Emerging Frontiers in Research and Innovation

Outcome Monitoring System

Final Report

Authors
Catharine Warner-Griffin
Stéphane Baldi
Meg Trucano
Amber Noel

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National Science Foundation
Office of Emerging Frontiers in Research and Innovation
4201 Wilson Boulevard
Arlington, VA 22231

Project Officer
Grace Yuan

Submitted by
Insight Policy Research, Inc.
1901 North Moore Street
Suite 1100
Arlington, VA 22209

Project Director
Stéphane Baldi

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TABLE OF CONTENTS

CHAPTER **PAGE**

EXECUTIVE SUMMARY ..... **I**

SURVEY PROCESS FINDINGS I
PILOT SURVEY RESULTS II

I. INTRODUCTION **1**

II. METHODOLOGY **2**

A. OVERVIEW 2
B. PHASE 1: MODEL ASSESSMENT 2
C. PHASE 2: COGNITIVE INTERVIEWS 3
D. PHASE 3: PILOT SURVEYS 4

III. SURVEY PROCESS FINDINGS **7**

A. MINIMIZE RESPONDENT BURDEN 7
B. CLARIFY KEY SURVEY GOALS AND IDENTIFY THE MOST KNOWLEDGEABLE RESPONDENT 9

IV. PILOT SURVEY RESULTS **11**

A. RESPONSE RATES, SAMPLE CHARACTERISTICS, SURVEY BURDEN, AND ITEM NONRESPONSE 11
B. PILOT SURVEY FINDINGS 16

V. SUMMARY AND CONCLUSION **31**

REFERENCES **33**

APPENDIX A. NSF'S EFRI PRELIMINARY QUESTIONNAIRE **A-1**

APPENDIX B. ONLINE SURVEY EMAILS **B-1**

A. INVITATION EMAILS B-1
B. FIRST REMINDER EMAILS B-2
C. FINAL REMINDER EMAILS B-3
D. THANK-YOU EMAILS B-4

APPENDIX C. ITEM NONRESPONSE **C-1**

LIST OF TABLES

Table III.1. Number and Percentage of Pilot Respondents by Respondent Type 11
Table III.2. Abbreviation, Fiscal Year, and Title for EFRI Award Topics 12
Table III.3. Response Bias Across Key Grant Characteristics by Survey Respondent 13
Table III.4. Company Partnerships and New Research Products by Grant Status 18
Table III.5. Research Products and Company Partnerships by Grant Duration 19
Table III.6. Research Products and Company Partnerships by Grant Topic 20
Table III.7. Accomplishments and Collaboration by Grant Status 23
Table III.8. Accomplishments and Collaboration by Grant Status 23
Table III.9. Accomplishments and Collaboration by Grant Duration 24
Table III.10. Accomplishments and Collaboration by Grant Topic 25
Table III.11. EFRI Student Successes and Curricular Changes by Grant Status 28
Table III.12. EFRI Student Successes and Curricular Changes by Grant Duration 29
Table III.13. EFRI Student Successes and Curricular Changes by Grant Topic 30
Table III.14. EFRI Student Interest in Career Pathways 31

EXECUTIVE SUMMARY

The National Science Foundation's (NSF) Emerging Frontiers in Research and Innovation (EFRI) program offers grant funding to projects that support interdisciplinary, cutting-edge engineering research at academic institutions. The purpose of this study was to refine and launch an online pilot survey that would track key long-term outcomes and accomplishments not captured through other NSF data collection efforts. The purpose of this report is to address two key study goals:

1. Provide process recommendations on survey methodology that can be applied to future EFRI survey efforts and other NSF programs.
2. Provide preliminary data and analysis from an online survey pilot of EFRI grantees and students.

The study team conducted this project in three phases:

1. An assessment of the program goals and logic model
2. Cognitive interviews with NSF program directors, EFRI principal investigators (PIs), and EFRI students
3. Data collection and analysis of three online surveys

Several key findings related to survey process and data analysis results from the pilot survey appear below.

SURVEY PROCESS FINDINGS

The methodology developed for the pilot survey improves survey response rates and provides flexibility for adaptation to additional NSF survey initiatives. The following results from our findings in phases 1 and 2 of the project relate to creating survey questions and content.

Test the instrument

- Test an instrument with PIs (or the relevant respondents) to identify areas needing improvement. Even interviews with just one or two PIs would provide improvements to question phrasing and organization.

Specify survey goals

- Give clear instructions to respondents about the goals of the data collection effort.
- Give respondents examples of how the data will be used and assure them of confidentiality.
- Organize survey questions within specific content areas so respondents understand what information is needed.

Minimize respondent burden

- Use skip logic to allow respondents to bypass follow-up questions not pertinent to their individual experiences. This will increase response rates and improve the accuracy of the data collected.
- Prepopulate fields (as originally suggested by NSF's Engineering Evaluation and Assessment team) and focus questions only on knowledge respondents have readily available. This will reduce the time required to complete a survey and the need to seek additional information, thus reducing item nonresponse rates.
- Limit the survey's length to 30 minutes or less. Respondents will be more likely to complete the survey if it requires minimal time and effort to respond.

PILOT SURVEY RESULTS

Insight fielded three online surveys of EFRI grant recipients (PIs, co-PIs, and students). The excellent response rates for the surveys indicated the EFRI grantees' willingness to provide information on individual and grant-related long-term successes. The response rates were 70 percent for the PI survey, 45 percent for the co-PI survey, and 48 percent for the student survey.

A nonresponse bias analysis illustrated that the sample reflected characteristics of the EFRI population, though there were fewer PIs with closed grants compared to the population, and participation rates decreased as grant duration[1] (i.e., time elapsed since the grant was awarded) increased. The survey also failed to capture any grantees with COPN— Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology—an EFRI grant topic only four individuals received.

Following are key findings of the surveys for three survey topic areas: (1) company partnerships and research products, (2) grantee accomplishments and collaboration, and (3) EFRI student trajectories and curricular changes. Co-PIs answered a supplemental questionnaire that included 13 questions also on the PI survey. These questions focused on accomplishments and collaboration in addition to basic grant information.

Company partnerships and research products. More than 77 percent of PIs have begun partnership discussions, and this percentage was higher for those with closed grants, at 81 percent. Approximately half of the PIs engaged in some licensing activity, with one in four (27 percent) reporting they are in the planning stages of licensing efforts. Almost 60 percent of PIs reported the research community had used products (i.e., outputs) related to their EFRI research, with most of these products (48 percent) involving a new technique or method.

Grantee accomplishments and collaboration. Almost 45 percent of PIs reported generating additional funding related to their EFRI grant topic. The PIs reported funding averaging $1.9M per grant, with a minimum of $5,500 and a maximum of $25M. Almost twice as many PIs with closed grants reported the generation of additional funding compared to those with active grants, with 62 and 38 percent reporting additional funding, respectively. Among co-PIs, 26 percent reported the generation of additional funding. Again, almost twice as many co-PIs with closed grants reported receiving additional funding

[1] In this report, "grant duration" refers to the number of years that have elapsed since the original grant award. Grant duration encompasses both open and closed EFRI grants.

compared to those with open grants (38 and 21 percent, respectively). On average, PIs valued the contribution the EFRI grant had on their accomplishments, rating it an average of almost 4 on a 5-point scale, where 1 = Did Not Contribute at All and 5 = Contributed Significantly.

Student trajectories and curricular changes. PIs reported an average of four students working in labs of different disciplines, and an average of two students working in labs outside their home institution. PIs with closed grants reported a higher average number of students working in interdisciplinary arrangements. The majority of PIs responded that their students had become research scientists (89 percent), had postdoctoral positions (81 percent), or had tenure-track positions (74 percent). On the student survey, most students indicated that after completing their EFRI research, they would be more interested in pursuing nonacademic research careers (78 percent) or faculty positions at research-intensive universities (67 percent) than in pursuing faculty positions at teaching-intensive institutions (40 percent) or working in nonresearch careers (46 percent). Finally, approximately two thirds of PIs said they planned to provide supplements to existing courses, while fewer than 10 percent noted plans to create a new program or professional development materials. Of PIs with active grants, 100 percent reported they had not planned any curricular changes.

I. INTRODUCTION

The National Science Foundation's (NSF) Emerging Frontiers in Research and Innovation (EFRI) program supports cutting-edge research projects that aim to develop new, interdisciplinary frontiers with a goal of promoting innovation in engineering research and education. Since its inception in 2008, EFRI has solicited proposals from grantees across diverse topic areas based on national needs and priorities. To date, EFRI has funded approximately 115 awards in 14 different topic areas to principal investigators (PIs) at research institutions across the country. The projects funded often result in new techniques, methods, and models in engineering research that can benefit populations outside the field of engineering.

EFRI grantees are required to submit annual reports (Research Performance Progress Reports or RPPRs) as part of their grant award. However, to capture long-term outcomes and other important grantee information that extends beyond the life of an EFRI grant, NSF's Engineering Evaluation and Assessment team is designing and piloting a new EFRI program outcome monitoring system. The data are needed for effective administration, program monitoring and evaluation, and measuring attainment of NSF's strategic goals as identified by the President's Accountable Government Initiative, the Government Performance and Results Act Modernization Act of 2010, and NSF's Strategic Plan. NSF will use the information from this system to respond to queries from Congress, the public, NSF's external merit reviewers who serve as advisors (including the Committees of Visitors), and NSF's Office of the Inspector General. The information will also support the management and continuous improvement of the program.

To develop the EFRI outcome monitoring system, NSF first designed a logic model that incorporated several key indicators for the identified outcomes. Following this logic model design, NSF developed a preliminary questionnaire to collect data not captured in the standard NSF RPPR. At the start of this development process, a survey for PIs and their students represented the entirety of the EFRI program outcome monitoring system. As the effort evolved, the outcome monitoring system expanded to include a survey for co-PIs. Moving forward, the EFRI program plans to implement an ongoing outcome monitoring system based on the results of this field test.

The goals of this study by Insight Policy Research (Insight) were to (1) provide recommendations for best practices in fielding a new survey to grantees that can apply to subsequent EFRI and Directorate for Engineering data collection efforts; and (2) pilot, edit, and analyze results from the new survey.

ORGANIZATION OF THIS REPORT

The remainder of this report presents results and recommendations from the pilot test of the new survey instruments designed for the EFRI outcome monitoring system. Chapter II presents an overview of the study methods used to conduct the research. Chapter III illustrates the key findings, including recommendations and results. Chapter IV integrates the findings from analyses in previous chapters to discuss conclusions. Three appendices provide additional detail on the data sources and collection methods. Appendix A includes the original questionnaire developed by NSF for PIs and students. Appendix B includes all the email correspondence with PIs and co-PIs to encourage participation in the survey. Appendix C illustrates item nonresponse.

II. METHODOLOGY

A. OVERVIEW

To conduct an effective, comprehensive evaluation of the EFRI program's outcome monitoring system, the study team took a multipronged approach. The team designed the review to ensure a thorough, formative analysis of the system. The three phases of evaluation follow:

1. Model assessment: The study team conducted a thorough review and assessment of the existing NSF EFRI logic model and the preliminary version of the survey instrument to ensure all questions were accurate indicators of EFRI's long-term outcomes. The preliminary questionnaire provided by EFRI appears in appendix A.
2. Cognitive interviews: The study team conducted a series of in-person and cognitive interviews with NSF program directors, EFRI PIs, and students who had worked on EFRI research projects. In total, Insight conducted 18 cognitive interviews. The findings from these interviews informed the overall questionnaire design, the clarity of individual questions, and the data collection methods.
3. Pilot surveys: The study team collected data from EFRI grantees via the administration of three online survey instruments: one for PIs, one for co-PIs, and one for students who had worked on EFRI research projects. The team refined the surveys according to the phase 1 and phase 2 findings.

The methodology for each of these phases appears below.

B. PHASE 1: MODEL ASSESSMENT

The logic model indicates the resources, activities, and outputs necessary to achieve intended outcomes for the EFRI program. Prior to beginning cognitive interviews and pilot testing the EFRI program survey, Insight staff mapped the content of NSF's existing annual reports and the new program-monitoring questionnaire onto the EFRI program's logic model. During the process, Insight researchers assessed several factors:

- The key measures that could be used for each activity, output, and outcome in the program logic model
- Any duplication of questions in the new outcome monitoring system with the existing NSF RPPR requirements
- Any key outcomes that may lack a clear metric for tracking the accomplishment of the outcome or clear activities to produce the outcome

Through this process, it became easier to understand the extent to which the additional surveys would collect both new information about all EFRI grants and key long-term outcomes, especially of closed grants, that would improve measurement of the EFRI program's successes through the pilot outcome monitoring system. Following this step, the team revised the survey instrument and provided suggestions for logic model outcomes that can be difficult to measure through the use of questionnaires.

C. PHASE 2: COGNITIVE INTERVIEWS

1. NSF Program Directors

In September 2014, the study team conducted three in-person interviews with NSF program directors to ascertain the clarity and reliability of the preliminary EFRI PI survey instrument. Prior to these interviews, the study team made slight modifications to the wording of questions and the survey layout. These changes included moving the survey from PowerPoint to Word, reorganizing the survey to reflect key topic areas, and editing questions slightly to reflect a more closed-ended format.

To conduct the interviews, EFRI recommended several program directors who could offer feedback on the pilot instrument. Next, an email invitation from the EFRI Office requested program directors' participation in a review of the new PI monitoring system. Lastly, the study team scheduled in-person conversations to walk through the current survey protocol with program directors.

During interviews with three NSF program directors, the study team guided program directors through the survey, soliciting suggestions for improvement and identifying areas of potential redundancy. Following the walk-through of the survey instrument, respondents were asked general questions about the instrument's level of appropriateness for its target audience and about their own comprehension of the survey questions.

The study team sought suggestions from the program directors on three additional factors: (1) the survey's degree of overlap with existing EFRI reporting systems to assess potential burden for PI respondents, (2) their predictions of PI access to potential student respondents, and (3) their predictions of PI ability and willingness to provide information about co-PI accomplishments and grants. Based on the program directors' comments, the instrument was refined a second time. Finally, the analysts programmed the modified version into a web-based survey platform for self-administration by grantees.

2. EFRI PIs and Students

The study team conducted semistructured cognitive interviews with a sample of 11 NSF EFRI PIs and 4 students. The study team chose respondents using a sampling scheme to ensure representation across three key data characteristics of importance to the EFRI Office:

1. PIs with both active and closed grants
2. PIs with grants of varying duration
3. PIs with grants across a variety of EFRI's 14 topics

Because not all the sampled EFRI PIs would be able to participate, the study team also selected a replacement sample that included two additional sampling units with characteristics similar to the original. To increase the likelihood that PIs could accommodate the cognitive interviews in their schedule, the EFRI Office emailed all EFRI PIs, alerting them the study team might contact them regarding the program monitoring effort and informing of its importance to the EFRI program.

Prior to conducting the cognitive interviews, the study team created a cognitive interview protocol the PIs completed on the telephone following their completion of the online survey instrument. Staff used the cognitive interview protocol to capture instances when respondents indicated hesitation, confusion, or uncertainty by using the following codes for each question:

- HESITATE
- I DON'T KNOW
- SOURCE
- CLARIFY
- QUALIFY
- REPEAT

These codes enabled analysts to assess which questions needed further clarification. The cognitive interview protocol included several verbal prompts to obtain details about the meaning a respondent assigned to a key phrase or the accuracy of the response.

To begin, the team sent PIs and students a live survey link via email shortly before the interview began. If respondents gave verbal permission, Insight recorded the conversations for transcription. During the interview, the interviewer dictated each survey item and then asked PIs and students to consider the survey item itself (e.g., Is this question clear? What does this term mean to you?). Staff asked respondents to respond to the question verbally to get a better indication of reactions to the questionnaire items. PIs navigated through the survey as they normally would, vocalizing their reactions to the questions and their responses with occasional prompting from the interviewer. PIs and students were also free to provide additional comments at any time throughout the cognitive interview process.

In addition to requesting feedback on each survey question, the team also asked PIs to provide a more in-depth analysis of the questionnaire's feasibility, focusing on potential respondent burden and survey length. At the conclusion of each cognitive interview, the study team asked all PIs and students a series of debriefing questions (e.g., Overall, what did you think of the survey? Were any questions particularly difficult to answer? Were any items redundant, or have any items been asked of you before? Do you have any suggestions for the improvement of this survey?).

At the conclusion of each cognitive interview, the interviewer reviewed any notes taken during the interview. The study team summarized the notes with key findings highlighted. The study team then recorded, transcribed, and coded the interviews for analysis in NVivo. For analysis, researchers created a coding scheme to highlight recurring themes in the interview transcripts. The analysis resulted in a list of common themes, which were subsequently tallied and quantified. Following this analysis, the study team recommended final improvements to the survey instruments. This resulted in the formation of three online surveys: the PI survey, the co-PI survey, and a student survey. The study team refined each of the web-based survey instruments a final time based on the analysis of PI and student interviews.

D. PHASE 3: PILOT SURVEYS

After finalizing the three questionnaires for the program outcome monitoring system, the study team completed the online survey programming, which involved specifying additional logic and skip patterns to guide participants to appropriate portions of the survey, minimizing their burden (e.g., PIs with open grants would not see questions related to events that occur after a grant has closed).

Prior to launching the pilot survey, EFRI provided Insight with a list of EFRI PIs and co-PIs, which served as the sampling frame for the survey. The list contained information on the award identification number, the start and end date of the award, the award topic, and the award title.[2]

[2] In the original data sheet, there were five duplicate cases where the PI changed universities but continued the same grant, decreasing the total number of EFRI recipients to 115. Of the 115 recipients, 5 PIs received 2 EFRI awards. In these cases, the study team sent the PIs special instructions to complete a response for each EFRI grant received.

To ensure higher response rates, NSF sent an introductory email to all potential respondents informing them of the importance of the data collection initiative, explaining NSF's partnership with the study team, and instructing respondents to expect an email invitation. After this initial email, the study team sent each PI and co-PI an email invitation containing a live link to the survey. The invitation email appeared in respondent email inboxes as from "NSF via Insight Policy Research" and contained a subject line of either "NSF EFRI Principal Investigator Survey" or "NSF EFRI Co-Principal Investigator Survey."

The email invited respondents to respond to the survey by clicking on the embedded link and urged them to complete the survey within a 2-week timeframe. The survey platform automatically sent reminders at regular intervals to survey nonrespondents throughout the data collection window, and every email contained an "unsubscribe" link for respondents wishing to stop receiving email notifications. Respondents also automatically received a thank-you email upon successful completion of the survey.

PI Survey. The initial email invitations were sent to EFRI PIs on February 26, 2015, and respondents were encouraged to complete the survey by March 13. Automatic email reminders were sent to unresponsive PIs on March 3, 10, and 19. To increase the survey's response rate, NSF opted to send an additional email on March 12 encouraging all PIs to respond to the survey, and extending the survey's close date to March 20, 2015. The EFRI PI survey was open for approximately 3 weeks.

Co-PI Survey. Co-PIs received initial email invitations on March 3, 2015, and respondents were encouraged to complete the survey by March 17. Automatic email reminders were sent to unresponsive co-PIs on March 5, 13, and 23. As with the PI survey, NSF sent an email to all co-PIs on March 12 extending the survey's close date to March 24, 2015. The EFRI co-PI survey was open for a total of 3 weeks.

Student Survey. Because the PIs and co-PIs provided contact information for student participants during their surveys, the study team could not administer the EFRI student survey concurrently with the surveys for the PIs and co-PIs. The PI and co-PI surveys were fielded first, and after each survey closed, Insight extracted students' email contact information.

On March 24, 2015, the students received invitation emails from "NSF EFRI via Insight Policy Research" with the subject line "NSF's EFRI Program Requests Your Feedback." Students were encouraged to respond to the survey by March 31 and were automatically sent a thank-you email upon successful completion of the survey. Unresponsive students received reminder emails on March 26 and March 30, and the survey closed as scheduled on March 31. The student survey was open for 1 week. See appendix B for all PI, co-PI, and student email invitations and reminders.

After exporting the sample of complete survey data for PIs and co-PIs, the sample data were merged with the population data supplied by NSF using a unique identifier (email address) assigned to each PI and co-PI when the study team fielded the survey.[3] Following this matching process, the study team conducted a series of consistency checks.

First, the team checked all web survey responses to see if the respondent answered question 1 ("Have you submitted the final report for your EFRI grant?"). Two PIs did not respond to question 1; their data

[3] Analysts did not merge the student data with additional grant-specific information housed on a population file because NSF did not have immediate access to student email addresses and award identifiers.

were imputed based on the original population data supplied by NSF. These two cases are flagged with the variable EDITFLAG=1.[4]

Second, there were four cases in which PIs received multiple EFRI grants but did not specify grant numbers in their survey responses. In these cases, analysts assumed a PI's response referred to the most recent EFRI grant and included this grant ID in the data.[5] These cases are flagged with the variable EDITFLAG=2.

Third, one case was missing a response for question 1 and was completed by a PI with multiple awards who did not list a grant ID number. This case was edited with the same specifications described above and flagged with the variable EDITFLAG=3.

Last, three co-PIs held multiple EFRI grants and provided a response about only one of those grants, specifying the grant number on the survey. Analysts flagged these multiple-grant-recipient co-PIs with the variable EDITFLAG=4. Note that no reported values were changed, and values were not changed based on response patterns.

The study team edited the PI, co-PI, and student data to reflect the survey skip patterns prior to conducting tests of response bias and item nonresponse. In some cases, the presence of survey logic indicated that not all PIs and co-PIs viewed all the questions because they were not pertinent to their experiences.[6] Analysts coded missing values to "-8" (valid skip) for missing data resulting from skip patterns. The team coded missing values resulting from respondents' declining to answer as "-9" (respondent missing). Finally, if a series of questions had a "none of the above" option, missing values were coded to "0" (not selected) when a respondent selected at least one item in the list. If a respondent did not select any item in the list, including "none of the above," all variables for the list were set to "-9" (respondent missing).

[4] Question 1 served as a proxy for active and closed grants in the bivariate analyses. If the response was blank, analysts referred to the original population data provided by NSF and filled in the question as appropriate. If a grant's expiration date was after March 2015, it was considered active, and question 1 was filled with "No." If the grant's expiration date was prior to March 2015, it was considered closed, and question 1 was filled with "Yes."

[5] There were 62 cases where the PI did not provide a grant ID. However, analysts matched the survey records to the NSF population using unique identifiers for PI and co-PI respondents to supply the missing grant IDs.

[6] For example, some questions were limited to only respondents with closed grants. It is important to note whether the respondent never saw the question or instead chose to not answer the question.

III. SURVEY PROCESS FINDINGS

This chapter presents findings from phases 1 and 2 of the project, outlining recommendations that can serve as a process guide for fielding future online surveys. The study team designed the recommendations to help NSF field additional surveys with high response rates and minimal burden for respondents. To this end, the study team edited the original questionnaire provided by NSF to align with NSF objectives and reduce redundancy.

Section A outlines findings from the project designed to minimize respondent burden. Section B provides suggestions to clarify survey goals and identify the most knowledgeable respondent. At the start of the project, NSF indicated that key goals were to shape future waves of the survey to minimize respondent burden and to identify the best respondents (PIs, co-PIs, and students) to get specific information on long-term outcomes. The recommendations below can serve as a guide to achieving these goals in future survey efforts.

A. MINIMIZE RESPONDENT BURDEN

Attention to survey length and complexity of survey questions can minimize the burden on respondents. The complexity of survey questions may depend on the extent to which a question provides a short, closed-ended response and whether the information to answer the question can be easily recalled. Below are several recommendations.

Prioritize the use of survey logic and skip patterns; present fewer questions per screen. Respondents are more likely to answer survey questions if they answer only questions relevant to their experiences. Survey logic and skip patterns in the survey move respondents more efficiently through the survey, reduce unintentional item nonresponse (a respondent skipping a single question), and reduce the likelihood of response error (i.e., a respondent accidentally answering a question for which they have no experience) (Peytchev, Couper, McCabe, & Crawford, 2006).

Additional skip logic in a survey increases the number of pages per survey. However, in a test of different survey formats, with 1, 4, 10, and 20 items on a screen, researchers found that multiple items on the screen shorten the survey but create negative feelings in respondents about survey layout (Toepoel, Das, & Van Soest, 2009). As other nationally representative surveys (such as the American Community Survey) have moved online, they have followed a pattern of additional survey logic and fewer questions per screen (Tancreto, Davis, & Zelenak, 2012).

One example of survey logic included in the current PI survey asks PIs to indicate whether any companies have shown interest in their EFRI research. If companies have shown interest in their research, a PI would select "yes" to this question and would subsequently see a series of follow-up questions related to the specifics of those companies (e.g., company name, the nature of the inquiry). If the answer is "no," the respondent does not view any of the subsequent questions. This reduces the cascade effects of item nonresponse because it is clear subsequent questions were not answered because they did not apply.

Prepopulate survey fields with key identifying information. Prepopulating survey fields eliminates the need for manual entry of certain kinds of information, particularly static information. The method also signals to respondents that the survey creators have taken care to make use of existing data sources to personalize the survey and minimize the survey's length. PIs indicated the survey's length should be

minimized as much as possible and should not exceed 30 minutes. During interviews, several PIs predicted that future respondents would be particularly sensitive to the survey's length given their very tight schedules. One PI noted that "if [the survey] takes more than 30 minutes, [PIs] are going to be hesitant to do it." In interviews, both program directors and PIs suggested that any survey fields likely to remain constant (e.g., the PI's EFRI grant number, biographical information) should be prepopulated, as outlined in NSF's original data collection plan.

As planned by EFRI, the permanent version of the outcomes monitoring system will make use of cleaned and validated data sources to prepopulate key items such as co-PI names, grant number, grant topic, and grant conclusion date. Providing personal knowledge of respondents and minimizing the length of the survey show evidence of increased response rate (Dillman, Smyth, & Christian, 2009; Monroe & Adams, 2012).

Reduce ambiguity and specify response option categories. A survey's length can significantly affect response rates. Clarifying question content and increasing the use of closed-ended responses can reduce the length of the survey. During phase 2 of this study, NSF program directors and PIs noted the initial version of the EFRI PI survey used language that was too ambiguous to interpret. Many questions used terminology that could refer to many things.

The study team clarified the survey's language and modified question phrasing in many questions under the following topics: nature of partnership conversations, the ways startups used EFRI research, the ways research communities used EFRI research, the types of research communities, student laboratory usage, and curricular changes. Most importantly, the team edited the questions to provide mutually exclusive response options. The team added fields to accommodate longer responses (e.g., more open-ended fields to capture additional publications) and separated some response options into different categories. For example, a response option that initially read "Technology or Method" was revised to "Technique" and "Method."

In another example, PIs expressed confusion about the term "different disciplines" as it was used to refer to publications in disciplines different from respondents' own departmental discipline. To make this concept clearer, Insight changed the question to include an explanatory note indicating that "different disciplines" refer in this case to disciplines "outside one's departmental discipline."

Further, the respondent should be able to easily read and respond to the questions. Instructions and definitions should appear just at the point they are most needed (Dillman et al., 2009). Secondary task items (such as instructions and definitions) should appear as text at the top of the screen and/or in an "information" button if necessary.

Ask closed-ended, quantitative questions. Qualitative, open-ended questions can be onerous for survey respondents because they must actively input their own responses (Dillman et al., 2009; Miller & Dumford, 2014). Furthermore, qualitative data are more difficult and time-consuming to analyze, and data are often collapsed into more meaningful categories in the final analysis.

The initial version of the EFRI PI survey was largely qualitative and required respondents to provide information themselves, rather than selecting from a list of limited response choices. For example, one question on the initial survey instructed PIs to "please list all individual awards, promotions, leadership roles, or achievements of the PI and Co-PI involved in this EFRI research since they received EFRI funding." Several PIs independently characterized the initial version of the EFRI PI survey as "heavily qualitative." During phase 2, one PI asked, "Why does NSF care about the *names* of these things versus

how many and of what type?" Insight converted several survey items to be more quantitative when doing so would not alter the usefulness of the data collected.

B. CLARIFY KEY SURVEY GOALS AND IDENTIFY THE MOST KNOWLEDGEABLE RESPONDENT

One of the most important factors in determining if respondents will participate in a survey is whether they understand its overall aims and goals. Survey research indicates respondents are far more likely to respond to surveys when the survey is personally relevant to them and when they believe their responses will be useful (Dillman et al., 2009). Our recommendations to achieve these goals appear below.

Communicate the survey's goals at the outset. Respondents are less likely to experience survey fatigue, especially in an online mode, if informed about how long the survey will take to complete, why the data are being collected, how the data will be used, and how their information will be protected. Typically, this information appears in an introductory "welcome" page.

During phase 1, Insight refined the connections between the preliminary survey and strategic goals, highlighting areas where the EFRI Office might consider additional measures. During phase 2, both program directors and PIs felt the welcome language in the initial version of the survey was vague and needed refinement. Ideally, this language gives PIs a sense of whether and how the survey will be valuable rather than placing an additional burden on their time. One program director indicated she wanted to know whether the information being collected would be used to "change something specific about the program."

PIs also need a clear explanation of the survey's goals and how EFRI plans to use the data collected by the survey. For example, one PI wondered whether EFRI would use results to "change the EFRI [program] to make it more responsive to whatever it is that NSF wants it to be responsive to." To address this concern, the opening language will illustrate to PIs the value of completing the survey. As one PI noted, "Knowing why the survey is being fielded and how the results will be used can be incredibly motivating."

The study team also modified and expanded the survey's welcome language to include how EFRI intends to use the data collected. The guidance advises participants to have their most recent CVs nearby to report more efficiently on some survey items. Encouraging respondents to use their CVs in this way reduces their time burden. Finally, the welcome screen provides respondents with a valid OMB data collection control number and specific directions and contact information for those who may have questions regarding the survey's administration.

Build on knowledge respondents have readily available. One objective of the study was to identify the extent to which PIs could comment on recent co-PI activities and accomplishments. This assessment is important because the extent to which a respondent will answer a question depends on both the understanding of the question and whether the respondent has the necessary knowledge. Information provided by respondents on matters external to their own experience raises validity concerns, and survey best practices generally advise against asking respondents to report on behalf of another individual or group.

In phase 2, both program directors and PIs indicated PIs would likely be unwilling or unable to provide accurate, useful information about their EFRI project's co-PIs. Several PIs indicated any question related

to co-PI activity would constitute an immediate "stopping point" in the survey. At these "stopping points," respondents would be forced to submit an incomplete response, contact their co-PI to obtain the required information, or skip the question. These options can increase survey burden substantially.

As another factor, the EFRI program is interdisciplinary, with PIs and co-PIs often working at different institutions in various locations. This can make regular contact less frequent about matters unrelated to core project details. PIs also indicated that falling out of touch with co-PIs might be particularly pronounced for individuals whose grants had closed. To address this issue, the study team created an independent co-PI survey. The resulting co-PI survey is a shorter, less comprehensive version of the PI survey (containing a subset of questions from the PI survey).

IV. PILOT SURVEY RESULTS

A. RESPONSE RATES, SAMPLE CHARACTERISTICS, SURVEY BURDEN, AND ITEM NONRESPONSE

This section provides information on the response rates, the respondents themselves, and the length of time necessary to complete the three pilot surveys.

1. Response Rates

PI Survey. Of the 115 total EFRI grants awarded, 80 PI records were exported from the survey platform.[7] Seventy-four records were marked as complete cases, and six were considered partial cases, meaning the respondent did not reach the end of the survey. The PI survey had a response rate of 70 percent.[8]

Co-PI Survey. Of the 387 EFRI co-PI grantees, there were 175 unique co-PI responses recorded. There were 149 complete cases and 26 partial cases, for a response rate of 45 percent. Of the original email invitations, 18 (5 percent) were returned as undeliverable because of incorrect email addresses.

Student Survey. The student survey consisted of 271 individuals who worked on NSF grants; the email addresses were provided by both EFRI PIs and co-PIs who responded to the prior surveys. Of these emails, 10 (3.7 percent) were returned as undeliverable because of incorrect email addresses. The survey yielded 131 student responses (124 complete, 7 partial), for a total response rate of 48 percent. See table III.1.

Table III.1.
Number and Percentage of Pilot Respondents by Respondent Type

	PIs		Co-PIs		Students	
Respondent Type	**Number**	**Percent**	**Number**	**Percent**	**Number**	**Percent**
Universe of recipients	115	100.0	386	100.0	271	100.0
Incorrect email addresses	--	--	18	4.7	10	3.7
Respondents						
Complete	74	64.3	149	38.6	124	45.8
Partial	6	5.2	26	6.7	7	2.6
Response Rate	80	69.6	175	45.3	131	48.3

Source: EFRI PI Pilot Survey, 2015

2. Sample Characteristics

The sampling frame, or universe of PIs and co-PIs, contained selected characteristics for each grant in addition to contact information for each grantee. The study team compared these characteristics with the characteristics of the respondent sample to assess potential patterns of response bias in three key areas, including grant status (active or closed), grant duration, and topic of study. Results appear below.

[7] One additional record was found to be entirely blank and did not have an email address. This case was considered faulty and was not included in analysis. However, to provide the most information, this case was retained in the data file and flagged for data editing.

[8] This response rate assumes that partials will be used as complete cases.

Active PI grantees tended to have a higher response rate than inactive PI grantees. For PIs, a larger percentage of PI respondents had active grants compared to the universe of all PI grantees, 71 and 64 percent, respectively. A similar trend was apparent with co-PIs, where 67 percent of respondents had open grants compared to 61 percent in the universe of EFRI co-PI grantees.

PIs and co-PIs whose grants had been awarded longer ago had a lower response rate than those whose grants were awarded more recently. Comparing grant duration, the length of time since the grant was awarded, the largest potential bias was seen in grants awarded 7 or more years ago.[9] For example, among the grantees, 5 percent of PI respondents were in their 7th year compared to 11 percent of all the PI grantees. Similarly, for co-PIs, 5 percent of respondents held grants in their 7th year, compared to 12 percent of all grantees.

Across topic areas, PIs had similar response rates. Since 2007, the EFRI Office has solicited grants in 14 different cutting-edge research topics. See table III.2 for the title of each award, the fiscal year when awards were solicited, and the abbreviation or acronym of the award titles.

Table III.2.
Abbreviation, Fiscal Year, and Title of EFRI Award Topics

Abbreviated	Fiscal Year	Title
2-DARE	2014	Two-Dimensional Atomic-Layer Research and Engineering
ARES	2007	Autonomously Reconfigurable Engineered Systems Enabled by Cyberinfrastructure
BIOFLEX	2012–2013	Flexible Bioelectronics Systems
BSBA	2009	Renewable Energy Storage
CBE	2007	Cellular and Biomolecular Engineering
COPN	2008	Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology
HYBI	2009	Hydrocarbons from Biomass
M3C	2011	Mind, Machines, and Motor Control
MIKS	2011	Engineering New Technologies Based on Multicellular and Inter-kingdom Signaling
ODISSEI	2012–2013	Origami Design for Integration of Self-Assembling Systems for Engineering Innovation
PSBR	2012–2013	Photosynthetic Biorefineries
RESIN	2008	Resilient and Sustainable Infrastructure
RESTOR	2010	Renewable Energy Storage
SEED	2010	Science in Energy and Environmental Design

Source: Emerging Frontiers in Research and Innovation, Research Topics at www.efri.org

Among the grant topics, most topics were represented in the sample in proportion to the share in the grantee universe. However, there were no PI or co-PI survey respondents from the COPN (Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology) group. This group was the smallest of the EFRI topic areas, representing just 4 percent of all PI grantees and 3 percent of all co-PI grantees. The largest group of PI grantees was the BSBA group (12 percent of all awards and 9 percent of respondents). The largest groups of co-PI grantees received grants in the BSBA and ODISSEI solicitation; these two topic areas accounted for 11 percent of all EFRI co-PI awardees in both topic areas and 11 and 6 percent of co-PI respondents, respectively.

[9] Grant duration refers to the number of years that have elapsed since the original grant award, encompassing both open and closed EFRI grants.

Table III.3 highlights the response bias across these three key characteristics.

Table III.3.
Response Bias Across Key Grant Characteristics by Survey Respondent

	PIs				Co-PIs			
	All EFRI PIs		Survey Respondents		All EFRI Co-PIs		Survey Respondents	
Respondent Type	*N*	Percent	*N*	Percent	*N*	Percent	*N*	Percent
Total	115	100.0	80	100.0	387	100.0	175	100.0
Grant Status								
Open	74	64.4	57	71.3	235	60.7	116	66.7
Closed	41	35.7	23	28.7	152	39.3	58	33.3
Grant Duration								
Year 1	11	9.6	8	10.0	32	8.3	18	10.3
Year 2	14	12.2	12	15.0	43	11.1	21	12.1
Year 3	16	13.9	13	16.3	54	14.0	22	12.6
Year 4	14	12.2	13	16.3	47	12.1	26	14.9
Year 5	16	13.9	11	13.8	56	14.5	35	20.1
Year 6	23	20.0	13	16.3	73	18.9	30	17.2
Year 7	13	11.3	4	5.0	45	11.6	9	5.2
Year 8	8	7.0	6	7.5	37	9.6	13	7.5
EFRI Topic								
2-DARE	9	7.8	6	7.5	32	8.3	18	10.3
ARES	5	4.4	3	3.8	17	4.4	6	3.5
BIOFLEX	8	7.0	7	8.8	23	5.9	15	8.6
BSBA	14	12.2	7	8.8	43	11.1	19	10.9
CBE	7	6.1	4	5.0	25	6.5	8	4.6
COPN	4	3.5	0	0.0	12	3.1	0	0.0
HYBI	9	7.8	5	6.3	32	8.3	12	6.9
M3C	6	5.2	7	8.8	18	4.7	11	6.3
MIKS	8	7.0	6	7.5	29	7.5	15	8.6
ODISSEI	13	11.3	11	13.8	43	11.1	11	6.3
PSBR	9	7.8	8	10.0	31	8.0	17	9.8
RESIN	8	7.0	4	5.0	30	7.8	9	5.2
RESTOR	5	4.4	3	3.8	15	3.9	12	6.9
SEED	10	8.7	9	11.3	37	9.6	21	12.1

Source: EFRI PI Pilot Survey, 2015

3. Survey Burden

The study team calculated each survey's mean completion time by computing the average of all complete responses to a given survey; incomplete and partial responses are not included in this calculation. This method enables the study team to specify a timeframe for which an average completion time will be calculated on each survey. To accommodate for the extensions granted to both the PI and co-PI surveys, each survey's time period was specified for the exact dates when that particular survey was fielded.

Using this computation method, the average completion time for respondents who completed the PI survey between February 26 and March 20, 2015, was slightly more than 37 minutes. The average time for respondents to complete the co-PI survey between its field dates of March 10 and March 24, 2015,

was slightly more than 5 minutes. The average completion time of all completed responses received between March 24 and March 31, 2015, for the student survey was 31 minutes.[10] The median time to complete the survey, as measured from the time the survey was first accessed until the time the last page was submitted, was 14 minutes for PIs, 8 minutes for co-PIs, and 3 minutes for students.[11]

4. Item Nonresponse

Many questions on the PI survey had an item-level response rate less than 75 percent.[12] In particular, questions about licenses (planned, provisional, pending, issued, or other) and subsequent follow-up questions about these licenses had response rates less than 50 percent. Questions about leadership roles, promotions, awards, student career paths, and curricular changes all had a response rate of less than 25 percent.

The co-PI survey had similarly low response rates (approximately 50 percent) on questions with the following response options: leadership roles, promotions, and awards. In contrast, the student survey had only one question with a low response rate, an open-ended question asking students to describe their experiences; approximately one quarter of students answered this question. A full table that includes each survey item with a response rate less than 75 percent and the main reason for the nonresponse appears in appendix C.

Based on an analysis of item nonresponse for the variables displayed in appendix C, the study team isolated four key factors that contributed to low response rates: confidentiality, skip logic, recall, and cascade. Below, we discuss each of the four key factors and provide recommendations for addressing them in future survey administrations.

Confidentiality

Several survey items with response rates below 75 percent relate to information PIs may perceive as being sensitive or confidential. For example, more than 40 percent of PIs who indicated one or more companies had shown interest in their EFRI research declined to provide the names of those companies. Respondents may be unwilling to provide information they perceive to be confidential or that may constitute a conflict of interest, and they may simply skip the question as a result. Survey items requesting potentially confidential information can be retained in future survey administrations, though the nature of some lines of research may preclude full disclosure of the desired information.

Skip Logic

Some survey items with relatively high nonresponse rates relate to the design of the survey items themselves, and survey items that use skip logic have higher response rates. Often, respondents will skip an item if it requires them to select "0" or "None" from a series of response options displayed in a drop-

[10] Though the co-PI survey and the student survey were approximately the same length, on average, students took longer than co-PIs to complete the survey. This disparity in average completion times between the two groups may be partially because of the presence of an open-ended question asking students to provide any additional comments about the EFRI program.

[11] The median time spent is based on the start and end times of the survey, meaning from when respondents first viewed the survey until they submitted their responses. The median results do not calculate the minutes spent actively viewing and completing the survey.

[12] Item nonresponse refers to instances when individuals who have viewed the question choose not to provide a response to that item.

down menu, perhaps because they do not realize "0" or "None" are options. Rather than displaying a series of drop-down menus that include "0," "None," or "Not Applicable," Insight recommends including an initial filter question with radio buttons that clearly indicate whether a respondent should proceed to answer follow-up questions on that topic (e.g., "Yes," "No," "Cannot Recall").

A clear response to this initial filter question would trigger survey logic that directs respondents to items that relate to their experiences, thus diminishing the likelihood of nonresponse error for that item and subsequent items. For example, one EFRI PI survey item prompted respondents to indicate how many of each kind of licensing discussion or activity they may have had related to their EFRI research (planned, provisional, pending, issued, or other). Rather than requiring respondents to select "None" from the series of dropdown menus for each kind of licensing activity, a simple filter question may be added, asking *whether* respondents have had any of these experiences (e.g., "Have you had any licensing discussions or activities based on your EFRI research?"). This question may then be followed by questions that prompt for more specific information related to the number and description of these activities.

Recall

Some survey items with low response rates are likely the result of respondents' inability to recall the pertinent information. This effect may be more reflective of a respondent's inability to recall the information requested within the generic time period (i.e., "since the submission of your most recent report") than the inability to recall this information in general. For example, if a respondent did not respond to a question asking whether he or she had received any leadership roles, promotions, or other awards in the time since the submission of the most recent annual or final report, the reason may be the individual could not recall exactly what was provided on the most recently submitted report.

To address this issue in the future, Insight recommends modifying the survey in the following ways. First, questions related to activities that have occurred since the submission of a final report should be shown only to PIs with closed grants since respondents with active grants provide this information on their annual reports. Second, Insight recommends including specific timeframe references to guide participant responses. For example, "since the submission of your most recent report" might be changed to "within the last 2 years" to help respondents narrow their focus. Finally, where possible, Insight recommends including a response option for respondents who cannot recall the desired information (e.g., "I cannot recall if I have received any of these awards within the past 2 years" or "I cannot recall what I included on my most recent annual report"). This provides respondents with an alternative to skipping the question.

Cascade Effect

The remainder of survey items with high nonresponse rates are likely the result of a cascading nonresponse pattern in preceding items. The majority of items with high nonresponse rates fall within this category. For example, if a respondent declined to provide a number of provisional licenses they may have received, they are unlikely to provide answers to any follow-up questions related to provisional licenses (e.g., name, description, year licensed). To address this issue in future survey administrations, we recommend modifying the initial or key question to be as clear as possible to avoid this cascade nonresponse effect.

B. PILOT SURVEY FINDINGS

This section focuses on key findings in the EFRI PI survey protocol. The topics include—

1. Company partnerships and research products
2. Grantee accomplishments and collaboration
3. EFRI student trajectories and curricular changes

In each of these three areas, tables of bivariate findings based on grant status (e.g., open versus closed), grant duration (e.g., year 1 through year 8), and grant topic are presented.

1. Company Partnerships and Research Products

The PI survey requests information on company partnerships, the creation of new companies, and the extent to which the research community is using products (outputs) of their EFRI research or models associated with an EFRI grant. Tables III.4, III.5, and III.6 summarize the results for these long-term outcomes.

Company Interest, Partnerships, and Licensing Activity

Overall, 77 percent of PIs have begun partnership discussions, and this rate is higher for those with closed grants at 81 percent (table III.4). A higher percentage of PIs with closed EFRI grants report discussions with between four and six companies, compared to between one and three companies among those with open grants. Although the company interest is higher for closed grants, the variation in company interest by grant duration is minimal (table III.5). Between 75 and 100 percent of PIs reported some company interest each year of the grant, with the exception of grantees in year 4, with 39 percent of PIs reporting company interest (see table III.5).[13] The relationship of company interest to time since award is not linear, with some decline in the percentage of respondents reporting company interest even as grant duration extends. That said, 100 percent of PIs in year 8 of their grant ($n = 6$) reported company interest.

Although not highlighted in the tables, PIs described the nature of the company interest in their EFRI project, providing data on a total of 142 companies. Within these 142 companies, 63 percent expressed interest in the form of conversations related to research and technology.[14] PIs provided the names of 68 different entities; examples included Agilent, IBM, Nike, Samsung, Sapphire Energy, and the U.S. Army Corps of Engineers.

Grant topic refers to the topic of the EFRI solicitation the PI received. There were relatively few PIs within each individual EFRI topic, so it is difficult to isolate clear trends in activity across topics.

[13] There is a significant correlation between grant duration and grant status ($r = 0.5$), where those grants with longer duration are more likely to be closed grants.

[14] For each company in which a respondent was involved, the respondent provided information on the nature of the partnership. Questions 5a through 5f provide information on this, and 90 companies of the 142 provided were listed as research and technology conversations.

Recipients of ARES, BIOFLEX, CBE, and RESTOR grants were active in company partnerships (100 percent reported companies had shown interest; table III.6).

Approximately half of respondents have engaged in some licensing activity, with a quarter of respondents (27 percent) reporting they are planning to license their product. Relatively few PIs have pending or provisional licenses, and those who do are in year 3 or later of their grant activity (table III.5). Recipients of ARES, BIOFLEX, CBE, HYBI, and RESTOR grants were active in company partnerships (more than 80 percent reported licensing activity) (table III.6).

Startups and Research Community Engagement

Eighty five percent of the 13 startups described by PIs used technology and/or methods associated with the respondent's EFRI research. Startups were more common for closed grants. One third (33 percent) of PIs with closed grants reported a startup connected to their EFRI research, as compared to 7 percent of PIs with open grants (table III.4). Respondents in years 6, 7, or 8 of their grant were more likely to report startups that used their research than grantees in years 1 through 5 (table III.5). PIs with grant topics in BIOFLEX, BSBA, CBE, HYBI, M3C, MIKS, RESTOR, and SEED all reported startups involved in their EFRI research (table III.6).

Almost 60 percent of PIs reported the research community had used products related to their EFRI research, noting a total of 88 technology/research products used by the research community (table III.4). Although not shown in the tables, most of these products (48 percent) involve a new technique or method. Some examples include design of a water treatment system, a model of algae growth, a smart parking system, and techniques for improving energy content in plants. The most common types of research communities mentioned by respondents include the following: new, regular meeting; workshops or writing groups; and symposium (41, 55, and 38 percent of respondents, respectively).[15]

Fewer PIs with year 1 or year 2 grants reported use of their EFRI research by the research community at 12 and 27 percent, respectively, compared to individuals with longer grant duration, more than 50 percent of whom reported use by the research community (table III.5). With the exception of 2-DARE grantees, EFRI's most recent solicitation topic, at least 30 percent of respondents in each grant topic reported the research community engaged grant findings (table III.6).

[15] Total is more than 100 percent because respondents can select more than one type of new research community.

Table III.4.
Company Partnerships and New Research Products by Grant Status

PI Survey	All Grants	Active Grants	Closed Grants
Companies have shown interest (*n* = 77)			
No	23.4	25.0	19.1
Yes	76.6	75.0	81.0
Number of companies interested (*n* = 58)			
Between 1 and 3	81.0	88.1	62.5
Between 4 and 6	15.5	7.1	37.5
Seven or more	3.5	4.8	0.0
Licenses			
Any licensing activity (*n* = 53)			
No	49.1	50.0	46.2
Yes	50.9	50.0	53.9
Planned (*n* = 60)			
0	73.3	68.2	87.5
1+	26.7	31.8	12.5
Provisional (*n* = 45)			
0	88.9	88.2	90.9
1+	11.1	11.8	9.1
Pending (*n* = 45)			
0	91.1	91.2	90.9
1+	8.9	8.8	9.1
Issued (*n* = 48)			
0	85.4	93.8	68.8
1+	14.6	6.3	31.3
Other (*n* = 33)			
0	93.9	92.3	100.0
1+	6.1	7.7	0.0
Number of startups (*n* = 77)			
0	85.7	92.9	66.7
1 to 3	14.3	7.1	33.3
Research community uses EFRI product (*n* = 77)			
No	40.3	44.6	28.6
Yes	59.7	55.4	71.4

Source: EFRI PI Pilot Survey, 2015
Notes: The number of speaking roles represents the average for each group of respondents.

Table III.5.
Company Partnerships and Research Products by Grant Duration

	PI Survey								
	All Grants	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Companies have shown interest (*n* = 77)									
No	23.4	12.5	18.2	15.4	61.5	9.1	25.0	25.0	0.0
Yes	76.6	87.5	81.8	84.6	38.5	90.9	75.0	75.0	100.0
Number of companies interested (*n* = 58)									
Between 1 and 3	81.0	100.0	100.0	72.7	100.0	80.0	77.8	66.7	40.0
Between 4 and 6	15.5	0.0	0.0	18.2	0.0	10.0	22.2	33.3	60.0
Seven or more	3.5	0.0	0.0	9.1	0.0	10.0	0.0	0.0	0.0
Licenses									
Any licensing activity (*n* = 53)									
No	49.1	80.0	33.3	45.5	70.0	25.0	50.0	66.7	0.0
Yes	50.9	20.0	66.7	54.6	30.0	75.0	50.0	33.3	100.0
Planned (*n* = 60)									
0	73.3	100.0	50.0	58.3	70.0	66.7	88.9	100.0	100.0
1+	26.7	0.0	50.0	41.7	30.0	33.3	11.1	0.0	0.0
Provisional (*n* = 45)									
0	88.9	100.0	100.0	100.0	87.5	57.1	100.0	100.0	50.0
1+	11.1	0.0	0.0	0.0	12.5	42.9	0.0	0.0	50.0
Pending (*n* = 45)									
0	91.1	100.0	100.0	85.7	87.5	100.0	87.5	100.0	50.0
1+	8.9	0.0	0.0	14.3	12.5	0.0	12.5	0.0	50.0
Issued (*n* = 48)									
0	85.4	83.3	100.0	85.7	100.0	80.0	77.8	75.0	66.7
1+	14.6	16.7	0.0	14.3	0.0	20.0	22.2	25.0	33.3
Other (*n* = 33)									
0	93.9	100.0	100.0	83.3	100.0	66.7	100.0	100.0	100.0
1+	6.1	0.0	0.0	16.7	0.0	33.3	0.0	0.0	0.0
Number of Startups (*n* = 77)									
0	85.7	87.5	100.0	84.6	76.9	100.0	75.0	75.0	80.0
1 to 3	14.3	12.5	0.0	15.4	23.1	0.0	25.0	25.0	20.0
Research community uses EFRI product (*n* = 77)									
No	40.3	87.5	72.7	23.1	46.2	18.2	33.3	0.0.	20.0
Yes	59.7	12.5	27.3	76.9	53.9	81.8	66.7	100.0	80.0

Source: EFRI PI Pilot Survey, 2015

Table III.6.
Company Partnerships and Research Products by Grant Topic

	PI Survey													
	All Grants	2-DARE	ARES	BIOFLEX	BSBA	CBE	HYBI	M3C	MIKS	ODISSEI	PSBR	RESIN	RESTOR	SEED
Companies have shown interest (*n* = 77)														
No	23.4	16.7	0.0	0.0	28.6	0.0	25.0	57.1	66.7	30.0	12.5	25.0	0.0	11.1
Yes	76.6	83.3	100.0	100.0	71.4	100.0	75.0	42.9	33.3	70.0	87.5	75.0	100.0	88.9
Number of companies interested (*n* = 58)														
Between 1 and 3	81.0	100.0	50.0	85.7	100.0	50.0	66.7	100.0	100.0	66.7	100.0	33.3	66.7	87.5
Between 4 and 6	15.5	0.0	50.0	14.3	0.0	50.0	33.3	0.0	0.0	16.7	0.0	66.7	33.3	0.0
Seven or more	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	12.5
Licensing activity (*n* = 53)														
No	49.1	100.0	0.0	14.3	50.0	0.0	0.0	60.0	80.0	83.3	25.0	100.0	0.0	25.0
Yes	50.9	0.0	100.0	85.7	50.0	100.0	100.0	40.0	20.0	16.7	75.0	0.0	100.0	75.0
Planned (*n* = 60)														
0	73.3	100.0	100.0	14.3	80.0	100.0	100.0	60.0	80.0	87.5	66.7	100.0	100.0	57.1
1+	26.7	0.0	0.0	85.7	20.0	0.0	0.0	40.0	20.0	12.5	33.3	0.0	0.0	42.9
Provisional (*n* = 45)														
0	88.9	100.0	0.0	100.0	100.0	100.0	100.0	75.0	100.0	100.0	100.0	100.0	50.0	60.0
1+	11.1	0.0	100.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	50.0	40.0
Pending (*n* = 45)														
0	91.1	100.0	0.0	100.0	83.3	100.0	100.0	75.0	100.0	85.7	100.0	100.0	100.0	100.0
1+	8.9	0.0	100.0	0.0	16.7	0.0	0.0	25.0	0.0	14.3	0.0	0.0	0.0	0.0
Issued (*n* = 48)														
0	85.4	100.0	100.0	66.7	83.3	33.3	50.0	100.0	100.0	100.0	100.0	100.0	50.0	75.0
1+	14.6	0.0	0.0	33.3	16.7	66.7	50.0	0.0	0.0	0.0	0.0	0.0	50.0	25.0
Other (*n* = 33)														
0	93.9	100.0	100.0	100.0	100.0	--	--	100.0	100.0	100.0	66.7	100.0	--	66.7
1+	6.1	0.0	0.0	0.0	0.0	--	--	0.0	0.0	0.0	33.3	0.0	--	33.3
Number of Startups (*n* = 77)														
0	85.7	100.0	100.0	71.4	85.7	50.0	75.0	71.4	83.3	100.0	100.0	75.0	100.0	88.9
1 to 3	14.3	0.0	0.0	28.6	14.3	50.0	25.0	28.6	16.7	0.0	0.0	25.0	0.0	11.1
Research community uses EFRI product (*n* = 77)														
No	40.3	100.0	50.0	28.6	28.6	0.0	50.0	42.9	50.0	50.0	62.5	0.0	33.3	11.1
Yes	59.7	0.0	50.0	71.4	71.4	100.0	50.0	57.1	50.0	50.0	37.5	100.0	66.7	88.9

-- Missing

Source: EFRI PI Pilot Survey, 2015

2. Individual Accomplishments and Research Collaboration

Tables III.7, III.8, III.9, and III.10 highlight EFRI grantees' successes in generating additional funding, receiving special recognition, dissemination efforts through speaking opportunities on their grant topic, and co-authoring peer-reviewed articles with authors outside the PI's discipline. Table III.8 includes co-PI survey results because this is the major area where the co-PI survey questions supplemented PI survey results.

Generating Additional Funding

Both PIs and co-PIs provided information as to whether their EFRI award generated any additional funding. Since the submission of their most recent annual report, almost 45 percent of PIs reported the generation of additional funding (table III.7). These PIs reported a total of 54 additional grants generated from their EFRI awards, with funding averaging $1.9M per grant, a minimum of $5,500 and a maximum of $25M.[16] Almost twice as many PIs with closed grants reported the generation of additional funding compared to those with active grants, with 62 and 38 percent reporting additional funding, respectively.

Co-PIs also reported on the generation of additional funding through their EFRI research. Twenty-six percent of all co-PIs reported additional funding. The percentage among co-PIs with closed grants was even higher than the sample average, with 38 percent of co-PIs with closed grants reporting additional funding projects (table III.8).

A larger percentage of PIs with grants of longer duration reported generating additional funding compared to PIs with relatively recent grants. Only 25 percent of PIs in year 1 reported generating additional funding, whereas 100 percent of PIs in year 8 indicated they had additional funding (see table III.9). PIs from all grant topics reported securing additional funding, in particular ARES and CBE, where 100 percent of PIs responded affirmatively (table III.10). Of the co-PIs, only about one quarter of respondents indicated they had generated additional funding.

Accomplishments and Speaking Roles

Respondents provided information about any special recognition they may have received since their most recent annual report. Thirty-eight percent of PIs reported no new recognition or awards since their most recent annual report, though 62 percent of PIs noted they had received at least one or two awards or promotions. Examples of PI accomplishments include promotion to full professor, directing a topical program, and receiving a fellowship position. PIs generally favored the effects the EFRI grant had on their accomplishments, rating it an average of almost 4 on a 5-point scale, where 1 = Did Not Contribute at All and 5 = Contributed Significantly.

The findings on PI accomplishments by grant duration are inconclusive. There were relatively few respondents in their first 5 years of their EFRI awards likely because they did not have additional accomplishments since their most recent annual report. Those PIs with grants whose duration was longer were more likely to respond with 75 percent of PIs in year 8 reporting one or two new accomplishments (table III.10).

[16] These calculations are the result of additional analyses based on the number of grants funded rather than PI observation.

PIs reported an average of three keynote addresses, two talks at their home institution, and nearly five talks at other institutions. PIs with active grants reported giving an average of almost four keynote addresses, while those with closed grants reported an average of three keynote addresses. This finding is contrary to other categories in which grantees with closed awards more often have additional items to report compared to those with active grants. PIs with SEED grants were most likely to be asked to give keynote addresses and talks at outside institutions, with respondents working with a SEED topic reporting an average of 10 such speaking engagements (table III.10).

Co-PIs also reported on invited talks and keynote addresses, reporting an average of two keynote addresses, two invited talks at their home institution, and three invited talks at other institutions. Co-PIs with active grants reported an average of two keynote addresses compared to co-PIs with closed grants, who reported an average of three keynote addresses.

PI and Co-PI Interdisciplinary Collaboration

Since their most recent progress report, 55 percent of PIs reported completing at least one peer-reviewed article with a co-author from outside their discipline.[17] On average, these PIs completed 3.5 articles each, for a total of 39 articles reported. Of the co-PIs, 41 percent reported completing a peer-reviewed article with a co-author from outside their discipline. Nearly half of respondents with closed grants reported interdisciplinary co-authorship, compared with 38 percent of those with active grants.

Table III.7.
Accomplishments and Collaboration by Grant Status

PI Survey			
	All Grants	Active Grants	Closed Grants
Generation of additional funding (*n* = 76)			
No	55.3	61.8	38.1
Yes	44.7	38.2	61.9
Types of accomplishments (*n* = 21)			
0	38.1	0.0	42.1
1	38.1	50.0	36.8
2	23.8	50.0	21.1
EFRI contribution to accomplishments (*n* = 13)			
Average	3.9	3.5	4.0
Speaking roles			
Number of keynote addresses (*n* = 22)	3.1	3.5	3.1
Number of invited talks at home institution (*n* = 19)	1.6	1.0	1.7
Number of invited talk at another institution (*n* = 21)	4.6	3.0	4.7
Interdisciplinary co-authorship (*n* = 22)			
No	45.5	50.0	45.0
Yes	54.6	50.0	55.0

Source: EFRI PI Pilot Survey, 2015
Notes: The types of accomplishments may include leadership position, award, promotion, or other. The number of speaking roles represents the average for each group of respondents.

[17] The item nonresponse on this variable is particularly high. This issue is discussed more fully above. However, because of the low response rate, the findings for this question are not generalizable to a larger EFRI sample and must be treated with caution.

Table III.8.
Accomplishments and Collaboration by Grant Status

Co-PI Survey	All Grants	Active Grants	Closed Grants
Generation of additional funding (*n* = 164)			
No	73.8	79.3	62.3
Yes	26.2	20.7	37.7
Speaking roles (average number)[1]			
Number of keynote addresses (*n* = 54)	2.4	2.1	2.8
Number of invited talks at home institution (*n* = 62)	1.7	1.8	1.5
Number of invited talk at another institution (*n* = 92)	2.9	2.8	3.0
Interdisciplinary co-authorship (*n* = 157)			
No	59.2	62.4	52.1
Yes	40.8	37.6	47.9

Source: EFRI Co-PI Pilot Survey, 2015
[1] Note: The number of speaking roles represents the average for all respondents who reported more than zero.

Table III.9.
Accomplishments and Collaboration by Grant Duration

PI Survey	All Grants	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Generation of additional funding (*n* = 76)									
No	55.3	75.0	63.6	69.2	66.7	45.5	41.7	50.0	.
Yes	44.7	25.0	36.4	30.8	33.3	54.6	58.3	50.0	100.0
Types of accomplishments (*n* = 21)[1]									
0	38.1	--	0.0	50.0	0.0	0.0	44.4	66.7	25.0
1	38.1	--	100.0	0.0	0.0	100.0	44.4	0.0	50.0
2	23.8	--	0.0	50.0	100.0	0.0	11.1	33.3	25.0
EFRI contribution to accomplishments (*n* = 13)[2]									
Average	3.9	--	2.0	5.0	3.0	2.0	4.4	2.5	4.7
Speaking roles (average number)[3]									
Number of keynote addresses (*n* = 22)	3.1	2.0	2.0	4.0	4.0	10.0	2.0	4.0	3.0
Number of invited talks at home institution (*n* = 19)	1.6	1.0	0.0	2.0	1.0	2.0	2.0	1.0	2.0
Number of invited talk at another institution (*n* = 21)	4.6	2.0	3.0	3.0	10.0	10.0	3.1	5.0	6.3
Interdisciplinary co-authorship (*n* = 22)									
No	45.5	0.0	0.0	100.0	0.0	100.0	55.6	33.3	25.0
Yes	54.6	100.0	100.0	0.0	100.0	0.0	44.4	66.7	75.0

--Missing
Source: EFRI PI Pilot Survey, 2015
[1] Note: The types of accomplishments may include leadership position, award, promotion, or other.
[2] Note: EFRI contribution to accomplishments represents the average rating on a 1 to 5 scale, where 1 is "Did Not Contribute at All" and 5 is "Contributed Significantly."
[3] Note: The number of speaking roles represents the average for each group of respondents.

Table III.10.
Accomplishments and Collaboration by Grant Topic

	PI Survey													
	All Grants	2-DARE	ARES	BIOFLEX	BSBA	CBE	HYBI	M3C	MIKS	ODISSEI	PSBR	RESIN	RESTOR	SEED
Generation of additional funding (n = 76)														
No	55.3	83.3	0.0	42.9	42.9	0.0	50.0	71.4	60.0	90.0	62.5	50.0	33.3	44.4
Yes	44.7	16.7	100.0	57.1	57.1	100.0	50.0	28.6	40.0	10.0	37.5	50.0	66.7	55.6
Types of accomplishments (n = 21)[1]														
0	38.1	--	50.0	100.0	25.0	0.0	50.0	--	0.0	0.0	--	100.0	--	0.0
1	38.1	--	50.0	0.0	75.0	33.3	25.0	--	0.0	50.0	--	0.0	--	100.0
2	23.8	--	0.0	0.0	0.0	66.7	25.0	--	100.0	50.0	--	0.0	--	0.0
EFRI contribution to accomplishments (n = 13)														
Average	3.9	--	4.0	--	4.7	4.2	4.0	--	3.0	3.5	--	--	--	2.0
Speaking roles (average number)[2]														
Number of keynote addresses (n = 22)	3.1	--	4.0	3.0	1.0	4.7	2.0	--	4.0	3.0	--	2.7	--	10.0
Number of invited talks at home institution (n = 19)	1.6	--	0.5	--	1.0	3.5	0.8	--	1.0	1.0	--	3.7	--	2.0
Number of invited talk at another institution (n = 21)	4.6	--	5.0	--	2.5	8.3	3.0	--	10.0	2.7	--	3.7	--	10.0
Interdisciplinary co-authorship (n = 22)														
No	45.5	--	50.0	100.0	0.0	0.0	100.0	--	0.0	33.3		66.7	--	100.0
Yes	54.6	--	50.0	0.0	100.0	100.0	0.0	--	100.0	66.7		33.3	--	0.0

-- Missing

Source: EFRI PI Pilot Survey, 2015

[1] Note: The types of accomplishments may include leadership position, award, promotion, or other.

[2] Note: The number of speaking roles represents the average for each group of respondents.

3. Student Success and Curricular Changes

The section below describes EFRI graduate students' career trajectories and their interdisciplinary and cross-university laboratory research (tables III.11, III.12, III.13, III.14). The tables also provide PI findings on any curricular changes they have initiated (but not always implemented) as a result of their EFRI grant.

Student Interdisciplinary Lab Work

Table III.11 shows that 21 PIs reported students worked in a lab of a different discipline within the same university, and 19 PIs reported their students worked in a lab outside their home institution. On average, PIs reported four students working in a lab of a different discipline and an average of two students working in a lab outside their home institution. PIs with closed grants reported a higher average number of students working in interdisciplinary arrangements, with an average of almost four students working in a lab of a different discipline within the same institution, and an average of more than two students working in a lab outside their home institution.

Students working in a lab of a different discipline within the same institution were common in all years of the grant cycle, ranging from an average of five students in year 1 to just over three students in year 8 (table III.12). Students working in a lab at another institution were less common overall and were more common in later years of the grant cycle, with no PIs reporting students in labs at other institutions in years 1, 2, or 5.

The EFRI topic with the highest average number of students working in a lab of a different discipline was the BSBA group, with an average of eight students working in other labs at the same institution, whereas HYBI reported an average of one student, and ARES reported an average of two students (table III.13). For students working in a lab in a different institution, PIs with an ARES grant reported an average of six students working at an outside institution, whereas PIs with an ODISSEI or RESIN grant each reported an average of just one student working at an outside institution.

Student Career Pathways

The majority of PIs indicated their students had become research scientists (89 percent), had postdoctoral positions (81 percent), or had tenure-track positions (74 percent). Fewer than one quarter of PIs reported their students had gone on to careers such as nonengineering research scientists, entrepreneurs, and others. Among PIs with active grants, respondents were likely to report their students had gone on to postdoctoral or tenure-track positions (50 percent of PIs) or had become research scientists (100 percent of PIs).

Regardless of grant duration, PIs were likely to note their students had gone on to postdoctoral appointments, tenure-track positions, and research scientist positions. PIs in the later years (years 5 to 8) were more likely to report some students having gone on to nonengineering positions, entrepreneur positions, or other career pathways compared to respondents in years 1 to 4.

The same patterns discussed above emerged among the different EFRI topics. Most PIs, regardless of topic, reported that at least some of their students pursued a postdoctoral, tenure-track, or research scientist position. PIs with BIOFLEX and CBE grant topics were also likely to report students going on to become entrepreneurs.

The student survey also addressed career trajectories. Results from the EFRI student survey indicate that more than half of students (60 percent) recalled having a clear career goal when they first began their EFRI research, while the remainder reported having no clear initial career goals or were uncertain about their initial career plans (40 percent). The majority of students (74 percent) reported working on EFRI-related research for 2 or more years, and nearly one third of students (32 percent) reported having worked on EFRI-related research for 4 or more years (table III.14).

Students estimated their levels of interest in pursuing several career trajectories both prior to and after engaging in EFRI-related research.[18] Students rated their initial and current interest in pursuing faculty positions at research-intensive universities, faculty positions at teaching-intensive universities, nonacademic research positions, and nonresearch careers. When asked to recall their previous interest levels in these career pathways prior to working on EFRI projects, 73 percent of students indicated they would be interested in pursuing nonacademic research careers in various industries, including pharmaceutical, biotech, government, and entrepreneurial research. More than half of students (58 percent) reported initial interest in pursuing a faculty position at a research-intensive university, and fewer students (36 percent) reported initial interest in faculty positions at teaching-intensive institutions and nonresearch careers in industries such as consulting, policy research, science writing, patent law, or business (table III.14).

When asked to estimate their current interest in these career pathways after having worked on EFRI-related research, students reported slightly more interest in each of the listed career trajectories discussed above. The most notable increases in student interest levels over the course of their EFRI research occurred in faculty positions at research-intensive universities (8 percent increase) and interest in nonresearch careers (10 percent increase). The increased levels of interest in each of the listed career paths could reflect the process of students refining or solidifying their desired career paths resulting from their participation in EFRI research.

Curricular Changes

Two thirds of all PIs said they had planned supplements to existing courses, while fewer than 10 percent said they had plans to create a new program or create professional development materials. Of PIs with active grants, 100 percent reported they had not planned any curricular changes.

PIs in the later years of their grants were more likely to report planned changes across the board: Those PIs in years 1 or 2 of their grant were likely to report planning to supplement an existing course, or reported making no curricular changes at all. PIs in year 8 reported a range of activities, including developing new courses and creating new degree or certificate programs.

Looking at the different EFRI topics, most PIs reported having prepared supplemental materials to existing courses, regardless of grant type. PIs with BSBA and CBE grants were more likely to indicate other curricular changes, including developing new courses, creating new programs, and creating new degree or certificate programs (table III.13).

[18] Interest levels were calculated by combining students who indicated they were "moderately interested" or "very interested" in a given career trajectory in comparison to students who indicated they were "slightly interested" or "not at all interested" who were classified as less interested or uninterested in a given career trajectory.

Table III.11.
EFRI Student Successes and Curricular Changes by Grant Status

PI Survey			
	All Grants	Active Grants	Closed Grants
Number of students in lab of different discipline (n = 21)	3.8	2.0	3.9
Number of students in a lab outside the home institution (n = 19)	2.3	1.5	2.4
Student career pathways[1]			
Postdoctoral position (n = 21)	81.0	50.0	84.2
Tenure-track position (n = 19)	73.7	50.0	76.5
Research scientist (n = 18)	88.9	100.0	88.2
Research scientist, nonengineering (n = 14)	21.4	0.0	23.1
Entrepreneur (n = 15)	13.3	0.0	14.3
Other (n = 11)	9.1	0.0	10.0
Curricular changes[2] (n = 21)			
Supplement materials to existing course	66.7	0.0	73.7
Develop new course	23.8	0.0	26.3
Create new program	9.5	0.0	10.5
Create new degree/certificate program	14.3	0.0	15.8
Generate professional development materials	9.5	0.0	10.5
No curricular changes	28.6	100.0	21.1

Source: EFRI PI Pilot Survey, 2015

[1] *Note: Responses for student career pathways indicate the percentage of respondents that reported any graduate or postdoctoral students moving into these positions.*

[2] *Note: Responses for curricular change sum to more than 100 because respondents could choose more than one option.*

Table III.12.
EFRI Student Successes and Curricular Changes by Grant Duration

PI Survey									
	All Grants	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Number of students in lab of different discipline (*n* = 21)	3.8	5.0	1.0	3.0	2.0	3.0	3.9	5.7	3.3
Number of students in a lab outside the home institution (*n* = 19)	2.3	0.0	0.0	3.0	2.0	0.0	3.1	1.0	3.3
Student career pathways[1]									
Postdoctoral position (*n* = 21)	81.0	100.0	0.0	100.0	100.0	100.0	87.5	66.7	75.0
Tenure-track position (*n* = 19)	73.7	0.0	0.0	100.0	100.0	0.0	71.4	100.0	100.0
Research scientist (*n* = 18)	88.9	100.0	0.0	100.0	100.0	0.0	85.7	100.0	100.0
Research scientist, nonengineering (*n* = 14)	21.4	0.0	0.0	0.0	0.0	0.0	28.6	0.0	50.0
Entrepreneur (*n* = 15)	13.3	0.0	0.0	100.0	0.0	0.0	0.0	0.0	50.0
Other (*n* = 11)	9.1	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0
Curricular changes[2] (*n* = 21)									
Supplement existing course	66.7	100.0	0.0	50.0	100.0	100.0	50.0	100.0	75.0
Develop new course	23.8	0.0	0.0	0.0	100.0	0.0	25.0	0.0	50.0
Create new program	9.5	0.0	0.0	0.0	0.0	0.0	12.5	33.3	0.0
Create new degree/certificate program	14.3	0.0	0.0	50.0	0.0	0.0	12.5	0.0	25.0
Generate professional development materials	9.5	0.0	0.0	0.0	0.0	0.0	12.5	0.0	25.0
No curricular changes	28.6	0.0	100.0	50.0	0.0	0.0	37.5	0.0	25.0

Source: EFRI PI Pilot Survey, 2015

[1] *Note: Responses for student career pathways indicate the percentage of respondents that reported any graduate or postdoctoral students moving into these positions.*

[2] *Note: Responses for curricular change sum to more than 100 because respondents could choose more than one option.*

Table III.13.
EFRI Student Successes and Curricular Changes by Grant Topic

	PI Survey													
	All Grants	2-DARE	ARES	BIOFLEX	BSBA	CBE	HYBI	M3C	MIKS	ODISSEI	PSBR	RESIN	RESTOR	SEED
Number of students in lab of different discipline (n = 21)	3.8	--	2.0	3.0	7.5	4.0	1.3	--	2.0	3.0	--	4.3	--	3.0
Number of students in a lab outside the home institution (n = 19)	2.3	--	6.0	--	5.0	1.3	1.7	--	2.0	1.0	--	1.0	--	0.0
Student career pathways[1]														
Postdoctoral position (n = 21)	81.0	--	50.0	100.0	75.0	100.0	100.0	--	100.0	66.7	--	66.7	--	100.0
Tenure- track position (n = 19)	73.7	--	100.0	0.0	75.0	100.0	50.0	--	100.0	33.3	--	100.0	--	0.0
Research scientist (n = 18)	88.9	--	100.0	0.0	100.0	100.0	100.0	--	100.0	100.0	--	66.7	--	0.0
Research scientist, nonengineering (n = 14)	21.4	--	0.0	0.0	50.0	33.3	0.0	--	0.0	0.0	--	0.0	--	0.0
Entrepreneur (n = 15)	13.3	--	0.0	100.0	0.0	33.3	0.0	--	0.0	0.0	--	0.0	--	0.0
Other (n = 11)	9.1	--	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0	--	33.3	--	0.0
Curricular changes[2] (n = 21)														
Supplement existing course	66.7	--	100.0	100.0	75.0	66.7	33.3	--	100.0	33.3	--	66.7	--	100.0
Develop new course	23.8	--	50.0	0.0	25.0	33.3	33.3	--	100.0	0.0	--	0.0	--	0.0
Create new program	9.5	--	0.0	0.0	25.0	33.3	0.0	--	0.0	0.0	--	0.0	--	0.0
Create new degree/certificate program	14.3	--	0.0	100.0	25.0	33.3	0.0	--	0.0	0.0	--	0.0	--	0.0
Generate professional development materials	9.5	--	50.0	0.0	0.0	0.0	33.3	--	0.0	0.0	--	0.0	--	0.0
No curricular changes	28.6	--	0.0	0.0	25.0	33.3	33.3	--	0.0	66.7	--	33.3	--	0.0

-- Missing

Source: EFRI PI Pilot Survey, 2015

[1] *Note: Responses for student career pathways indicate the percentage of respondents that reported any graduate or postdoctoral students moving into these positions.*

[2] *Note: Responses for curricular change sum to more than 100 because respondents could choose more than one option.*

Table III.14
EFRI Student Interest in Career Pathways

Student Survey	
	Percent
Students possessing a clear career goal at onset of EFRI research (*n* = 123)	60.2
Duration of student involvement in EFRI-related research (*n* = 116)	
Less than 1 year	13.8
1 year	12.1
2 years	23.3
3 years	18.1
4 years or more	32.8
Initial moderate to high student interest in—	
Faculty position at research-intensive university (*n* = 125)	58.4
Faculty position at teaching-intensive university (*n* = 123)	36.6
Nonacademic research career (*n* = 124)	73.4
Nonresearch career (*n* = 124)	36.3
Current moderate to high student interest in—	
Faculty position at research-intensive university (*n* = 123)	66.7
Faculty position at teaching-intensive university (*n* = 122)	40.2
Nonacademic research career (*n* = 122)	77.9
Nonresearch career (*n* = 121)	46.3
Difference between current and initial moderate to high student interest in—	
Faculty position at research-intensive university	8.3
Faculty position at teaching-intensive university	3.6
Nonacademic research career	4.5
Nonresearch career	10.0

Source: EFRI Pilot Survey, 2015

V. SUMMARY AND CONCLUSION

The EFRI program offers cutting-edge researchers an opportunity to continue interdisciplinary collaborations on ideas at the frontiers of engineering innovation. Given the market successes and applied engineering accomplishments of many EFRI grant recipients, the NSF EFRI Office sought an opportunity to collect data systematically on the long-term results of these EFRI grants, even after funding has ended. NSF Engineering Evaluation and Assessment staff hoped the improvements to the survey questionnaires arising from this pilot could be applied to additional surveys in the future.

To accomplish this goal, the study team used a three-phase study methodology to—

- Align the survey instrument with EFRI program strategic plans.
- Provide direct feedback on the clarity, redundancy, and burden of the data collection methods for EFRI PIs, co-PIS, and students.
- Supply NSF staff members with three databases housing long- and short-term successes associated with EFRI grants.

There are two major sets of findings outlined in the report. First, we provide process recommendations to improve the existing EFRI instrument and for fielding new surveys in other NSF programs. Second, we summarize the sample characteristics and key grant successes for the EFRI PI and co-PI pilot surveys.

NSF approached this study with two key goals for the survey process: reduce survey burden and determine the best processes for fielding an online survey for grantees. The cognitive interviews and pilot test indicate the importance of survey logic, skip patterns, and easy-to-recall reference periods for fielding surveys. The survey logic and skip patterns reduce the length of the survey and the burden associated with answering questions that are not relevant to a particular respondent. Additional clarity in question wording and reference periods assists respondents with recall, and articulating how the survey's results will influence program changes illustrates the survey's value, which can motivate respondents to complete the survey.

Results from the pilot survey indicate that in instances where PIs are unable to assess the answer immediately, they are unlikely to refer to their CV or most recent annual report for details. Therefore, as the EFRI Office fields additional surveys at regular intervals, questions should refer to a recent time interval. A decision must be made between the potential redundancy of information that *could* be included in an annual report and the data needed from the collection effort. Questions geared to individual contact information or individual experiences of colleagues should be kept to a minimum and asked directly of those individuals.

The PI EFRI Pilot Survey achieved a 70-percent response rate, significantly higher than the more typical 50-percent response rates experienced with online surveys. Respondents with closed grants and grants of longer duration were less likely to respond to the survey than those with active grants or grants of shorter duration. However, those with closed grants and grants of longer duration reported more company partnership conversations, research community usage of grant products, creation of startups, new licensing efforts, additional grant funding, and interdisciplinary co-authorship.

The item response rate on new accomplishments and speaking roles provided limited information. However, the respondents who offered qualitative information about the accomplishments also indicated that receiving the EFRI grant contributed to their accomplishments in a significant way.

Finally, a larger portion of graduate students involved with EFRI grants later moved to postdoctoral positions, tenure-track positions, and research scientist positions in the engineering field compared to those who left the engineering field or became entrepreneurs. Results were not overwhelmingly positive with regard to changes as a result of EFRI grants, though these items also suffered from low item-response rates. Overall, more PIs created supplementary materials to existing courses than to developing a new course, program, or professional development materials with their EFRI grants.

Both sets of findings indicate the EFRI Pilot Outcome Monitoring System was successful. It—

- Provided new results not accessed and summarized through the RPPR system
- Minimized the burden to respondents through a survey taking fewer than 30 minutes
- Provided data indicative of more long-term successes to come as a result of EFRI program funding

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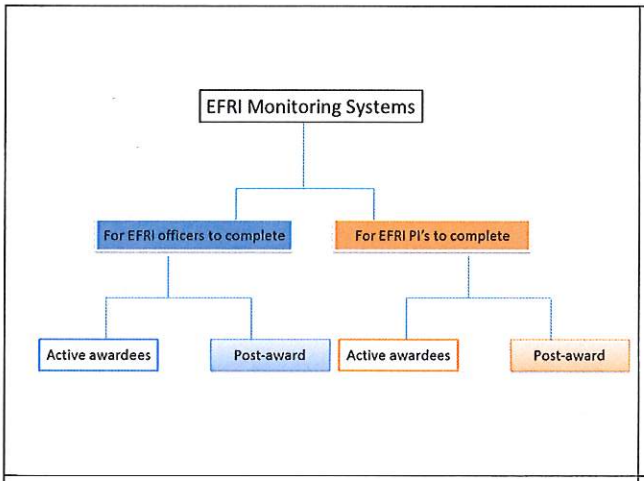
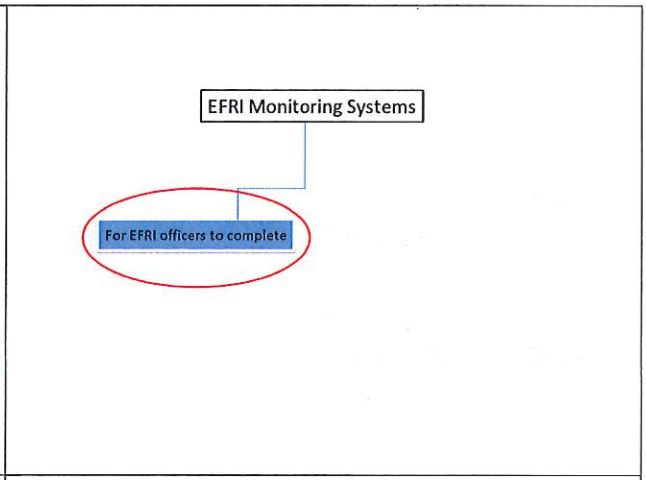
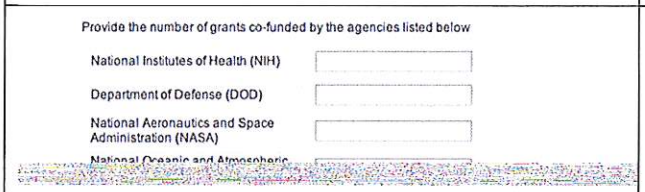
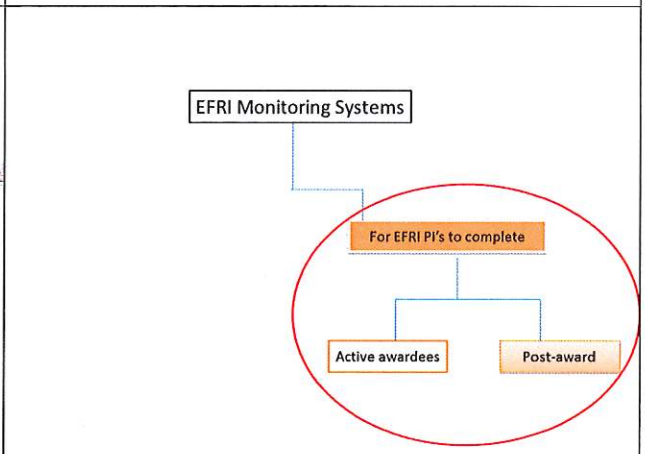
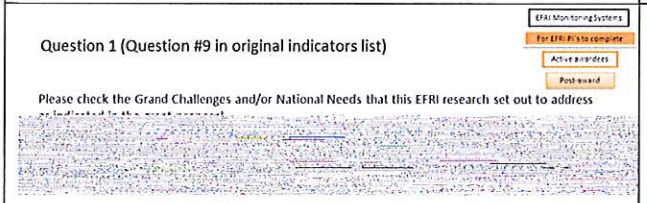
APPENDIX A. NSF'S EFRI PRELIMINARY QUESTIONNAIRE

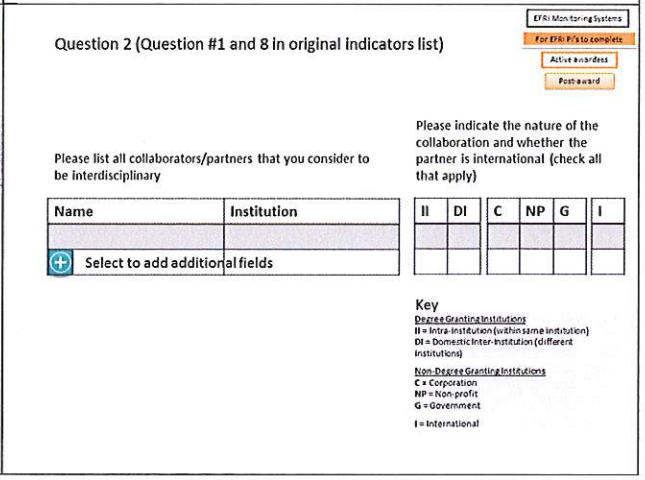












EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Question 3 (Question #2 in original indicators list)

Number of accepted publications with co-authors from different disciplines

field only

Question 4 (Question #4 in original indicators list)

Please list all achievements of all the PI's involved in the EFRI research in the appropriate category

PI Name	Achievement	Description
Lead PI (name pre-populated)	Recognition Awards Leadership Roles Promotions Other	
Select to add additional fields		
Co-PI #1 (name pre-populated)		
Select to add additional fields		
Co-PI #2 (name pre-populated)		
Select to add additional fields		
Etc...		

Question 5 (Question #5 and 10 in original indicators list)

Has this research generated additional funding from other sources (other NSF programs or other agencies) for all PI's and Co-PI's involved in this EFRI project research?
Please collect this data for all PI's listed below.
Past-PI's are displayed in gray, with option to add information if additional funding is in any way related to the EFRI research

PI Name	Grant Title	Agency	> $2 Million/ grant
Lead PI (name pre-populated)			Yes/No
Select to add additional fields			
Co-PI #1 (name pre-populated)			
Select to add additional fields			
Co-PI #2 (name pre-populated)			
Select to add additional fields			
Etc...			

Question 6 (Question #6 in original indicators list)

Please list any researchers who have spent more than 10% of their time in a laboratory at a different institution (including EFRI partner laboratories)

Name	Host Institution	Title
		PI Co-PI Research Faculty Post-Doctorate Graduate Student Undergraduate Research Assistant Visiting Researcher Other
Select to add additional fields		

Question 7 (Question #11 in original indicators list)

Please list any companies or start-ups that were developed directly or indirectly based on the research funded by EFRI

Companies/Start-Ups	Product/Service/or Process	Description of Product/Service/or Process	Year Founded
	Product Service Process Other		
Select to add addit			

Question 8 (Question #13 in original indicators list)

Please answer the following questions about any licensing activity that has resulted from your EFRI research

Technology being licensed	Type of license	Year of licensing agreement
	Patent Other	
Select to add additional fiel		

Question 9 (Question #14 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Please list any companies that have demonstrated interest in partnering activities related to your EFRI research. Please gather this information from all leadership in the EFRI grant.

Company	Please describe nature of interest for partnership
	Continued Conversations Monetary Commitment Contractual Agreement Other
Select to add additional fields	

Question 10 (Question #15 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Post-award

Post award monitoring systems only

Please list new research capabilities resulting from EFRI research that is being utilized and adopted by the research community in the appropriate categories

Description	Type
	Technique or Method Tool or Equipment Resource Model Device Other
Select to add additional fields	

Question 10 (Question #15 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Post-award

Post award monitoring systems only

Please list new research capabilities resulting from EFRI research that is being utilized and adopted by the research community in the appropriate categories

Description	Type
	Technique or Method Tool or Equipment Resource Model Device Other
Select to add additional fields	

Question 11 (Question #16, 17, and 18 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Please indicate if this EFRI research has led to curriculum changes at any educational level, collegiate or pre-collegiate

Curriculum change	Describe	Education Level
New Course Supplement to existing course Course Substitution New Program Program modification Other		PK-12 College
Select to add additional fields		

Question 12 (Question #20 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Post-award

Post award monitoring systems only

Please provide the following information about former EFRI-supported students who have become involved in high-risk/ high-reward research.

Name	Current Title	Field of Research
	PI Staff Scientist Post Doctorate Graduate Student Undergraduate Research Assistant Visiting Researcher Other	
Select to add additional fields		

Could possibly pre-populate fields with names of researchers from RPPR

Question 13 (Question #21 in original indicators list)

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Please list new indicators of new research communities that have formed around EFRI topics

New Meetings/ Conferences	New Journals	New Workshops/ Working groups	News coverage/ press release	Other (ex: congressional hearings, website, social-media, professional society)
Select to add additional fields				

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Question 14 (Question #22 and 23 in original indicators list)

Your research team, including senior, stipend, for-credit, and volunteer personnel will be contacted to collect information on demographics and career path decisions. Please list all researchers that have participated in the EFRI research.

Name	Email	Role in the laboratory
		Research Faculty Post-Doctorate Graduate Student Undergraduate Research Assistant Visiting Researcher Other

Select to add additional fields

Could possibly pre-populate fields with names of researchers from RPPR (capturing current and past trainees within the grant)

- Auto-generate different emails for different categories of researchers (ie. Grad students, post-docs, etc.) to be sent out to those participants asking them the following questions found on the following slides

Please list any significant achievements that resulted from your EFRI research involvement.

Achievement	Describe
conference presentation awards scholarships/fellowships recognition other	

dditional fields

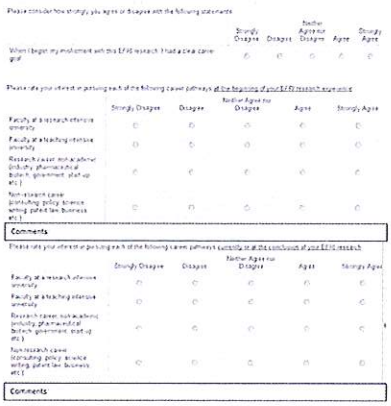
Please list any outreach activities you participated in for work related to your EFRI project?

Formal Education	Describe
guest lecture class instruction webinars other	

d additional fields

Informal Education	Describe
public speaking museum exhibit participation	

Questions sent to students



APPENDIX B. ONLINE SURVEY EMAILS

A. INVITATION EMAILS

1. Principal Investigators

Dear EFRI Principal Investigator:

I hope this note finds you well. I am writing in follow-up to an email you received from Dr. Sohi Rastegar, the EFMA Director at NSF. Insight Policy Research is conducting a survey on behalf of NSF's Directorate for Engineering, collecting data from all past and present Emerging Frontier in Research and Innovation (EFRI) Principal Investigators on long-term accomplishments related to their grants.

We hope you can respond to this important survey by **March XX, 2015.**

This survey will take less than 30 minutes of your time. We would like to collect key data about your interdisciplinary collaboration, individual leadership roles, and new products related to the EFRI grant, not tracked through existing annual reports. This data will be used to improve the program. Results will only be shared in the aggregate, and specific findings will not be attributed to particular individuals.

Please click this link to begin.

We at Insight and NSF know how busy your schedules are, and we appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link"), title="Unsubscribe"]

2. Co-Principal Investigators

Dear EFRI Co-Principal Investigator:

I hope this note finds you well. I am writing in follow-up to an email you received from Dr. Sohi Rastegar, the EFMA Director at NSF. Insight Policy Research is conducting a survey on behalf of NSF's Directorate for Engineering, collecting data from all past and present Emerging Frontier in Research and Innovation (EFRI) Co-Principal Investigators on long-term accomplishments related to their grants.

We hope you can respond to this important survey by **March XX, 2015.**

This survey will take less than 30 minutes of your time. We would like to collect key data about your interdisciplinary collaboration, individual leadership roles, and new products related to the EFRI grant, not tracked through existing annual reports. This data will be used to improve the program. Results will only be shared in the aggregate, and specific findings will not be attributed to particular individuals.

Please click on this link to begin.

We at Insight and NSF know how busy your schedules are, and we appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link"), title="Unsubscribe"]

B. FIRST REMINDER EMAILS

1. Principal Investigators

Dear EFRI Principal Investigator:

This email is a reminder on behalf of NSF's Directorate for Engineering for you to complete the following survey. The survey will collect data from all past and present Emerging Frontier in Research and Innovation (EFRI) Principal Investigators on long-term accomplishments related to their grants.

Please click this link to begin.

We hope you can respond to this important survey by **March XX, 2015.**

We appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link"), title="Unsubscribe"]

2. Co-Principal Investigators

Dear EFRI Co-Principal Investigator:

This email is a reminder on behalf of NSF's Directorate for Engineering for you to complete the following survey. The survey will collect data from all past and present Emerging Frontier in Research and Innovation (EFRI) Co-Principal Investigators on long-term accomplishments related to their grants.

Please click on this link to begin.

We hope you can respond to this important survey by **March XX, 2015.**

We appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below: [invite("unsubscribe link"), title="Unsubscribe"]

C. FINAL REMINDER EMAILS

1. Principal Investigators

Dear EFRI Principal Investigator:

This email serves as a final reminder on behalf of NSF's Directorate for Engineering for you to complete the following survey. The survey will collect data from all past and present Emerging Frontier in Research and Innovation (EFRI) Principal Investigators on long-term accomplishments related to their grants.

Please click this link to begin.

We hope you can respond to this important survey by **March XX, 2015.**

We appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link"), title="Unsubscribe"]

2. Co-Principal Investigators

Dear EFRI Co-Principal Investigator:

This email will serve as a final reminder on behalf to complete the following survey from NSF's Directorate for Engineering. The survey will collect data from all past and present Emerging Frontier in Research and Innovation (EFRI) Co-Principal Investigators on long-term accomplishments related to their grants.

Please click on this link to begin.

We hope you can respond to this important survey by **March XX, 2015.**

We appreciate you sharing your time to further NSF's objectives.

If you have any questions about the survey or its administration, please contact Meg Trucano by phone at 571-758-5006 or by email at mtrucano@insightpolicyresearch.com.

Sincerely,
Meg Trucano

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link"), title="Unsubscribe"]

D. THANK-YOU EMAILS

1. Principal Investigators

Dear Principal Investigator:

On behalf of NSF, we would like to thank you very much for your time in completing the NSF EFRI Principal Investigator survey. Your responses are very important to us.

If you have any questions about the survey or its administration, please contact Meg Trucano at Insight Policy Research using the contact information below.

Meg Trucano, Ph.D.
Insight Policy Research, Inc.
(571) 758-5006
mtrucano@insightpolicyresearch.com

This message was sent by [account("physical address")]. To unsubscribe, click below:
[invite("unsubscribe link")]

2. Co-Principal Investigators

Dear Co-Principal Investigator:

On behalf of NSF, we would like to thank you very much for your time in completing the NSF EFRI Co-Principal Investigator survey. Your responses are very important to us.

If you have any questions about the survey or its administration, please contact Meg Trucano at Insight Policy Research using the contact information below.

Meg Trucano, Ph.D.
Insight Policy Research, Inc.
(571) 758-5006
mtrucano@insightpolicyresearch.com

APPENDIX C. ITEM NONRESPONSE

Item Response Rates Below 75 Percent by Question

		Response Rate			
Item		Eligible Respondents	Number	Percent	Key Nonresponse Factor
PI Survey					
pq6a	Company One - Name	59	35	59.3	Confidentiality
pq7b	Provisional license – Number of discussions	80	45	56.3	Skip Logic
pq7c	Pending license - Number of discussions	80	45	56.3	Skip Logic
pq7d	Issued license - Number of discussions	80	48	60.0	Skip Logic
pq7e	Other - Number of discussions	80	33	41.3	Skip Logic
pq8a1	Planned license - Name/Brief Description	37	15	40.5	Cascade
pq8b1	Provisional license - Name/Brief Description	42	6	14.3	Cascade
pq8c1	Pending license - Name/Brief Description	41	5	12.2	Cascade
pq8d1	Issued license - Name/Brief Description	41	9	22.0	Cascade
pq8e1	Other license - Name/Brief Description	51	5	9.8	Cascade
pq8a2	Planned license - Year Licensed	36	2	5.6	Cascade
pq8b2	Provisional license - Year Licensed	40	3	7.5	Cascade
pq8c2	Pending license - Year Licensed	40	2	5.0	Cascade
pq8d2	Issued license - Year Licensed	39	7	18.0	Cascade
pq8e2	Other license - Year Licensed	49	3	6.1	Cascade
pq9a	Planned license - Patented	65	46	70.8	Cascade
pq9b	Provisional license - Patented	65	37	56.9	Cascade
pq9c	Pending license - Patented	63	38	60.3	Cascade
pq9d	Issued license - Patented	63	37	58.7	Cascade
pq9e	Other license - Patented	69	29	42.0	Cascade
pq18	Describe new research communities	61	43	70.5	Recall
pq23	Have you received - Leadership role	80	13	16.3	Recall
pq24a	Have you received - Promotion	80	13	16.3	Recall
pq24b	Have you received - Award	80	13	16.3	Recall
pq24c	Have you received - Other	80	13	16.3	Recall
pq24d	Have you received - None of the above	80	21	26.3	Recall
pq25a	How many - Leadership role	72	4	5.6	Cascade
pq25b	How many - Promotion	72	5	6.9	Cascade
pq25c	How many - Award	72	8	11.1	Cascade
pq25d	How many - Other	60	1	1.7	Cascade
pq26a	How important was EFRI - Leadership role	72	4	5.6	Cascade
pq26b	How important was EFRI - Promotion	72	5	6.9	Cascade
pq26c	How important was EFRI - Award	72	8	11.1	Cascade
pq26d	How important was EFRI - Other	60	1	1.7	Cascade

Item Response Rates Below 75 Percent by Question, continued

Item		Response Rate			
		Eligible Respondents	Number	Percent	Key Nonresponse Factor
PI Survey, continued					
pq27a	Details - Leadership role	63	4	6.3	Cascade
pq27b	Details - Promotion	64	5	7.8	Cascade
pq27c	Details - Award	67	8	11.9	Cascade
pq28a	How many - Plenary or keynote talk	80	22	27.5	Skip Logic
pq28b	How many - Invited talk at your own institution	80	19	23.8	Skip Logic
pq28c	How many - Invited talk at a different institution	80	21	26.3	Skip Logic
pq28d	Co-authored any publications with authors from different disciplines	80	22	27.5	Recall
pq29a	Have students - Worked in a lab in a different discipline	80	21	26.3	Recall
pq29b	Have students - Worked in a lab at a different institution	80	19	23.8	Recall
pq30a	Have students - Post-doctoral appointment/fellowship	80	21	26.3	Recall
pq30b	Have students - Tenure-track faculty position	80	19	23.8	Skip Logic
pq30c	Have students - Research scientist in an industry position	80	18	22.5	Skip Logic
pq30d	Have students - Research scientist in a non-engineering field	80	14	17.5	Skip Logic
pq30e	Have students -Entrepreneur	80	15	18.8	Skip Logic
pq30f	Have students - Other	80	11	13.8	Skip Logic
pq32a	Planned - Supplement an existing course	74	15	20.3	Recall
pq32b	Planned - Development of a new course	74	15	20.3	Recall
pq32c	Planned - Creation of a new program	74	15	20.3	Recall
pq32d	Planned - Creation of a new degree or certificate program	74	15	20.3	Recall
pq32e	Planned - Course substitution	74	15	20.3	Recall
pq32f	Planned - Program modification	74	15	20.3	Recall
pq32g	Planned - Professional development material	74	15	20.3	Recall
pq32h	Planned - No curricular changes	80	21	26.3	Recall
pq32i	Planned - Other changes	74	15	20.3	Recall
pq32i2	Planned - Other (please describe)	74	0	0.0	Recall
pq33a	Level - Supplement to an existing course	74	14	18.9	Cascade
pq33b	Level - Development of a new course	74	5	6.8	Cascade
pq33c	Level - Creation of a new program	74	2	2.7	Cascade
pq33d	Level - Creation of a new degree or certificate program	74	3	4.1	Cascade
pq33e	Level - Professional development	74	2	2.7	Cascade
pq34a	Implemented - Supplement to an existing course	74	14	18.9	Cascade
pq34b	Implemented - Development of a new course	74	5	6.8	Cascade
pq34c	Implemented - Creation of a new program	74	2	2.7	Cascade

Item Response Rates Below 75 Percent by Question, continued

Item		Response Rate			
		Eligible Respondents	Number	Percent	Key Nonresponse Factor
PI Survey, continued					
pq34d	Implemented - Creation of a new degree or certificate program	74	3	4.1	Cascade
pq34e	Implemented - Professional development material	74	2	2.7	Cascade
pq35	Have you continued with the line of research that was funded through the EFRI grant?	23	16	69.6	Sample Size
pq36	How many new members have you added to your team in order to continue research related to your EFRI topic?	23	16	69.6	Sample Size
pq37a	New team member - Name	23	11	47.8	Confidentiality
pq37b	New team member - Email	23	9	39.1	Confidentiality
pq37c	New team member - Role	23	6	26.1	Cascade
pq38a	New team member - Name	23	9	39.1	Cascade
pq38b	New team member - Email	23	8	34.8	Cascade
pq38c	New team member - Role	23	6	26.1	Cascade
pq39a	New team member - Name	23	12	52.2	Cascade
pq39b	New team member - Email	23	10	43.5	Cascade
pq39c	New team member - Role	23	6	26.1	Cascade
pq40a	New team member - Relationship	23	12	52.2	Cascade
pq40b	New team member - Relationship	23	10	43.5	Cascade
pq40c	New team member - Relationship	23	6	26.1	Cascade
pq45	EFRI Grant Number	80	18	22.5	Recall
Co-PI Survey					
cq8	Have you received - Leadership role	59	30	50.9	Recall
cq9a	Have you received - Promotion	59	34	57.6	Recall
cq9b	Have you received - Award	58	34	58.6	Recall
cq9c	Have you received - Other	58	29	50.0	Recall
cq9e	Have you received - Other, describe	58	4	6.9	Recall
cq16c	EFRI Grant Number	174	128	73.6	Recall
Student Survey					
sq6	Additional comments or feedback about your experience	131	31	23.7	Fatigue

Source: EFRI PI Pilot Survey, 2015

EMERGING FRONTIERS IN RESEARCH AND INNOVATION

PILOT PROGRAM MONITORING SYSTEM

Overview

- Information Briefing Roadmap
  - Introduction and Approach
  - Survey Process Findings
  - Pilot Survey Results
  - Conclusions
- EFRI Program
  - EFRI supports engineering discoveries through investment in interdisciplinary research that pushes the envelope of innovation
- Efforts to Date
  - EFRI funded 115 grants across 14 topic areas between 2007 and 2014

PROJECT GOALS

- ENG/EFRI Goals:
  - Capture long-term outcomes for EFRI Grantees that extend beyond the life of the Grant
  - Revise and streamline the existing EFRI questionnaire with attention to respondent burden and response rates
- Insight's Project Goals
  - Gather feedback on the original questionnaire
  - Provide survey process recommendations for future surveys
  - Compile, edit, and analyze results from the pilot survey

EFRI Program Activities and Goals

Grantee Activities

- Engage in interdisciplinary collaboration
- Involve students in interdisciplinary work
- Disseminate new research ideas
- Engage students from underrepresented groups

Short and Long Term Outcomes

- Partner with companies
- Continue project funding
- Establish curricular changes
- Introduce new research fields

Approach

- Logic Model Assessment
- Data Collection
  - Cognitive Interviews
    - Program directors (n = 3)
    - Principal investigators (n = 11)
    - Students (n = 4)
  - Pilot Surveys
    - Principal investigators (n = 80)
    - Co-principal investigators (n = 175)
    - Students (n = 131)

SURVEY PROCESS FINDINGS AND RECOMMENDATIONS

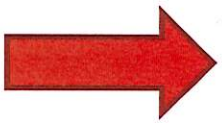
Survey Process Recommendations

- Based on results obtained from the cognitive interviews and pilot surveys, Insight identified two key survey process recommendations
- Recommendation 1: Minimize Respondent Burden
  - Prioritize the use of survey logic and skip patterns
  - Reduce ambiguity and specify response option categories
  - Ask close-ended, quantitative questions
- Recommendation 2: Clarify Key Program Goals
  - Communicate aims and goals of the survey
  - Build on knowledge that respondents have readily available
  - Make future survey administrations an iterative progression toward stated goals

Prioritize Survey Logic and Skip Patterns
(Recommendation 1)

- Central Issue
  - Respondents may skip items that require them to repeatedly indicate "0," "None," or "N/A"
- Recommendations
  - Use filter questions that will guide respondents to items with which they have direct experience
  - Design more pertinent questions, even if it results in an increased number of pages per survey

"How many of the following kinds of licensing discussions or activities have you had related to your EFRI research?"



Filter 1 "Have you had any licensing discussions related to your EFRI researcher?" Yes or No.
Filter 2 If yes, "Select from the following list the kinds of licensing discussions or activities you have had related to your EFRI research. Select all that apply."
Follow-up: "How many *[pending licenses]* do you have related to your EFRI research?"

Reduce Ambiguity and Specify Response Options
(Recommendation 1)

> *"I still have trouble with the [term] 'different disciplines,' because different from what? With authors that'll have different disciplines from each other?. . . It seems to have two definitions here, or two descriptors. One is that since the most recent report, and then, in addition, authors with different disciplines, so I'm wondering why you have both of those."*
>
> *–PI Interview*

- Central Issue
  - Ambiguity can decrease response rates and results in less useful data
- Recommendations
  - Clarify question content
  - Use closed-ended questions with discrete response options
  - Provide mutually exclusive response options

Ask Closed-ended, Quantitative Questions
(Recommendation 1)

"You might be better off asking in general [if] maybe they know approximately how many publications. [PIs] probably could come up with that. But if you ask them for a specific citation, that might be kind of tough."

–PI Interview

- Central Issue
  - Respondents may skip questions that require them to input their own responses
  - Numerous qualitative questions increase respondent burden
- Recommendation
  - Convert open-ended, qualitative questions to closed-ended questions with radio button response options where possible

"Please list the citations for any publications you have authored or coauthored since the submission of your most recent report:"

"How many peer-reviewed publications have you written with authors from disciplines different from your own since your most recent progress report?"

Communicate the Survey's Aims and Goals
(Recommendation 2)

"I don't really have a sense exactly of how this information is going to be used or what the purpose of it is, except in the most vague, general terms. Is this meant to drive potential future EFRI topics? Is it meant to evaluate the health of the EFRI in the sense of, 'Should the EFRI be continued in the future? Is it supposed to assess how to change the EFRI to make it more responsive to whatever it is that NSF wants it to be responsive to?' So that kind of information I think would be helpful and would be motivating."

–PI Interview

- Central Issue
  - Respondents less likely to participate in the survey if the goals and intended use of data are unclear
- Recommendations
  - Include the following in "Welcome" language:
    - Survey duration
    - Why data is being collected
    - How data will be used
    - How respondents' information will be protected
    - What information/materials respondents will need to complete the survey (e.g., CV)

Build on Knowledge Respondents Have Readily Available (Recommendation 2)

"I'm not going to know the details of [Co-PIs'] other proposal writing and things, and so if I had to put a yes or a no there, then that would require me to go and talk to them. I wouldn't be able to just continue with the survey. It would be a stopping point. I'd have to stop and then e-mail them or call them, and it might be 2 days till they respond, and then I have to go find the survey again."

–PI Interview

- Central Issue
  - Asking participants to respond on behalf of another person or group raises validity concerns
  - If respondents must stop to consult another source to answer a question, they are more likely to skip the question or terminate the survey entirely
- Recommendation
  - Administer separate PI and co-PI surveys

Future Surveys: Iterative Progression Toward Goals

- Recommendation One
  - Where possible, prepopulate survey fields to reduce repeated manual entry of unchanging, key identifying information and subsequent respondent burden
- Recommendation Two
  - Build on information from previous surveys so ideally, respondents add only new information to build upon existing successes

> *"If you were thinking of having the survey taken by the same PI more than once you might want to [ensure that by] the third time they take it, it's not asking the same questions but building upon them . . . That way you might get more insight."*
>
> *–PI Interview*

PILOT SURVEY RESULTS

Survey Composition

- Key Survey Findings Presented
  - Sample descriptive statistics
  - Survey burden
  - Company partnerships
  - Licensing activities
  - Research communities
  - Receipt of additional funding
  - Publications
  - PI and Co-PI accomplishments
  - Student trajectories
  - Curricular changes

EFRI Program Activities and Goals

Grantee Activities

- Engage in interdisciplinary collaboration
- Involve students in interdisciplinary work
- Disseminate new research ideas
- Engage students from underrepresented groups

Short and Long Term Outcomes

- Partner with companies
- Continue project funding
- Establish curricular changes
- Introduce new research fields

Additional Survey Topics

- PI Survey (up to 47 questions)
  - Also gathers information on national needs, new team members, grant-related talks and presentations, and qualitative data related to descriptions of the above categories
- Co-PI Survey (up to 13 questions)
  - Also gathers information on additional Funding, presentations, and EFRI students
- Student Survey (up to 11 questions)
  - Also gathers feedback on interdisciplinary lab work and open-ended opportunity for feedback

Survey Burden

	PIs	Co-PIs	Students
Burden (Average)	37 minutes	5 minutes	31 minutes
Burden (Median)	14 minutes	8 minutes	3 minutes
Field Dates	February 26–March 20	March 10–March 24	March 24–March 31

Survey Sample Descriptive Statistics

Response Rates

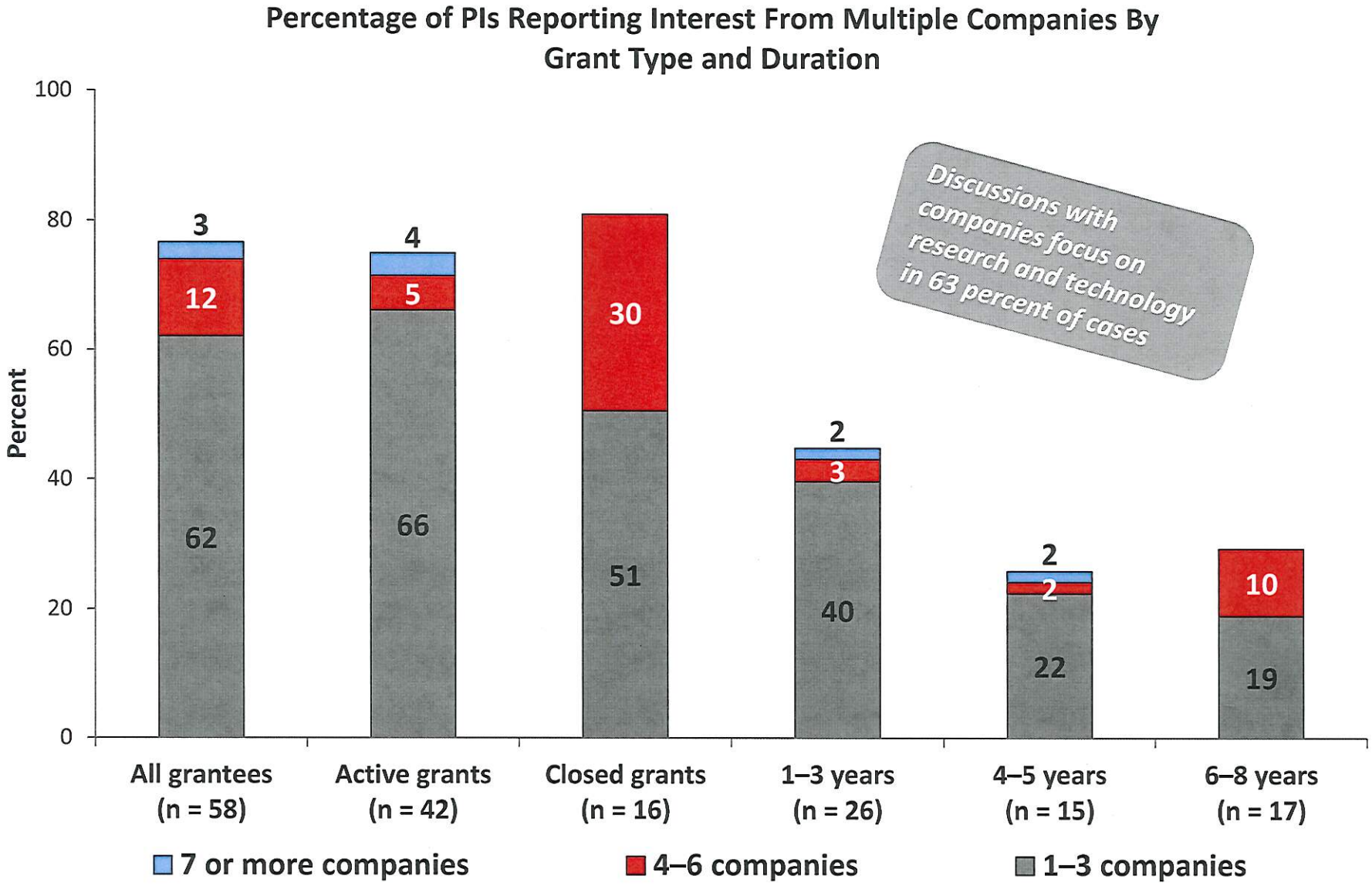
- PI: 70 percent
- Co-PI: 45 percent
- Student: 58 percent

Response Bias

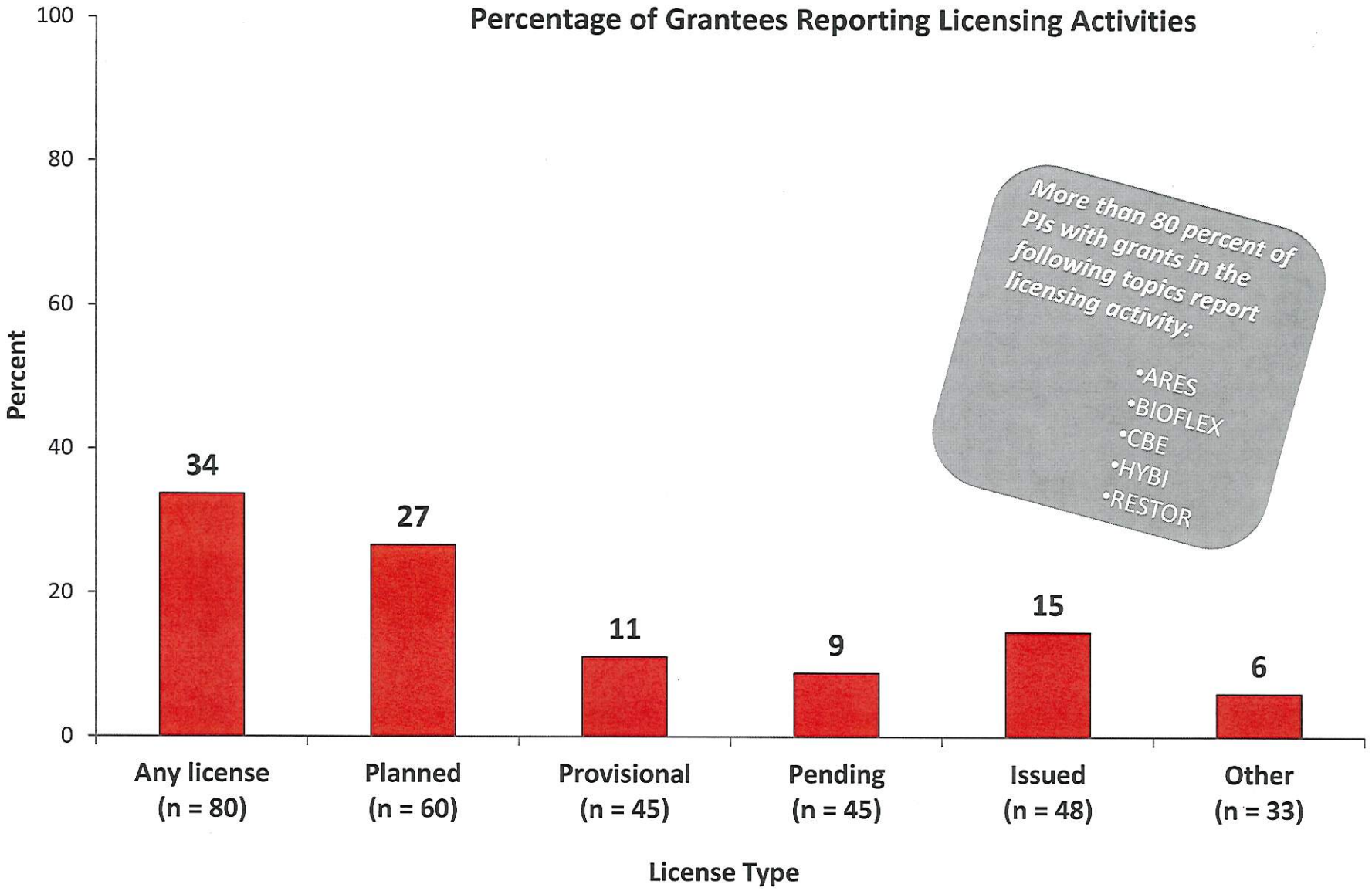
- Response rates were slightly higher for PIs with active grants than for those with inactive grants
- Response rates were lower for PIs and co-PIs with longer grant duration
- Response rates were similar for PIs across all topic areas, with the exception of Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology (COPN)

KEY FINDINGS

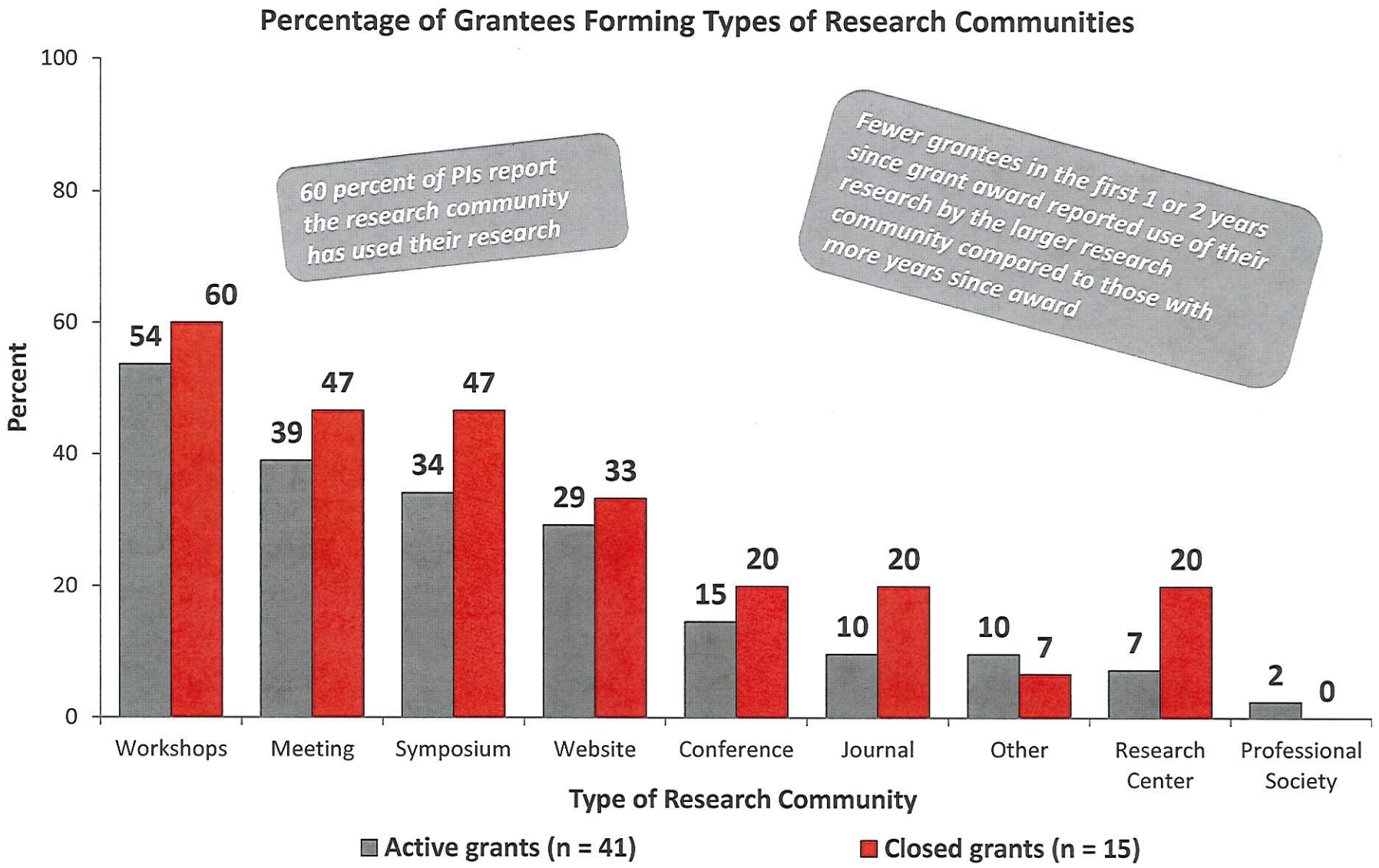
High Rates of Interest from Companies



Licensing Activity



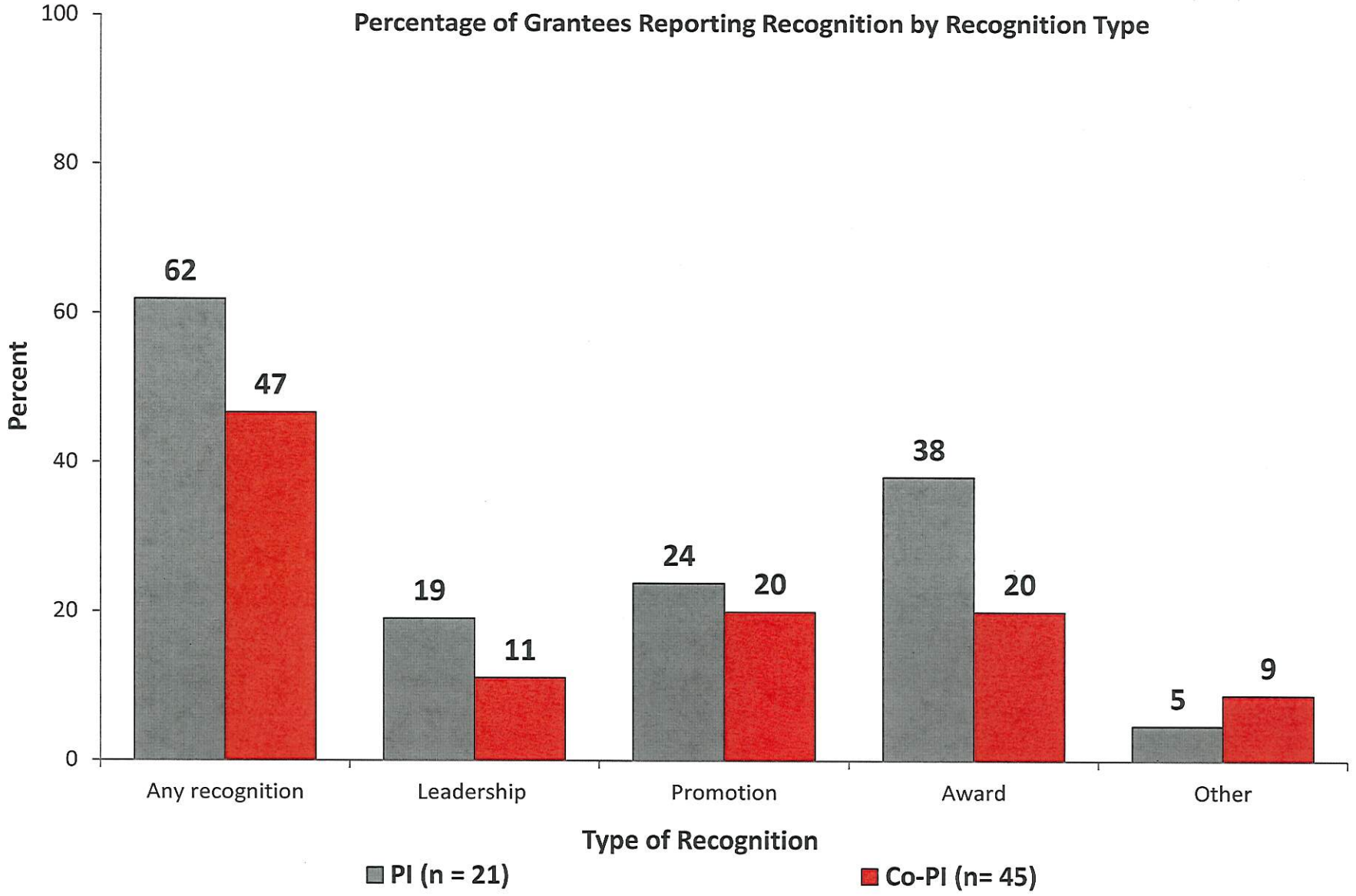
Formation of Research Communities



Generation of Additional Funding

PIs	Co-PIs
• 45 percent reported obtaining additional funding	• 26 percent reported obtaining additional funding
• Total of 54 additional grants	• 38 percent of co-PIs with closed grants reported additional funding
• Average of $1.9 million in additional funding ($5,500–$25 million)	
• PIs with closed grants twice as likely as grantees with active grants to report obtaining additional funding	
• 100 percent of PIs in year 8 reported additional funding	

PI Recognition



Interdisciplinary Collaboration

- PI and co-PI respondents with closed grants more likely to report interdisciplinary authorship (50 percent) than those with active grants (38 percent)
- PIs
  - 55 percent reported completing at least one interdisciplinary peer-reviewed research article
  - Total of 39 articles reported
  - Average of 3.5 articles each
- Co-PIs
  - 41 percent reported completing at least one interdisciplinary peer-reviewed research article

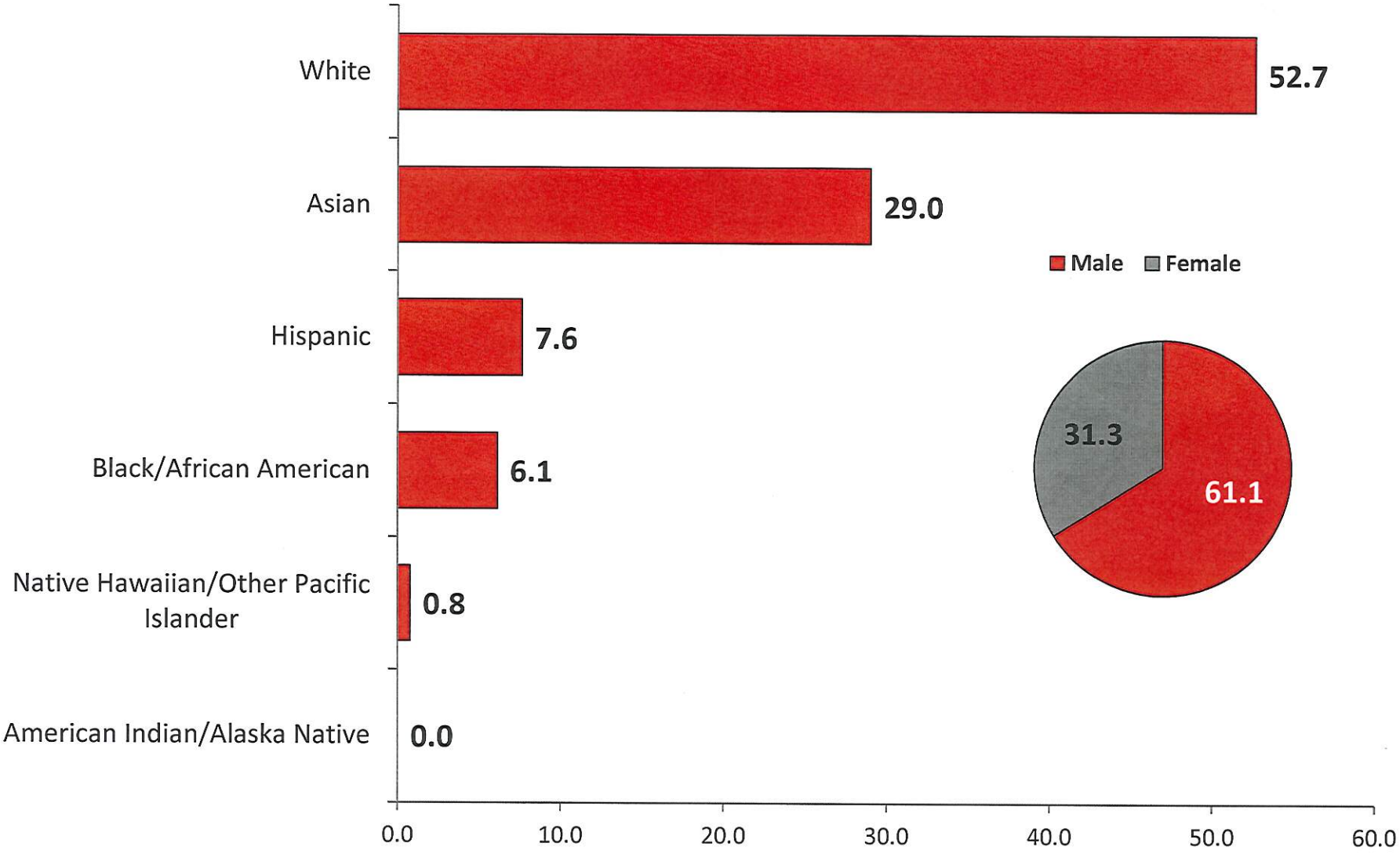
Student Career Pathways

Career Pathway	Prior to EFRI Research	After EFRI Research
Faculty Position (Research-Intensive University)	58 percent	66 percent
Faculty Position (Teaching-Intensive University)	36 percent	40 percent
Non-Academic Research Position	73 percent	77 percent
Non-Research Position	36 percent	46 percent

PIs reported students entering the following career pathways:

- Research scientist positions (89 percent of PIs)
- Postdoctoral appointments (81 percent of PIs)
- Tenure-track positions (74 percent of PIs)
- Non-engineering research scientists, entrepreneurs, and other (less than 25 percent of PIs)

Student Race and Gender



Curricular Changes

- Most commonly reported curricular change, overall
  - Supplementary materials to existing courses developed (66 percent)
- Least commonly reported curricular changes, overall
  - Creation of a new program (< 10 percent)
  - Generation of professional development materials (< 10 percent)
- PIs in later grant stages reported more planned curricular changes

SUMMARY AND CONCLUSION

Summary of Findings

- Grantees are willing to participate in the data collection effort
- Provided data indicative of' long-term successes resulting from EFRI program funding
- EFRI grantees are largely successful, showing positive efforts for the following:
  - Interdisciplinary collaboration
  - Company partnerships
  - Additional grant funding
- Provided new data about grantee outcomes not captured in RPPR system
- Minimized respondent burden; surveys took fewer than 30 minutes (on average)

Next Steps

- Recommendations for future survey iterations
  - Identify a clear sample of EFRI PIs and Co-PIs, updated with each new cohort
  - Note for survey administration the receipt of a second EFRI grant
  - Pre-populate fields with existing RPPR information when possible
  - Select a reasonable time between collection efforts (2+ years)
  - Build on information collected in the previous round
  - Adjust the survey questions to capture new kinds of information as respondents advance in their company partnership and dissemination efforts
  - Inform grantees upon award they may be contacted beyond the life of the grant for occasional, brief (30 minute) web-based surveys

ADDITIONAL DATA

Companies Started Based on PI Research

- PIs reported 13 total startups based on their EFRI research
  - 85 percent utilize a research-based technology or method
- Startups more common for PIs with closed grants
  - PIs 6, 7, or 8 years since grant award were more likely to report startups than PIs with fewer than 6 years since grant award
- PIs in the following topics reported startups based on their EFRI research
  - BIOFLEX
  - BSBA
  - CBE
  - HYBI
  - M3C
  - MIKS
  - RESTOR
  - SEED

Item Nonresponse

Item	Response Rate
PI Survey	
• Licenses (planned, provisional, pending, issued, other) and subsequent follow-up questions	< 60 percent
• Leadership roles (promotions, awards)	< 25 percent
• Student career paths	< 25 percent
• Curricular changes (planned, implemented)	< 25 percent
Co-PI Survey	
• Leadership roles (promotions, awards)	< 50 percent
Student Survey	
• Describe experiences	< 25 percent

Key Nonresponse Factors

Confidentiality

- Respondents skip items due to the perceived confidential or sensitive nature of the question
- ***Retain questions, remain aware some respondents will refrain from full disclosure***

Skip Logic

- Respondents skip items if they must select "0," "None," or "N/A" repeatedly
- ***Include filter questions that direct respondents toward items that directly apply to them***

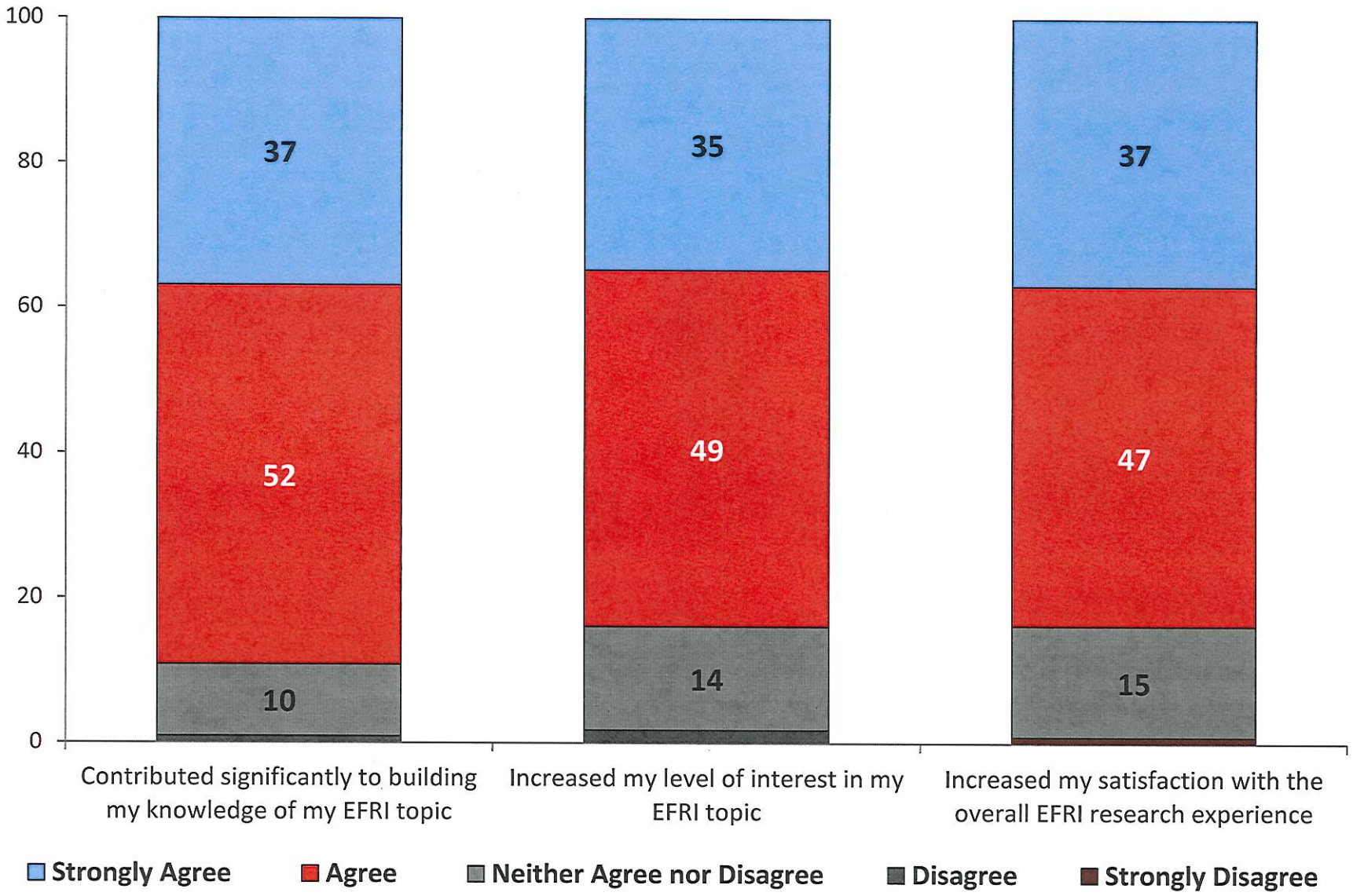
Recall

- Respondents skip items when they cannot recall specific information within a generic time frame (e.g., "since your most recent report")
- ***Refine time frame references (e.g., "within the past 2 years")***

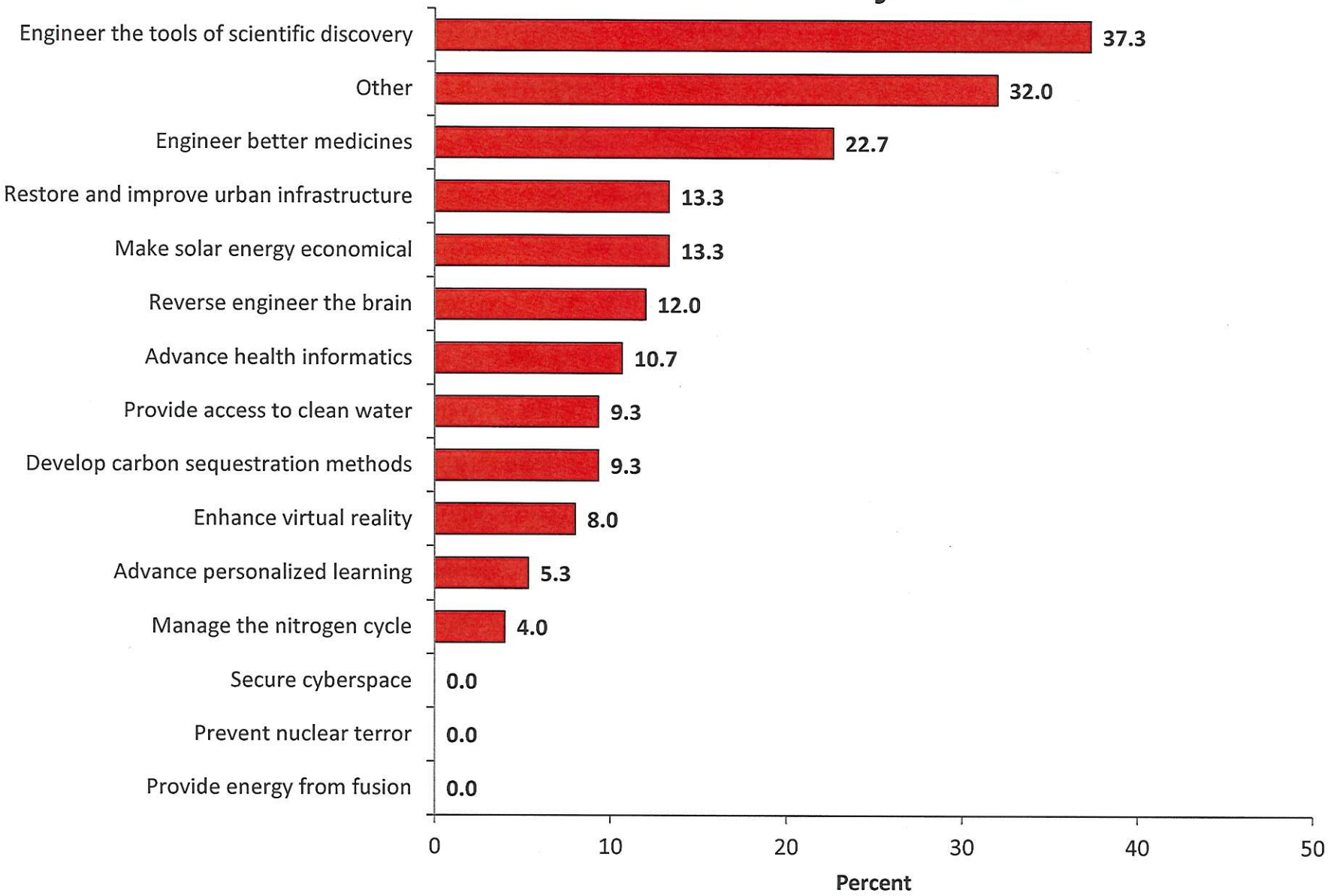
Cascade Effect

- Refers to patterns of nonresponse after an initial key item
- Respondents unlikely to respond to follow-up questions if they skip initial question
- ***Clarify initial items as much as possible to avoid cascade nonresponse effect***

Time Students Spent in Labs Other than their Own



National Needs Addressed by Research



NSF EFRI Principal Investigator Survey

How many of the following kinds of licensing discussions or activities have you had related to your EFRI research?

Planned license	-- Please Select --
Provisional license	-- Please Select --
Pending license	-- Please Select --
Issued license	-- Please Select --
Other	-- Please Select --

Revised PI Survey

Please describe this research or technology:

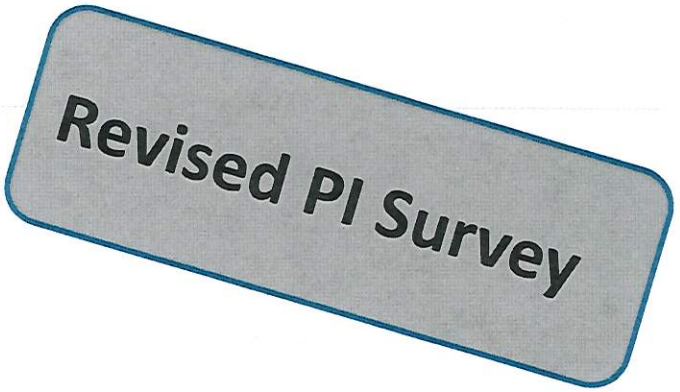
	Name/Brief Description	Year Licensed (If Applicable)
Planned license		
Provisional license		
Pending license		
Issued license		
Other		

Has this technology been patented?

	Yes	No
Planned license	○	○
Provisional license	○	○
Pending license	○	○
Issued license	○	○
Other	○	○

How many companies have been started based on your EFRI-funded research (whether directly or indirectly)?

- ○ 0
- ○ 1-3
- ◉ 4-6
- ○ 7 or more



How did this company/startup use your research?

Company/Startup One	-- Please Select --
Company/Startup Two	-- Please Select --
Company/Startup Three	-- Please Select --
Company/Startup Four	-- Please Select --
Company/Startup Five	-- Please Select --
Company/Startup Six	-- Please Select --

If possible, please provide the following information about these companies or startups:

	1st Company/Startup	2nd Company/Startup	3rd Company/Startup	4th Company/Startup	5th Company/Startup	6th Company/Startup
Name/Description						
Year Founded (If Startup)						

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Question 1 (Question #9 in original indicators list)

Please check the Grand Challenges and/or National Needs that this EFRI research set out to address as indicated in the grant proposal

- ☐ Make solar energy economical
- ☐ Provide energy from fusion
- ☐ Develop carbon sequestration methods
- ☐ Manage the nitrogen cycle
- ☐ Provide access to clean water
- ☐ Restore and improve urban infrastructure
- ☐ Advance health informatics
- ☐ Engineer better medicines
- ☐ Reverse-engineer the brain
- ☐ Prevent nuclear terror
- ☐ Secure cyberspace
- ☐ Enhance virtual reality
- ☐ Advance personalized learning
- ☐ Engineer the tools of scientific discovery
- ☐ National Need

Have there been any changes or additions to the Grand Challenges and/or National Needs that are now being addressed by the active, ongoing research? Yes ○ No ○

If yes, please check all of the Grand Challenges or National Needs that the research now addresses.

- ☐ Make solar energy economical
- ☐ Provide energy from fusion
- ☐ Develop carbon sequestration methods
- ☐ Manage the nitrogen cycle
- ☐ Provide access to clean water
- ☐ Restore and improve urban infrastructure
- ☐ Advance health informatics
- ☐ Engineer better medicines
- ☐ Reverse-engineer the brain
- ☐ Prevent nuclear terror
- ☐ Secure cyberspace
- ☐ Enhance virtual reality
- ☐ Advance personalized learning
- ☐ Engineer the tools of scientific discovery
- ☐ National Need

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Question 2 (Question #1 and 8 in original indicators list)

Please list all collaborators/partners that you consider to be interdisciplinary

Please indicate the nature of the collaboration and whether the partner is international (check all that apply)

Name	Institution	II	DI	C	NP	G	I
⊕ Select to add additional fields							

Key

Degree Granting Institutions
II = Intra-institution (within same institution)
DI = Domestic Inter-institution (different institutions)

Non-Degree Granting Institutions
C = Corporation
NP = Non-profit
G = Government

I = International

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

Question 3 (Question #2 in original indicators list)

Number of accepted publications with co-authors from different disciplines
field only

EFRI Monitoring Systems
For EFRI PI's to complete
Active awardees
Post-award

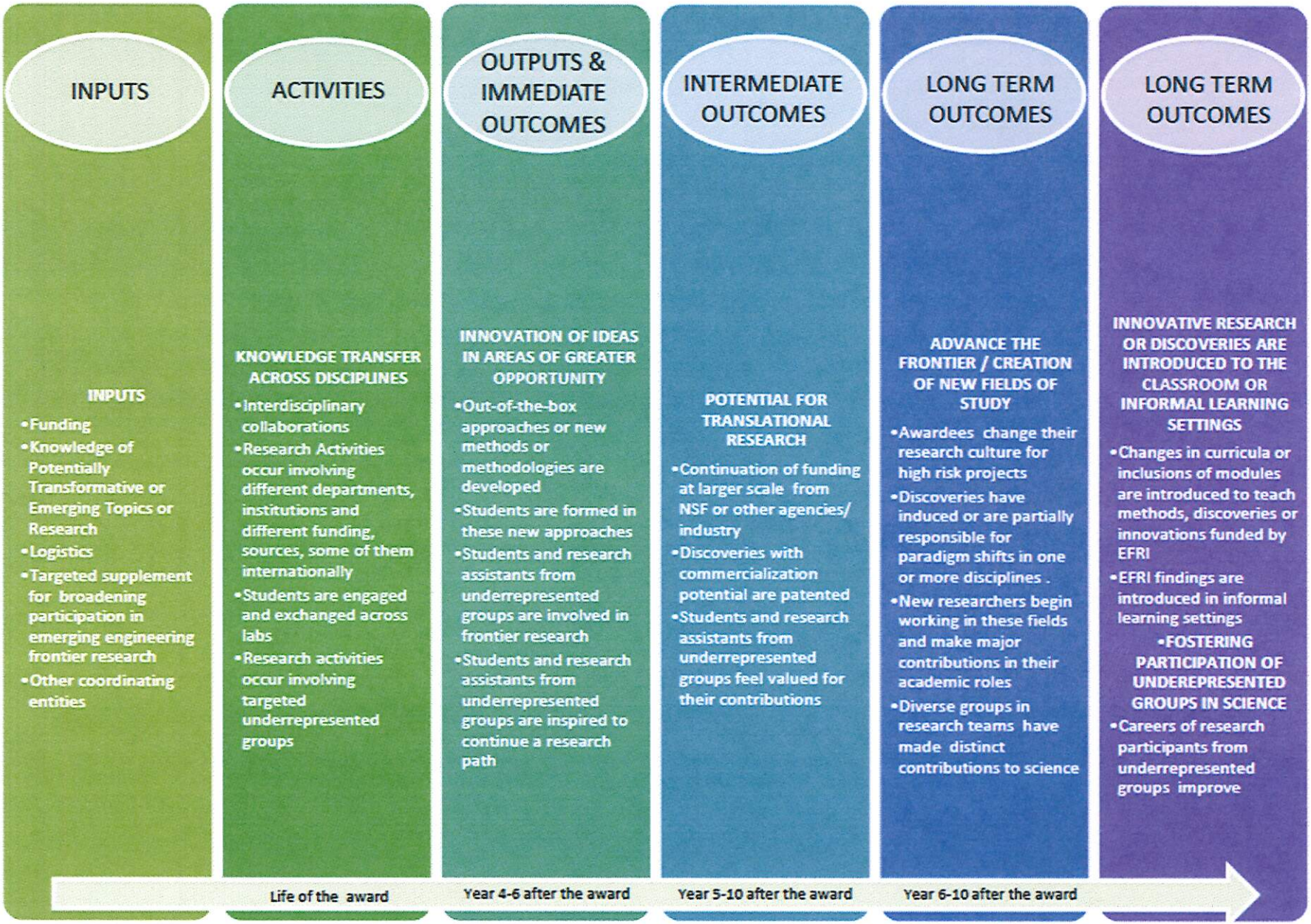
Question 4 (Question #4 in original indicators list)

Please list all achievements of all the PI's involved in the EFRI research in the appropriate category

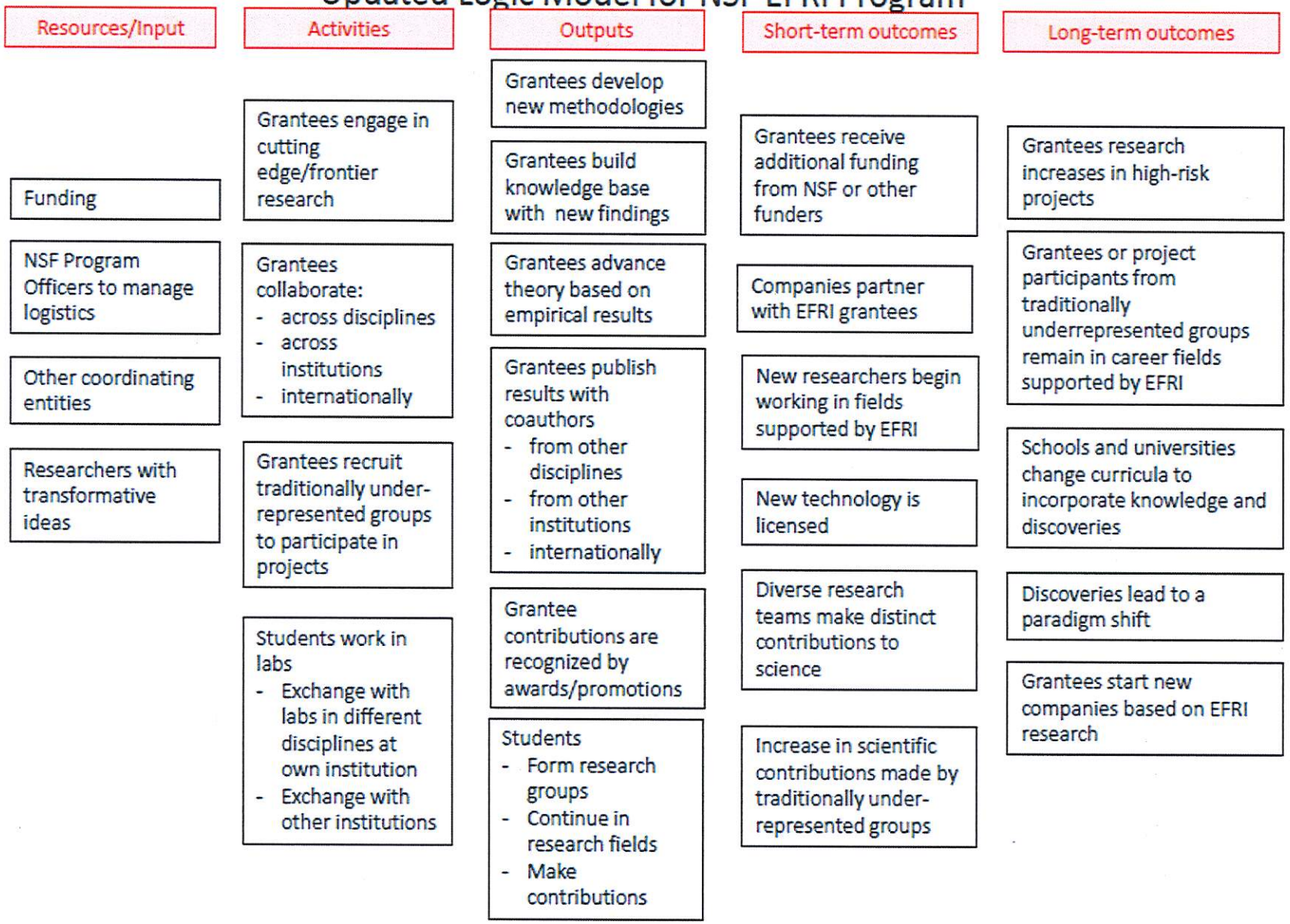
PI Name	Achievement	Description
Lead PI (name pre-populated)	○ Recognition Awards ○ Leadership Roles ○ Promotions ○ Other	
⊕ Select to add additional fields		
Co-PI #1 (name pre-populated)		
⊕ Select to add additional fields		
Co-PI #2 (name pre-populated)		
⊕ Select to add additional fields		
Etc...		

Original PI Survey

EFRI LOGIC MODEL



Updated Logic Model for NSF EFRI Program



EFRI Topics

Abbreviated	Fiscal Year	Title
2-DARE	2014	Two-Dimensional Atomic-Layer Research and Engineering
ARES	2007	Autonomously Reconfigurable Engineered Systems Enabled by Cyberinfrastructure
BIOFLEX	2012–2013	Flexible Bioelectronics Systems
BSBA	2009	Renewable Energy Storage
CBE	2007	Cellular and Biomolecular Engineering
COPN	2008	Cognitive Optimization and Prediction: From Neural Systems to Neurotechnology
HYBI	2009	Hydrocarbons from Biomass
M3C	2011	Mind, Machines, and Motor Control
MIKS	2011	Engineering New Technologies Based on Multicellular and Inter-kingdom Signaling
ODISSEI	2012–2013	Origami Design for Integration of Self-Assembling Systems for Engineering Innovation
PSBR	2012–2013	Photosynthetic Biorefineries
RESIN	2008	Resilient and Sustainable Infrastructure
RESTOR	2010	Renewable Energy Storage
SEED	2010	Science in Energy and Environmental Design