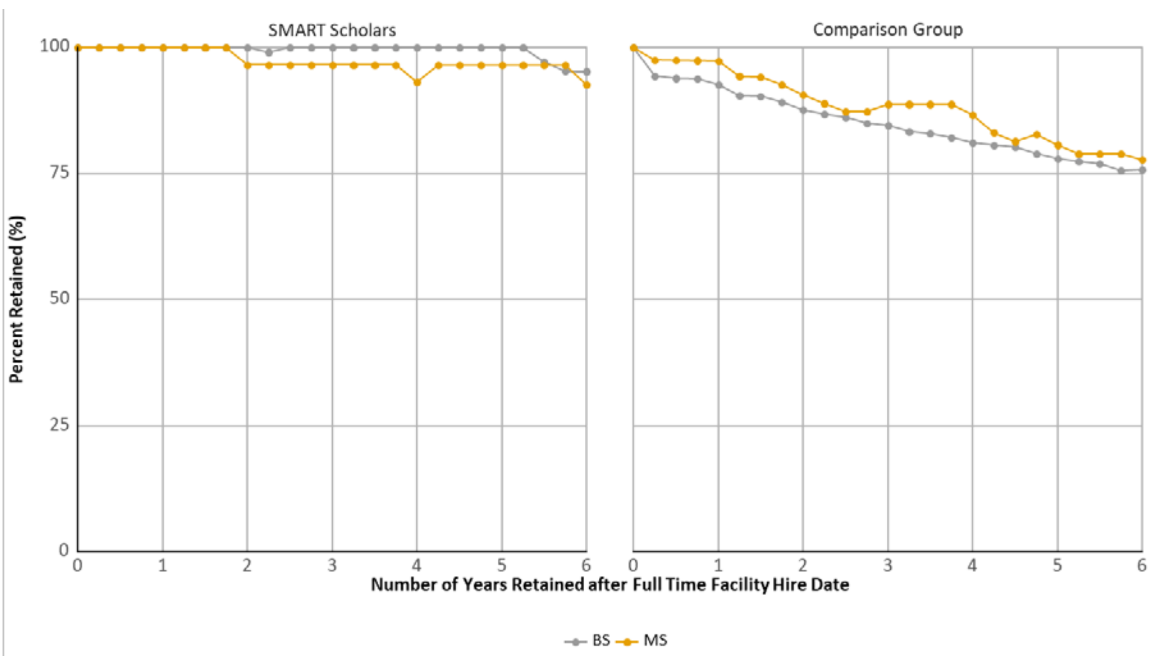
Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 58. Retention Rate among Recruitment Scholars and their Comparison Group, by Service



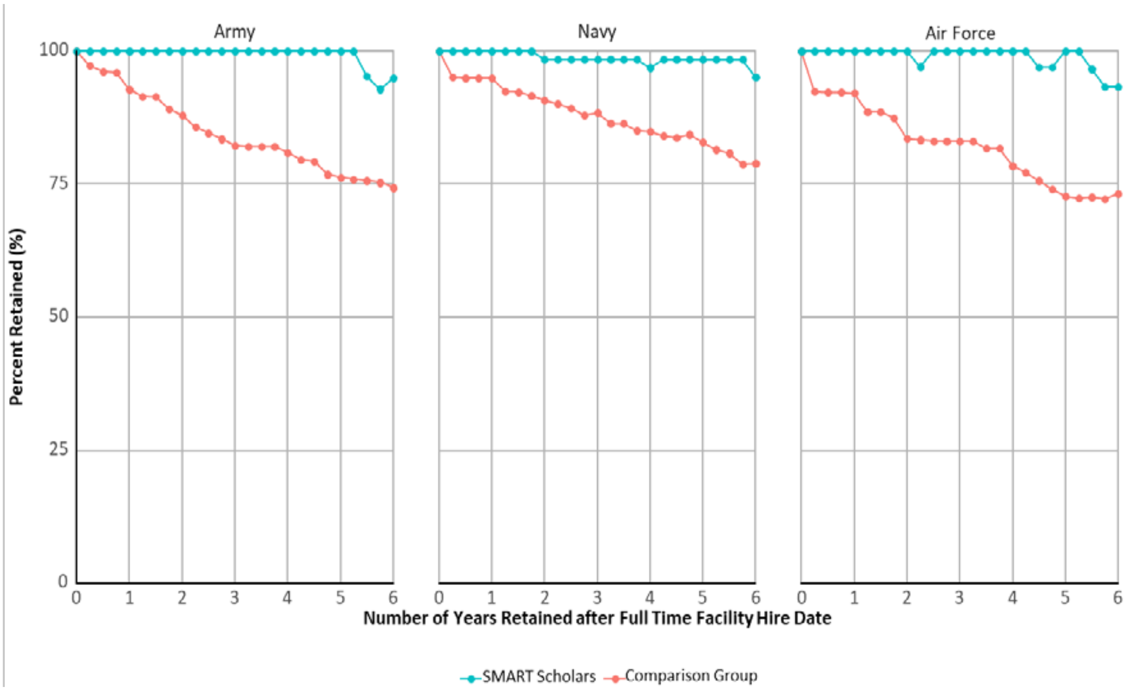
Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 59. Retention Rate among Retention Scholars and their Comparison Group, by Degree Level



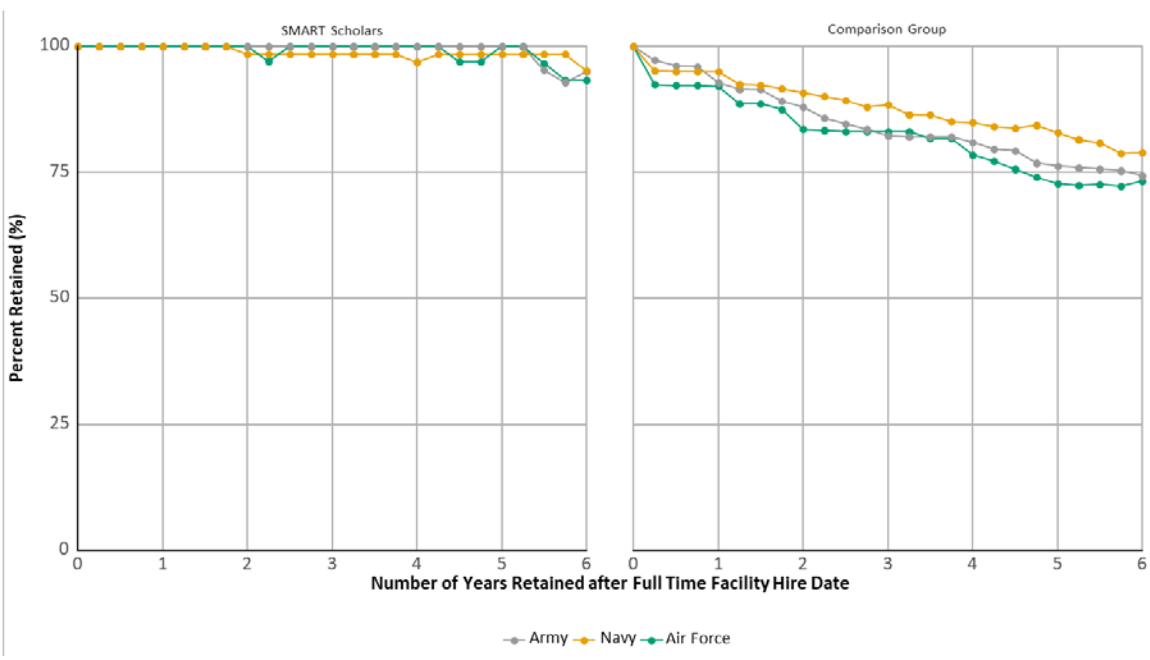
Note: Retention scholars are matched with their degree prior to the SMART program. Therefore, there are very few that are considered to be PhDs. These are omitted. The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 60. Retention Rate among Retention Scholars and their Comparison Group, by Degree Level



Note: Retention scholars are matched with their degree prior to the SMART program. Therefore, there are very few that are considered to be PhDs. These are omitted. The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 61. Retention Rate among Retention Scholars and their Comparison Group, by Service



Note: The percent retained increased because the number that could have been retained (denominator) decreased at a faster rate than the number retained (numerator).

Figure 62. Retention Rate among Retention Scholars and their Comparison Group, by Service

Quality Analyses

Quality of an employee is an inherently difficult thing to measure. It is by definition vague and can be broken down into many categories (e.g., leadership ability, team working capability, effective communication). Additionally, it can be difficult to measure any one of these more specific definitions in a rigorously quantitative way. For our population of interest, DoD S&E civilian employees, we do not have employer evaluations (which might have their own bias) or any other direct measurement of quality. However, using the data we were able to procure from DMDC, we attempted to model quality of SMART scholars using salary and promotion data. The following subsections below describe the methodology and findings related to SMART scholars' quality. Additionally, we describe the three topics we used to model quality, difference-in-difference model, logistic regression, and multilevel modeling.

Starting Salary

Assumptions and Sample

We modeled starting salary for recruitment scholars using a linear regression to determine if SMART scholars have a different starting salary than their comparison group. All recruitment scholars and their paired comparison group (N = 2,094) are included in the model. Degree level, race, ethnicity, sex, service, occupation bin, and age in 2018 are included in the model as independent variables and are used to control for factors that might impact our variable of interest, SMART scholar status, and our outcome, starting salary. We do not model starting salary for retention scholars because we only have salary data starting in October 2006, and many retention scholars started before then.

Findings

The regression results indicate that SMART recruitment scholars have a lower starting salary than their counterparts, controlling for everything else (Table 36). Additionally, four other variables are found to be statistically significant. The following variables are associated with lower starting salaries for SMART scholars and their comparison group, controlling for everything else:

- Army civilians compared to other services
- Younger civilians
- Civilians with bachelor's degrees
- Civilians who did not report ethnicity compared to non-Hispanic employees

Table 36. Recruitment Scholar and Comparison Group Starting Salary Regression Results

	Coefficient (Std. Error)
Constant	7,073.10 (3,857.42)
SMART Scholar	-4,756.38*** (535.59)
Degree Level-Master's	8,731.96*** (673.70)
Degree Level-PhD	21,065.15*** (829.90)
Ethnicity-Hispanic	-1,094.33 (1,711.76)
Ethnicity-Unknown	-13,668.99*** (3,699.72)
Sex-M	814.34 (567.58)
Service-Air Force	6,513.03*** (714.35)
Service-Navy	8,269.66*** (621.37)
Service-Other DoD	8,811.28* (3,576.33)
Occupation Bin-Education Group	-8,068.14 (7,997.24)
Occupation Bin-Engineering	1,387.21 (2,177.43)
Occupation Bin-Information Technology	5,490.92 (3,594.12)
Occupation Bin-Mathematical Sciences	1,809.62 (2,257.85)
Occupation Bin-Medical, Dental, and Public Health	-1,876.32 (5,359.78)
Occupation Bin-Physical Sciences	505.40 (2,363.12)
Occupation Bin-Social Sciences and Psychology	4,386.95 (2,876.64)
Age in 2018	1,123.56*** (68.50)
Race-African American	-3,999.23 (2,297.94)
Race-Native Hawaiian	1,929.12 (6,609.61)
Race-American Indian	-4,919.16 (2,794.43)
Race-White	-1,562.63 (2,113.12)
Race-Asian	-2,374.59 (2,339.42)
Observations	2,094
R^2	0.60
Adjusted R^2	0.59
Residual Std. Error	12,192.50 (df = 2071)

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

The regression diagnostics indicate that the residuals are approximately normally distributed (normal q-q plot) and that there is no obvious misspecification pattern in the residuals (residuals vs fitted plot) (Figure 63). However, some of the model assumptions do not seem to hold, and our analysis accounts for this. First, the scale-location plot indicates non-constant variance at different fitted values, a violation of homoscedasticity. To account for this, we used robust standard errors, with all of the significance tests using these unbiased standard errors. Second, there are a few outliers in the dataset, as seen in the Cook's distance plot. However, there is no clear indication that these are mistaken observations and so we do not exclude them.

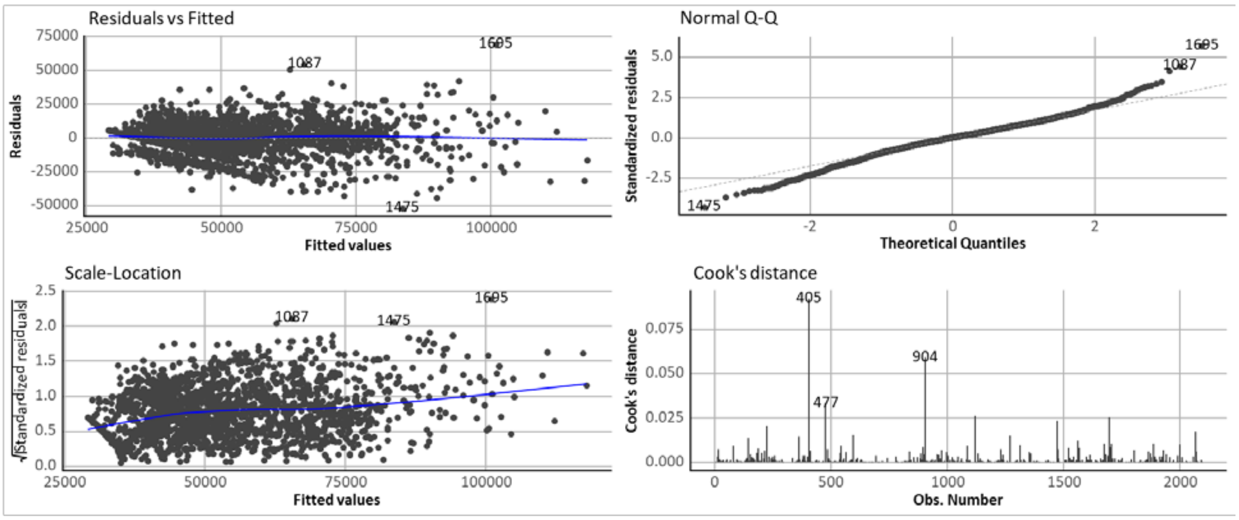


Figure 63. Recruitment Scholar and Comparison Group Starting Salary Regression Diagnostics

Salary Change

Recruitment Scholars

We attempted to model salary change for recruitment scholars and their comparison group. However, the variability of percent salary change is large in the dataset. For example, one civilian jumps from $25,000 to $34,000 to $55,000 in the span of 3 years. We therefore restricted our analysis to scholars on the GS pay plan in an attempt to use their grade-step to help model this variation.

Even with information about a civilian's status in the pay plan, there is a lot of variation within the same grade. Therefore, we used a multilevel model for salary progression of recruitment scholars.

Multilevel Modeling

To explore differences in salary growth among SMART recruitment scholars and similar DoD S&E civilians, we employed an alternative analysis—a multilevel growth model. This modeling framework is popular in contexts where data are *nested*. The mixed modeling approach affords several advantages, including the ability to handle individuals assessed at different chronological times, unevenly spaced time intervals, and individuals who contribute different numbers of observations. These data are characterized by all of the above. Here, because we have one or more observations for each individual, we say that observations are nested within an individual. Further, because individuals may belong to one or more UICs over time, we have a *cross-classified* effect of UIC. Individuals are not strictly nested within UIC given this possibility of changing UICs over time. By implementing a modeling approach that accounts for these sources of dependence in the data, we were able to more clearly understand differences between SMART recruitment scholars and their counterparts.

Assumptions and Sample

Using this modeling framework, we evaluated salary differences over time between SMART recruitment scholars and their comparison group, quantified as differences in starting point and rate of change over time. We did this while controlling for relevant covariates, such as sex, race and ethnicity, and age. Moreover, this analysis framework allowed us to control for the fact that individuals are nested within UIC, meaning that multiple persons are members of the same UIC, and are more alike than members of other UICs. By accounting for this hierarchical structure, we accounted for UIC-specific differences in salary when drawing inference about salary growth.

To implement the model, we employed an iterative sampling approach. First, we reduced the sample of DoD S&E civilians to better reflect the characteristics of the SMART scholars. The summary of decisions is shown below, where we removed (1) all interns, (2) DoD S&E civilians with pay plans not represented by SMART scholars, (3) individuals with less than a bachelor's degree, (4) DoD S&E civilians with occupation bins not represented by SMART scholars, (5) part-time employees, (6) individuals older than 41, (7) observations at more than 5 years since hire date, and (8) retention SMART scholars. This left N = 60,031 DoD S&E civilians and N = 1,037 SMART recruitment scholars for subsequent models.

Model Building Procedure

In order to arrive at the best-fitting model, we drew a sample of DoD S&E civilians (N = 1,037) at random, balanced by education level. We combined these N = 1,037 individuals (N = 1,037) with our sample of SMART scholars (N = 1,037) to form a data set that we used for model building. We balanced both samples on education level, such that the proportion of individuals selected with bachelor's, master's, and doctoral degree matched the proportion of bachelor's, master's, and doctoral degrees among SMART recruitment scholars. At this point, we began with the simplest model to characterize change over time—an unconditional linear growth model. From this model, we added terms representing additional complexity. First, we established the functional form of the trajectory as quadratic, meaning that there is curvature in salary growth over time. Next, we allowed for individual variability in salary growth over time, such that individuals have different starting points and different rates of change over time. Next, we estimated a random effect of UIC, accounting for UIC-specific dependence in the data. Finally, we added predictors of starting point and rate of change over time (Table 37). Figure 64 describes the number of unique individuals remaining in the group of DoD S&E Civilians used as a comparison and SMART Scholars. Table 37 summarizes these steps, and notes the significant improvement in model fit in each subsequent model, beginning with the simplest model and ending with the most complex. We used restricted maximum likelihood for estimation.

Table 37. Model Characterization Steps

Model	Model degrees of freedom	Akaike information criterion (AIC)	Bayesian Information Criterion (BIC)	χ^2	Test degrees of freedom	p-value
Unconditional linear model	6	141423.0	141464.1	NA	NA	NA
Add quadratic term	7	141345.7	141393.6	79.31	1	<.001
Add random effect of intercept and slope	10	141027.9	141096.4	323.82	3	<.001
Add random effect of UIC	11	140630.5	140705.9	399.34	1	<.001
Add SMART as predictor of intercept and slope	14	140302.3	140398.2	334.23	3	<.001
Add age as a predictor of intercept	15	139399.6	139502.3	904.72	1	<.001
Add demographic predictors of intercept	30	139069.2	139274.7	360.37	15	<.001
Add demographic predictors of slope	35	138903.5	139143.2	175.70	5	<.001

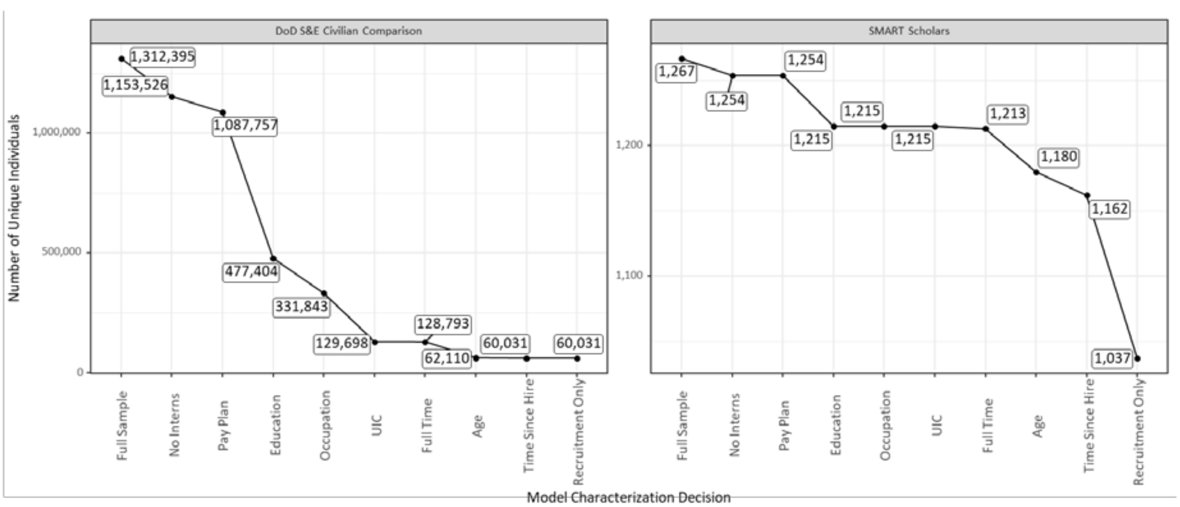


Figure 64. Model Characterization Decision by the Number of Unique Individuals

Findings

Across all education levels, we see that SMART recruitment scholars have lower starting salaries, controlling for age, sex, race, and occupation. This effect is more pronounced at the master's and doctoral levels. Though SMART recruitment scholars begin lower than their counterparts, they increase more rapidly over time. At the doctoral level, SMART scholars have not achieved parity with their counterparts 5 years post-hire (Table 38, Figure 65).

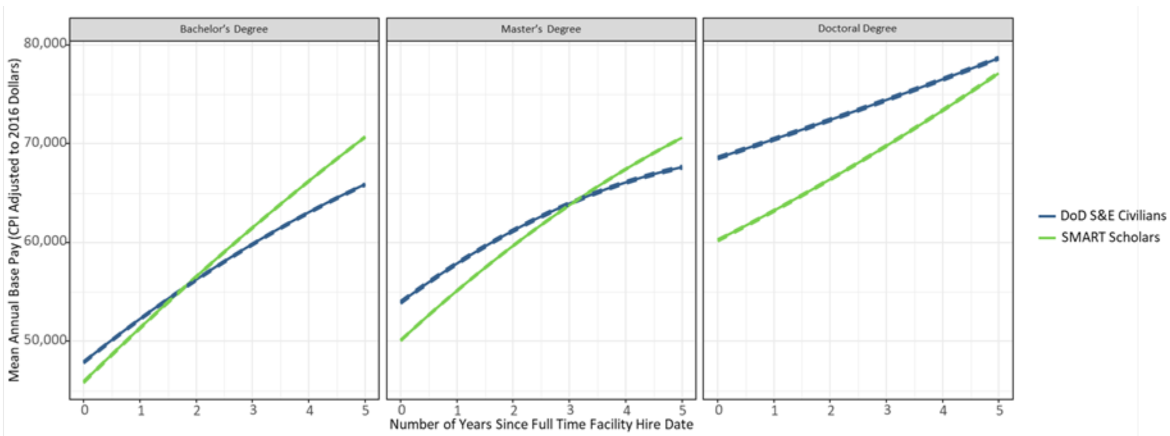
We generated these results using predicted values. In order to do so, we fit the model using 500 bootstrap samples. In this process, a sample of DoD S&E civilians (*N* = 1,037) is drawn iteratively, with replacement, from the sample of DoD S&E civilians (*N* = 60,031), and combined with the sample of SMART recruitment scholars (*N* = 1,037). We generate predicted values across 0–5 years since hire date, and set several covariates to a reference level (e.g., White, female, 26 years old at hire date, averaging across all occupation bins). With each of the 500 models, we generated model-predicted values for salary. The figure below depicts the predicted salary across these 500 bootstrapped samples. The table below contains the average coefficient for each model term across the 500 bootstrapped samples, as well as the lower 2.5th and upper 97.5th percentile.

Table 38. Model Predicted Salary Trajectories (2016 Dollars)

Model term	Average	2.5th percentile	97.5th percentile
Intercept	54,084.58	50,853.65	57,652.42
Time since hire (ref 0 = 2.5 years)	3,473.23	3,305.48	3,643.54
I(Time since hire^2)	-183.41	-240.60	-127.04
SMART	900.47	-45.74	1,855.94
Age at hire (ref 0 = 26)	1,371.68	1,292.99	1,459.96
Master's (ref = Bachelor's)	4,400.81	2,711.06	6,106.31
PhD (ref = Bachelor's)	12,419.38	10,332.50	14,556.21
Female	-739.14	-1,565.53	42.08
White	99.00	-1,039.95	1,362.81
African American	-1,284.39	-2,793.57	589.41
Asian	-830.64	-1,908.18	207.50
Occupation—Education (ref = Bio Sciences)	18,856.89	10,551.71	27,747.48
Occupation—Engineering	8,064.63	4,598.50	11,061.33
Occupation—Information Technology	3,538.36	-1,008.70	7,633.16
Occupation—Mathematical Sciences	6,801.47	3,266.88	9,863.94
Occupation—Medical Public Health	3,748.35	-1,027.04	9,420.82
Occupation—Physical Sciences	4,660.60	950.60	7,630.09
Occupation—Social Science	4,680.03	308.60	8,493.39
Time since hire * SMART	1,241.13	1,096.73	1,381.05
I(Time since hire^2) * SMART	52.54	5.25	100.42
Master's * SMART	-1,987.73	-3,674.26	-318.29
PhD * SMART	-5,408.15	-7,520.56	-3,377.23

Model term	Average	2.5th percentile	97.5th percentile
Time since hire * Female	-22.45	-211.29	178.48
Time since hire * Master's	-812.70	-996.90	-655.15
Time since hire * PhD	-1,448.01	-1,653.15	-1,264.31
I(Time since hire^2) * Master's	-104.71	-173.21	-34.39
I(Time since hire^2) * PhD	227.75	156.95	297.57

Note: p < 0.05 *; p < 0.01 **; p < 0.001 ***



Note: Across N = 500 bootstrapped samples. Shows White females, pooling across occupation bin.

Figure 65. Model Predicted Trajectories, Ensembles, across Bootstrapped Samples

Model Diagnostics

The residual structure is symmetric, with deviation from a normal distribution at the tails. Specifically, the residuals are slightly heavy-tailed relative to the normal distribution as described in the quantile-quantile plot in Figure 66. The residual by fitted plot does not reveal any problematic outliers, nonlinearity, or heteroscedasticity across the range of predicted salary (Figure 67).

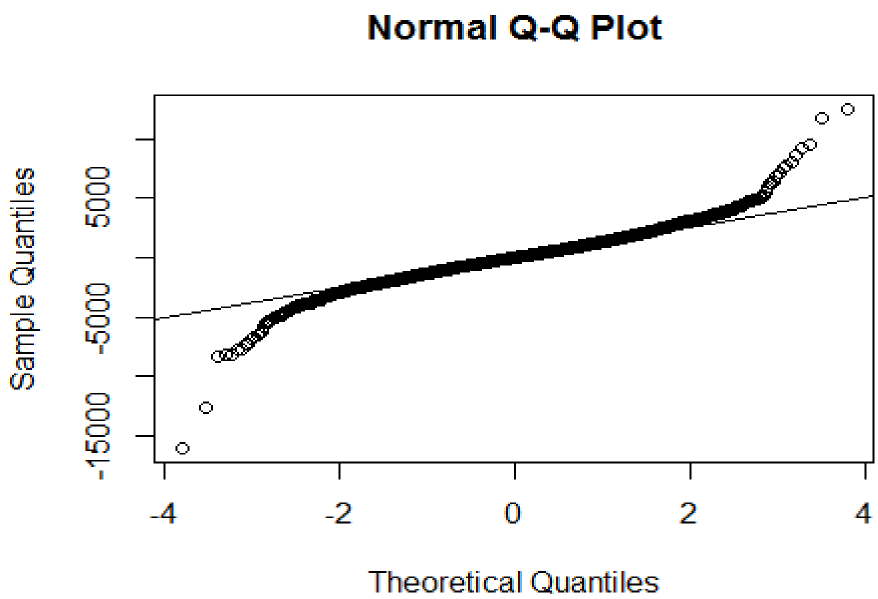


Figure 66. Normal Q-Q Plot

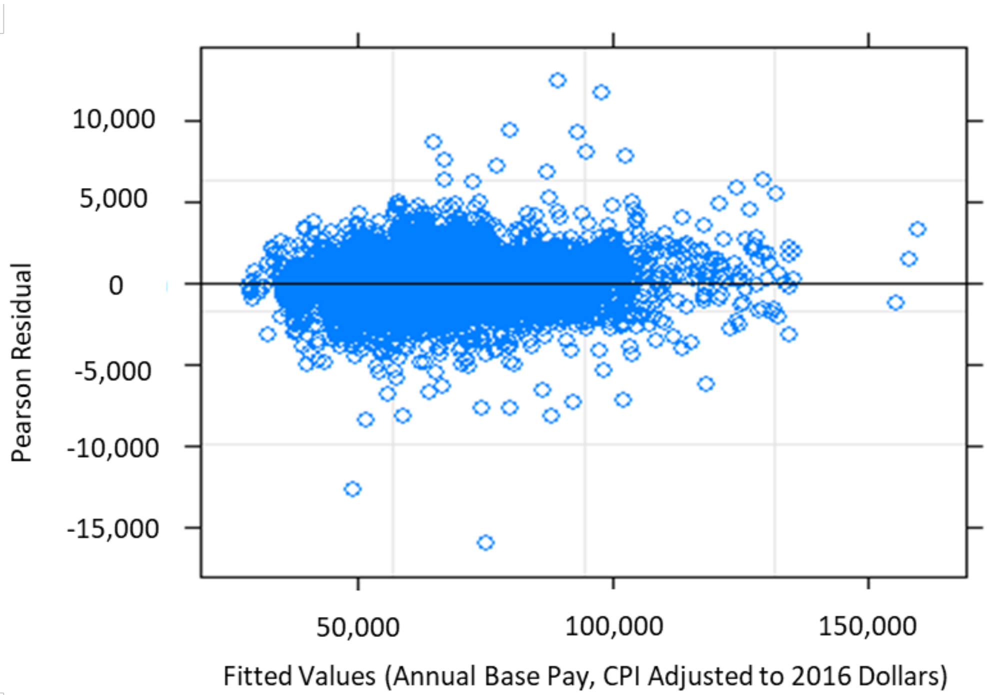


Figure 67. Pearson Residuals

Retention Scholars

Assumptions and Sample

Retention scholars offer the unique opportunity to model their time in the SMART program as a before-and-after treatment. A natural model for this setting is a Difference in Differences (DID) regression (NBER 2007). DID regressions attempt to model the difference in the change in an outcome between a treatment and control group after a treatment. In this regression, we were interested in modelling percent change in salary before and after the SMART program for both the SMART scholars and their matched pairs. We sampled from our retention scholar and comparison group pairs who both have at least 2 years of data before and after their scholar's program started, and do not have a PhD before the SMART program (N SMART = 52; N Comparison Group = 52).

Using a DID regression requires certain assumptions to be met (Columbia University). These assumptions are:

- **Spillover**: Effect of treatment on treatment group does not impact control group.
- **Treatment Assignment**: Being in the treatment group is not related to past values of the outcome.
- **Parallel Trends**: Trends in the outcome variable for the treatment and control group are parallel before treatment.

The spillover assumption and treatment assignment assumption cannot be empirically tested. First, we do not believe that there is any spillover in the effect of being a SMART scholar, i.e., one individual completing the SMART program does not affect their comparison group pair's percent change in salary. However, there may be circumstances where this is not the case—after a SMART scholar finishes the program, they may positively or negatively influence other employees in a highly collaborative environment, which in turn could affect their percent change in salary. Second, although we cannot test the treatment assignment assumption, we do not believe that being a SMART retention scholar is related to past percent change in salary. Although, again, there may be circumstances where a DoD S&E civilian has a low percent change in salary, and may view the SMART program as a way to increase their salary faster in the future.

The parallel trends assumption can be measured empirically. We visually inspected the parallel trends assumption prior to the SMART program (Figure 68). We want the trends in percent change in salary to be the same so that any effect after the SMART program can be attributed to the program and not a latent difference between the two groups. Because of the different start times for civilians in the data and the different timings of the SMART program for scholars, we could not look at the trend in percent change in salary at every point in time. Instead, we took the average percent change in salary for the first year in the data and the average percent change in salary for the year when the SMART program starts.[44] Connecting these two averages gives us a straight-line approximation of any trends for these two groups. The parallel trends assumption does not seem to hold for this dataset. We can assume that our results therefore have some bias, although we believe they are still a good start in examining the effect of the SMART program on retention scholars and their salary trajectory.

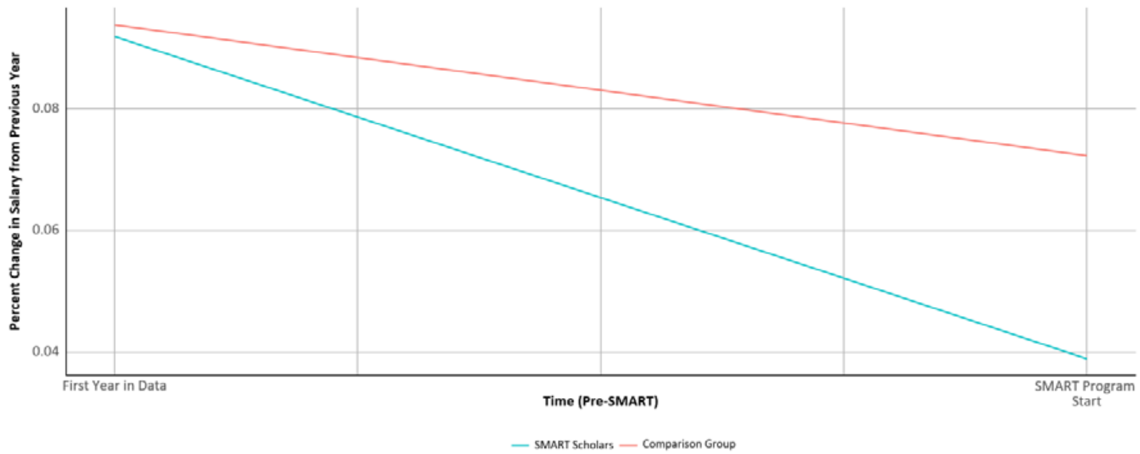


Figure 68. Parallel Trends Assumption

The summary tables of the variables used in the regression indicate a similar distribution to the original matched dataset for most variables (Tables 39–40). There does seem to be a higher proportion of individuals who are in the Navy in this sample compared to the full matched dataset (Appendix C). However, it is unclear if and how this would affect the results.

Table 39. Retention Scholar Percent Salary Regression Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Age in 2018	37.5	6.55	26	34	36	39	63
First salary in data (in Thousands)	59.2	18.7	18.54	46.69	58.59	71.57	108.05

Note: Data includes both SMART retention scholars and their comparison group.

44 For the comparison group, the year in which they started the SMART program is considered to be their start year plus the number of years between when their SMART match started the data.

Table 40. Retention Scholar Percent Salary Regression Categorical Variable Summary

Variable	Value	% of Sample
Ethnicity	Hispanic	5%
	Not Hispanic	79%
	Unknown	15%
Occupation Bin	Biological Sciences	2%
	Engineering	76%
	General Administration	2%
	Information Technology	2%
	Mathematical Sciences	8%
	Physical Sciences	7%
	Social Sciences & Psychology	2%
Service	Air Force	25%
	Army	22%
	Other DoD	2%
	Navy	51%
Sex	Female	23%
	Male	77%
Race	African-American	2%
	White	73%
	Asian	4%
	American Indian	1%
	Unknown	22%

Note: Data includes both SMART retention scholars and their comparison group.

<u>Findings</u>

The regression results indicate that there is no difference in percent change in salary for retention scholars (i.e., the *DID SMART Scholar* is not statistically significant) (Table 41). Although other variables are listed as significant in Table 41, the only variable of interest is DID SMART Scholar.

Table 41. Retention Scholar and Comparison Group DID Regression Results

	Coefficient (Std. Error)
Constant	0.10** (0.03)
DID SMART Scholar	-0.02 (0.02)
SMART Scholar	0.01 (0.01)
Post SMART Program Years	-0.02 (0.02)
3rd Year in Data	-0.01 (0.01)

Coefficient (Std. Error)	
4th Year in Data	-0.002 (0.01)
5th Year in Data	-0.04*** (0.01)
6th Year in Data	-0.06*** (0.01)
7th Year in Data	-0.07*** (0.01)
8th Year in Data	-0.07*** (0.02)
9th Year in Data	-0.06*** (0.01)
Starting Salary (in Thousands)	-0.002*** (0.001)
Service-Army	0.03 (0.03)
Service-Other DoD	0.01 (0.02)
Service-Navy	0.003 (0.01)
Sex-M	-0.003 (0.01)
Race-American Indian	0.09 (0.17)
Race-White	-0.01 (0.01)
Race-Asian	-0.03 (0.02)
Race-African American	-0.03 (0.03)
Ethnicity-Not Hispanic	0.01 (0.02)
Ethnicity-Unknown	0.01 (0.02)
Occupation Bin-Engineering	0.06 (0.04)
Occupation Bin-General Administration	0.04 (0.03)
Occupation Bin-Information Technology	0.02 (0.02)
Occupation Bin-Mathematical Sciences	0.06 (0.04)
Occupation Bin-Physical Sciences	0.02 (0.02)
Occupation Bin-Social Sciences and Psychology	0.08 (0.05)
Age in 2018	0.001 (0.001)
Observations	777
R^2	0.17
Adjusted R^2	0.14
Residual Std. Error	0.11 (df = 748)

Note: p < 0.05 *; p < 0.01 **; p < 0.001 ***

Model Diagnostics

The regression diagnostics indicate that the residuals are approximately normally distributed (normal q-q plot) (Figure 69). There does seem to be a pattern in the residuals versus fitted plot, indicating there are some relationships we were not fully accounting for in our model. Heteroscedasticity is present, but we use robust standard errors with all of the significance tests for unbiased standard errors.

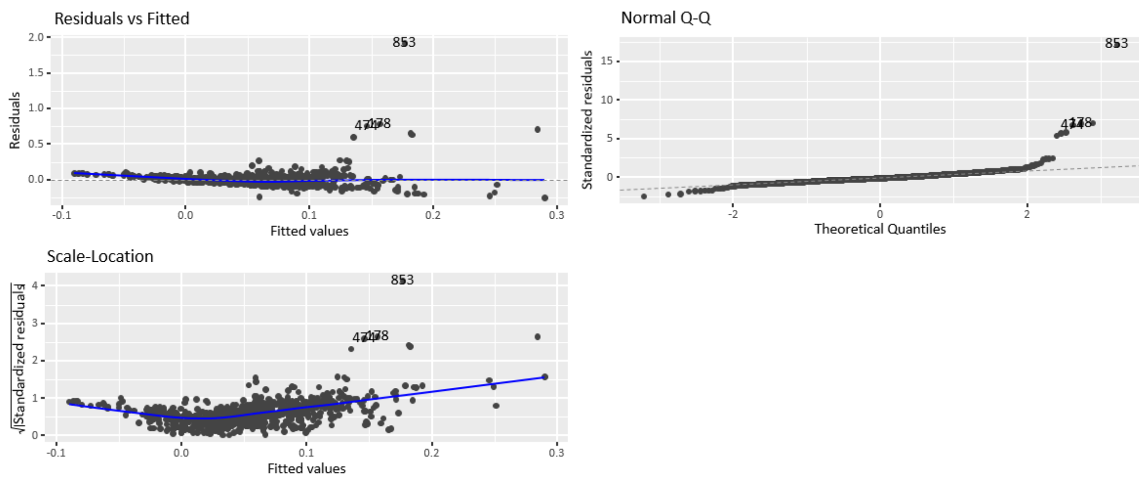


Figure 69. Retention Scholar and Comparison Group DID Regression Diagnostics

Promotion Rate

Promotion Rate Definition

We defined promotion rate on an individual level using the expected progression along the GS classification and pay system (U.S. Office of Personnel Management [OPM]). Given an employee's expected progression through the GS payment plan, we can calculate how many times an individual progresses faster than expected. The expected progression is constantly readjusted to the last promotion and expected progression is always assumed to end at step 12 for any grade. In this way, we can calculate a promotion rate for each individual: the number of times an employee progresses faster than expected divided by the amount of times the employee can progress (the number of years employed minus 1).

$$promotion\ rate_i = \frac{n_{promotions,i}}{n_{years,i} - 1}$$

It is important to note that this rate does not include information on the magnitude of the difference from expected.

Logistic Regression

Logistic regression is a technique used to estimate the effects of independent variables on a dichotomous outcome—an outcome between 0 and 1. In our analysis, the outcome is promotion rate, a value that is bounded by 0 and 1. For logistic regression to estimate these effects in an unbiased and consistent manner, the following assumptions must be met:

- **Logit Linearity**: The independent variables are linear with respect to the logit transformation of the outcome.

- **No Multicollinearity**: The independent variables cannot predict each other accurately.
- **Exogeneity**: The residuals are independent of any independent variable.

Additionally, a logistic regression is just one way to link independent variables to our dependent variable. To make sure this link is the correct one, we test each model with a link test that checks if the square of predicted values from the regression is a statistically significant variable when used as a predictor in the same regression (Hinkley 1985).

Recruitment Scholars

Assumptions and Sample

We modeled promotion rate with a weighted logistic regression, where the weights correspond to the number of years in the data for each individual (to mediate the effect of employees being in the data for differing lengths of time). Our final sample for this regression is all individuals in our matched dataset who are on the GS pay scale (*N* SMART = 515; *N* Comparison Group = 458). The other remaining 58 percent of the comparison group and 51 percent of the SMART scholars are on different, inconsistent pay plans that are impossible to consolidate with the GS pay scale analysis. Starting grade-step, degree level, race, ethnicity, sex, service, occupation bin, and age in 2018 are included in the model as variables and are used to control for factors that might impact our variable of interest, SMART scholar status, and our outcome, promotion rate. A squared form of starting grade-step is included to account for the nonlinear relationship between starting grade-step and promotion rate.

The summary tables of the variables used in the regression (Tables 42, Table 43) indicate a similar distribution to the original matched dataset for most variables. There does seem to be a lower proportion of PhDs on the GS pay scale (7 percent compared to 21 percent) in this sample compared to the full matched data (Table 42, Table 43).

Table 42. Recruitment Scholar Promotion Rate Regression Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Age in 2018	31.6	7.23	24	27	30	33	75
Promotion Rate	0.57	0.42	0	0	0.67	1	1
Starting Grade-Step	8.25	2.46	1	7	7.3	9.2	15.5

Note: Data includes both SMART recruitment scholars and their comparison group.

Table 43. Recruitment Scholar Promotion Rate Regression Categorical Variable Summary

Variable	Value	% in Sample
Degree Level	Bachelor's	64%
	Master's	29%
	PhD	7%
Ethnicity	Hispanic	2%
	Not Hispanic	96%
	Unknown	1%
Occupation Bin	Biological Sciences	1%
	Engineering	71%
	General Administration	2%
	Information Technology	18%
	Mathematical Sciences	1%
	Physical Sciences	7%
	Social Sciences & Psychology	1%
Service	Air Force	36%
	Army	48%
	Other DoD	1%
	Navy	15%
Sex	Female	28%
	Male	72%
Race	African-American	3%
	White	92%
	Asian	3%
	American Indian	1%
	Unknown	3%

Note: Data includes both SMART recruitment scholars and their comparison group.

Findings

The regression results indicate that SMART scholars have statistically significant higher odds of being promoted every year compared their counterparts, controlling for everything else (Table 44). Additionally, six other variables are found to be statistically significant. The following variables are associated with higher odds of being promoted every year for both SMART scholars and their comparison group, when controlling for everything else:

- Lower starting grade-step
- Female civilian employees

- Engineering; Mathematical Sciences; and Medical, Dental, and Public Health occupations compared to the Biological Sciences occupation
- Air Force civilian employees compared to Army civilian employees

Table 44. Recruitment Scholar Promotion Rate Regression Results

	Odds Ratio (Std. Error)
Constant	1.32 (1.15)
SMART Scholar	2.05*** (0.37)
Starting Grade-Step	0.79*** (0.01)
Starting Grade-Step Squared	0.98*** (0.01)
Degree Level-Master’s	0.88 (0.08)
Degree Level-PhD	1.10 (0.26)
Race-African American	0.83 (0.25)
Race-American Indian	1.97 (2.11)
Race-White	0.91 (0.27)
Race-Asian	0.90 (0.29)
Ethnicity-Hispanic	0.62 (0.14)
Ethnicity-Unknown	0.57 (0.15)
Sex-M	0.79* (0.06)
Service-Navy	1.22 (0.18)
Service-Air Force	1.28* (0.16)
Service-Other DoD	1.93 (1.54)
Occupation Bin-Engineering	3.04* (4.68)
Occupation Bin-Information Technology	1.83 (1.95)
Occupation Bin-Mathematical Sciences	4.06** (8.48)
Occupation Bin-Medical, Dental, and Public Health	9.61** (73.16)
Occupation Bin-Physical Sciences	2.30 (2.70)
Occupation Bin-Social Sciences and Psychology	1.87 (2.63)
Age in 2018	0.97*** (0.01)
Observations	973
Log Likelihood	-1,073.79
Akaike Inf. Crit.	2,193.57

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

This regression passed the link test, indicating that the logistic form for the model is appropriate. The starting grade-step variable was mean-centered in the regression to account for the multicollinearity present between it and its squared term. Therefore, the only multicollinearity present in the model is related to the race variables (as reported in Appendix C). There are a few outliers in the dataset, as seen in the Cook's distance plot. However, there is no clear indication that these are mistaken observations and so we do not exclude them. Removing these observations does not change the interpretation of these results.

Retention Scholars

Assumptions and Sample

We modeled promotion rate with a weighted logistic regression, where the weights correspond to the number of years in the data for each individual (to mediate the effect of employees being in the data for differing lengths of time). Our final sample for this regression is all individuals in our matched dataset who are on the GS pay scale (*N* SMART = 42; *N* Comparison Group = 52). As with recruitment scholars, the other remaining 62 percent of the comparison group and 63 percent of the SMART scholars are on different, inconsistent pay plans that are impossible to consolidate with the GS pay scale analysis. First grade-step in data, degree level, race, ethnicity, sex, service, occupation bin, and age in 2018 are included as variables in the model and are used to control for factors that might impact our variable of interest, SMART scholar status, and our outcome, promotion rate. Because retention scholars may have potentially started employment before 2006 (our first year of data), we replaced starting grade-step with our best approximation, first grade-step in data. A squared form of the age variable is included to account for the nonlinear relationship between age and promotion rate. We mean centered the age variable to account for collinearity between it and its square.

We do not include the years a SMART scholar was in Phase I in the calculation of the promotion rate. Retention scholars are fulltime students during this time, and we would expect that they would be promoted very little if at all. This approach leads to additional portions of the sample being filtered out. We remove retention scholars who were promoted during Phase I (9 scholars), retention scholars who are in the data as GS employees for fewer years than their Phase I duration (3 scholars), and one PhD scholar from this subset.[45]

The summary tables of the variables used in the regression indicate a different distribution to the original matched dataset for some variables. We do not have any African Americans in our sample, and the proportion of Army employees is higher than in the full matched data (Table 45, Table 46).

[45] We redid our analysis without removing these scholars and no coefficients changed sign or significance.

Table 45. Retention Scholar Promotion Rate Regression Numeric Variable Summary

Variable	Mean	Standard Deviation	Min	25th Percentile	Median	75th Percentile	Max
Age in 2018	38.01	8.83	28	33	36	40	81
Starting Grade-Step	8.81	3.13	2	7	9	11.85	14.4

Note: Data includes both SMART retention scholars and their comparison group.

Table 46. Retention Scholar Promotion Rate Regression Categorical Variable Summary

Variable	Value	% in Sample
Degree Level	Bachelor's	85%
	Master's	15%
Ethnicity	Hispanic	1%
	Not Hispanic	83%
	Unknown	16%
Occupation Bin	Biological Sciences	2%
	Engineering	73%
	General Administration	2%
	Information Technology	2%
	Mathematical Sciences	5%
	Physical Sciences	12%
	Social Sciences & Psychology	3%
Service	Air Force	28%
	Army	44%
	Other DoD	4%
	Navy	24%
Sex	Female	29%
	Male	71%
Race	African-American	0%
	White	79%
	Asian	3%
	American Indian	1%
	Unknown	18%

Note: Data includes both SMART retention scholars and their comparison group.

Findings

The regression results indicate there is not a difference in promotion rate between SMART scholars and their comparison group, controlling for everything else (Table 47. Retention Scholar Promotion Rate Regression Results). Four variables are statistically significant. The following variables are associated with higher odds of being promoted every year for both SMART scholars and their comparison group, when controlling for everything else:

- Lower starting grade-step
- Non-Hispanic employees compared to Unknown ethnicity employees
- Biological Sciences occupation compared to General Administration
- Younger employees

Table 47. Retention Scholar Promotion Rate Regression Results

	Odds Ratio (Std. Error)
Constant	16.15* (350.01)
SMART Scholar	1.15 (0.26)
Starting Grade-Step	0.81*** (0.03)
Degree Level-Master's	1.85 (1.14)
Race-American Indian	0.25 (0.10)
Race-White	0.27 (0.08)
Race-Asian	0.21 (0.04)
Ethnicity-Hispanic	0.16 (0.03)
Ethnicity-Unknown	0.09* (0.01)
Sex-M	1.60 (0.62)
Service-Navy	1.16 (0.36)
Service-Air Force	1.63 (0.85)
Service-Other DoD	3.00 (5.19)
Occupation Bin-Engineering	0.67 (0.28)
Occupation Bin-General Administration	0.19* (0.03)
Occupation Bin-Information Technology	1.88 (3.30)
Occupation Bin-Mathematical Sciences	1.54 (2.08)
Occupation Bin-Physical Sciences	0.92 (0.57)
Occupation Bin-Social Sciences and Psychology	0.54 (0.26)
Age in 2018	0.94* (0.03)
Age in 2018 (Squared)	1.00 (0.001)
Observations	94
Akaike Inf. Crit.	338.61
Log Likelihood	-148.31

Note: $p < 0.05$ *; $p < 0.01$ **; $p < 0.001$ ***

Model Diagnostics

This regression passed the link test, indicating that the logistic form for the model is appropriate. The age variable was mean centered in the regression to account for multicollinearity present between it and its squared term, and so the only multicollinearity present is with the race variables referenced in Appendix C. There are a few outliers in the dataset, as seen in the Cook's distance plot, however there is no clear indication that these are mistaken observations and so we do not exclude them.

Illustrations

Figures

Tables

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Abbreviations

ACC	Air Combat Command
AFLCMC	Air Force Life Cycle Management Center
AFMC	Air Force Materiel Command
AFNWC	Air Force Nuclear Weapons Center
AFRL	Air Force Research Laboratory
AFSC	Air Force Sustainment Center
AFSPC	Air Force Space Command
AFTC	Air Force Test Center
AMC	Air Mobility Command
AMC	U.S. Army Materiel Command
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
ATEC	U.S. Army Test and Evaluation Command
BS	Bachelor of Science (degree)
CAGR	Cumulative Average Growth Rate
CAO	component administrating office
DID	Difference in Differences
DLE	Defense Laboratory Enterprise
DMDC	Defense Manpower Data Center
DoD	Department of Defense
DoDI	Department of Defense Instruction
FFRDC	Federally Funded Research and Development Center
FWCI	field-weighted citation impact
FY	Fiscal Year
GPA	grade point average
GS	General Schedule
GVIF	generalized variance inflation factor
HBCU	Historically Black Colleges and University
HR	human resources
IDA	Institute for Defense Analyses
IPEDS	Integrated Postsecondary Education Data System
LUCI	Laboratory University Collaboration Initiative
MCSC	Marine Corps Systems Command
MIs	Minority-Serving Institutions
MEDCOM	U.S. Army Medical Command
MS	Master of science (degree)
NAVAIR	Naval Air Systems Command
NAVSEA	Naval Sea Systems Command
NCES	National Center for Education Statistics
NDAA	National Defense Authorization Act

NRL	Naval Research Laboratory
NSF	National Science Foundation
OPM	Office of Personnel Management
PhD	doctor of philosophy (degree)
PIs	Principal Investigators
POC	point of contact
R&D	research and development
RDECOM	U.S. Army Research, Development and Engineering Command
ROTC	Reserve Officers Training Corps
S&E	science and engineering
SFS	scholarship-for-service
SMART	Science, Mathematics, and Research for Transformation
SPAWAR	Space and Naval Warfare Systems Command
STEM	science technology, engineering, and mathematics
TRADOC	U.S. Army Training and Doctrine Command
UIC	unit identification code
URM	underrepresented minority
USACE	United States Army Corps of Engineers
USASMDC	U.S. Army Space and Missile Defense Command
VBFF	Vannevar Bush Faculty Fellowship

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14. ABSTRACT

The Science, Mathematics, and Research for Transformation (SMART) scholarship for service program provides scholars with internships to prepare them to enter the Department of Defense (DoD) Science and Engineering (S&E) workforce. The program supports two types of individuals: recruitment and retention scholars. Recruitment scholars are students who are pursuing a degree and are not DoD civilian employees. Retention scholars are current DoD civilian S&E employees who have received the scholarship in support of an additional degree. All scholars intern at DoD sponsoring facilities within the Army, Navy, Air Force, or within another DoD agency while pursuing their degree. Upon degree completion, scholars serve out their scholarship service commitment at a DoD sponsoring facility. Between 2006 and 2016, the SMART program awarded 2,021 scholarships. IDA conducted an evaluation to understand how the program's goals are achieved (process evaluation) and the impact of the program (outcome evaluation) from inception in 2006 through the 2015–2016 academic year.

15. SUBJECT TERMS

Science, Mathematics, and Research for Transformation (SMART); Scholarship for Service (SFS); Defense Manpower Data Center (DMDC); recruitment scholars; retention scholars; science, technology, engineering, and mathematics (STEM)

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