Leveraging the ARIS BI Toolkit to Equip Faculty for Career—and CAREER—Success

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Abstract

Research development professionals at the University of Nebraska-Lincoln (UNL) used the Center for Advancing Research Impact in Society (ARIS) Broader Impacts (BI) Toolkit with early-career faculty preparing grant proposals for the National Science Foundation's Faculty Early Career Development Program (CAREER). This prestigious career-development funding mechanism places unique emphasis on the integration of research and education, positioning awardees to enhance the impact of their research programs through education initiatives like curriculum development, outreach, and community engagement. However, many early-career faculty lack experience or training to develop robust education plans that are thoughtfully aligned with and responsive to their research. With the aim of developing practical ways to help faculty gain these skills, the study team used mixed methods to analyze the integration of research and education in CAREER proposals submitted by UNL faculty. These methods included using the ARIS BI Rubric to evaluate the proposals, convening two panel review discussions, and interviewing principal investigators about their ARIS BI Toolkit use and approach to research-education integration. Case study findings reveal that while effective and impactful integration can take many forms, early-career faculty and those who support them can utilize the ARIS BI Toolkit strategically to strengthen this aspect of grant proposals, positioning faculty to write well-integrated CAREER proposals and potentially contributing to long-term grant-writing and research program success.

Consider a pre-tenure faculty member charting a course for their career. They are simultaneously establishing a lab, generating publications, and writing grant proposals, including one to the prestigious Faculty Early Career Development Program (CAREER) at the National Science Foundation (NSF). The NSF CAREER program supports the development of well-rounded researcher-scholars, encouraging its applicants to value education as part of a robust research program (National Science Foundation, 2024b). Our hypothetical faculty member served as a teaching assistant in graduate school; however, they lack hands-on experience developing education activities or engaging audiences outside the classroom (MacFadden, 2009; Stofer et al., 2022). Thus, they feel unprepared to make education or engagement activities an integral part of their future program of work (Smay, 2007). Our faculty member is at a critical juncture for developing self-efficacy and attitudes around broader impacts—NSF's term for the potential societal benefits of research (National Science Foundation, 2023).

The NSF CAREER program presents a unique opportunity—and challenge—for early-career faculty to develop a professional identity that integrates their long-term research aims with their educational goals. Traditional conceptions of scientists' identities emphasize scholarly contributions, disciplinary affiliation, and communication with professional peers—what NSF terms *intellectual merit* in their Proposal and Award Policies and Procedures Guide (National Science Foundation, 2024a). CAREER, by contrast, aligns with the more expansive

This article is included in a special issue focused on the Implementation and Evaluation of the ARIS Broader Impacts Toolkit project, which is designed to advance the understanding of mechanisms and supports needed to develop effective Broader Impacts (BI) statements. The full issue can be found at https://jces.ua.edu/37/volume/17/issue/2

concept of *impact identity* introduced by Risien and Storksdieck (2018). Impact identity situates a scientist's research in the broader context of their personal skills, capacities, and motivators; their institutional setting; communities and social groups to which they belong; and societal needs. Risien and Storksdieck argue that developing an effective impact identity "results from a *thoughtful and intentional integration* of a scientist's multidimensional self-concept" (2018, p. 58, emphasis added).

In the following case study, conducted at the University of Nebraska-Lincoln (UNL), we consider strategies for leveraging the Center for Advancing Research Impact in Society (ARIS) Broader Impacts (BI) Toolkit (Center for Advancing Research Impact in Society, 2023) to bolster the integration of research and education in CAREER proposals. Informed by the five elements of the NSF BI merit review criterion, the BI Toolkit consists of four tools: Guiding Principles, Planning Checklist, BI Wizard, and BI Rubric (McDonnell & Renoe, 2024). While none of these tools explicitly reference research-education integration, our study suggests that the BI Toolkit can be utilized to help early-career faculty consider broader impacts in the context of their research and increase their comfort integrating research and education. Further, by helping to promote the development of an integrated impact identity, use of the BI Toolkit may contribute to grant-writing and research program success well beyond CAREER.

Background

Education, Engagement, and Impact

To ensure that publicly funded research translates into tangible benefits to society, broader impacts is one of two merit review criteria on which NSF evaluates every funding request. NSF CAREER proposals must also include an education plan, as well as a description of how the education activities are integrated with the research (National Science Foundation, 2022). On one hand, the CAREER program is exceptional in that its required education plan has no real equivalent in a standard NSF proposal and is substantially more robust in scope than a typical BI section. On the other hand, the solicitation expressly states that the CAREER program "embodies NSF's commitment to encourage faculty and academic institutions to value and support the integration of research and education" (National Science Foundation, 2022, p. 5), thereby serving as an important mechanism by which NSF establishes its expectations for all future work proposed to the agency.

The program solicitation defines education broadly to include activities aimed at diverse target audiences and delivered through both formal and informal methods, including various forms of community outreach and stakeholder engagement. As a growing number of institutions place high value on university-community engagement (Koekkoek et al., 2021) and the current NSF–National Science Board Commission on Merit Review emphasizes the expansion of the BI criterion to drive the delivery of benefits for stakeholders (Willard, 2024), the CAREER education plan may also serve as a bellwether of evolving agency priorities. Its enhanced scope creates space for faculty to gain community engagement experience, and community-based participatory research offers one potential pathway to meet the CAREER expectation of research-education integration (Amauchi et al., 2021). Because of its high profile and impact, the CAREER program may be a uniquely powerful mechanism to expand and enhance the practice of community-engaged scholarship across disciplines.

CAREER: It's Kind of a Big Deal

The CAREER program offers early-career, pre-tenure faculty five years of financial support to build a firm foundation for future leadership in research and education, which is of great interest to faculty and their organizations. Submission rates are high—at UNL alone, 25 to 30 early-career science, technology, engineering, and mathematics (STEM) faculty submit CAREER proposals annually—and applicants are limited to three tries (i.e., three strikes and you're out). The program's competitiveness is compounded when overall NSF funding rates for new investigators lag behind those of established investigators, as reported in their most recent Merit Review Report (National Science Foundation, 2021).

While current CAREER submission and award rates have not been made public, data from 2016 suggest funding rates vary widely across directorates, from a high of 24% in the Directorate of Geosciences to a low of 15% in the Directorate of Education and Human Resources (Esperança, n.d.). That same year, the Directorate of Engineering received almost 1,000 CAREER proposals, only 16% of which were funded. An additional challenge CAREER proposers face

is tailoring their writing to various peer-review methods across NSF directorates (e.g., panel, ad hoc, combination of both; National Science Foundation, 2021).

Expectations for the integration of research and education also vary across programs—that is, what is considered a well-integrated proposal in engineering likely looks different from a well-integrated proposal in biological sciences or STEM education (Chandler et al., 2024). Prior work in the emerging broader impacts field suggests that effective integration may take different forms depending on a researcher's goals, skills, interests, and life experiences (Risien & Storksdieck, 2018). The CAREER solicitation acknowledges as much: "NSF recognizes that there is no single approach to an integrated research and education plan. … These plans should reflect the proposer's own disciplinary and educational interests and goals, as well as the needs and context of his or her organization" (National Science Foundation, 2022, p. 6).

NSF routinely offers NSF CAREER workshops for early-career faculty, but institutions vary widely in resources dedicated to guide faculty through the complexities of developing a robust education plan that is well integrated with an innovative and impactful research plan. Organizational supports range from no support to in-depth, cohort-based programs. At the writing of this article, a non-exhaustive web search showed at least 17 universities across the U.S. have outward-facing websites dedicated to CAREER grant-writing resources and programming. It is common for organizations to hire expert consultants to help with proposal development, which requires an investment of thousands of dollars per year. At least one consultant group has a standalone workshop for faculty writing CAREER proposals (Academic Research Grants, 2024). Such investments are obviously not feasible for all organizations.

In an academic environment that values CAREER as an indicator of prestige and potential, and where some organizations support early-career faculty pursuing these awards while others do not or cannot, the BI Toolkit has great promise as an accessible resource to support *all* faculty preparing CAREER proposals, helping to position them for long-term career success.

UNL CAREER Club

Beginning in 2013, NSF's Office of Integrative Activities (OIA) undertook a comprehensive data-mining project to uncover agency-wide trends in broader impacts, including the BI activities most valued by reviewers (National Alliance for Broader Impacts, 2018). Results of this effort were presented at several annual summits of the National Alliance for Broader Impacts (Iacono, 2019), inspiring members of UNL's Office of Research and Innovation to consider how specialized support, particularly around BI, might enhance faculty competitiveness for CAREER awards. In 2017, UNL piloted its CAREER Club program.

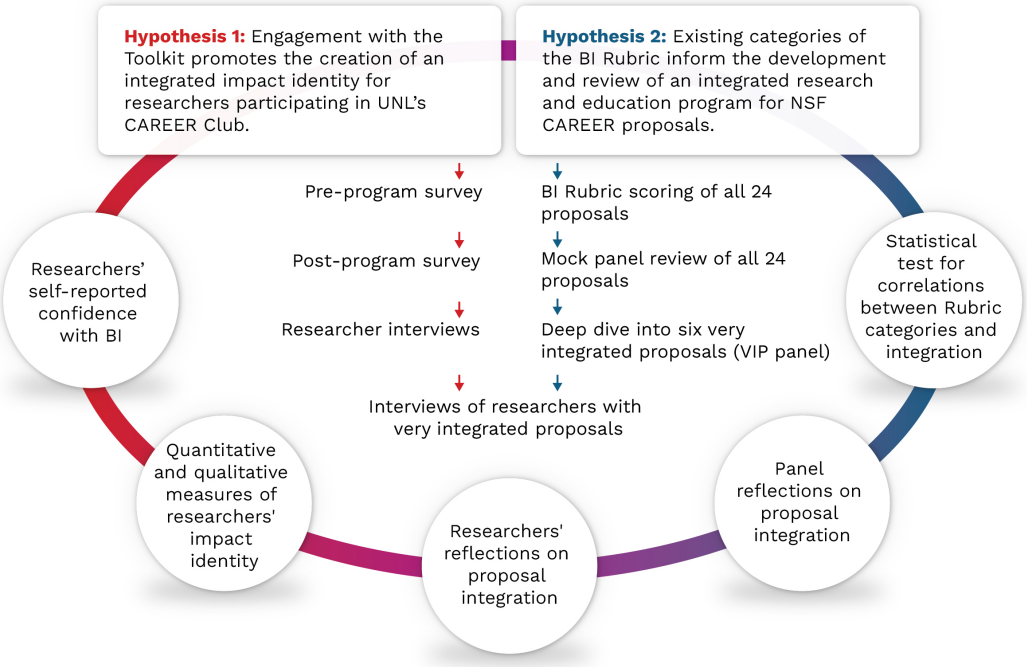
Early CAREER Club cohorts participated in a one-week series of lunch-and-learns; had access to quiet writing space; and met with an external consultant and in-house staff specializing in proposal development, program assessment, budget development, and graphic design. Survey data showed this cohort-based model had potential for impact, with 100% of participants finding the program beneficial and 100% saying they would recommend it to a colleague. Since then, the program has helped to more than quadruple the number of CAREER awards to UNL faculty (n = 1 or 2 to n = 8+/year). The now seven-month experience combines the benefits of introductory workshops with meaningful, ongoing support leveraging a three-pronged approach: 1) formal didactic sessions and informal lunch-and-learns, 2) comprehensive one-on-one proposal development and research impacts support, and 3) external feedback from technical experts and an experienced external consultant.

Case Study and Hypotheses

Coaching on education plans and the integration of research and education was largely ad hoc in CAREER Club until the introduction of the BI Toolkit into the program in 2022. In 2023, we formally integrated the BI Toolkit into CAREER Club programming and designed this case study to investigate its effectiveness.

The study team consists of UNL research development professionals—i.e., those charged with delivering strategic, proactive, catalytic, and capacity-building activities to position faculty for extramural funding success and to increase institutional competitiveness—who organized and administered the 2023 CAREER Club. Our case study focuses on 24 UNL faculty who submitted CAREER proposals to the July 2023 NSF deadline. Thirteen of these were first-time CAREER applicants, and most (n = 16) participated in the 2023 CAREER Club. They represent 15 academic departments within four colleges (Colleges of Agricultural Sciences and Natural Resources; Arts

Figure 1. Summary of Case Study Methodologies and Data Modalities



and Sciences; Education and Human Sciences; and Engineering), so the pool has disciplinary diversity within the confines of NSF CAREER eligibility criteria (National Science Foundation, 2022).

Within this context, we explored the impact of the BI Toolkit through the lens of two hypotheses:

1. Engagement with the BI Toolkit promotes the creation of an integrated impact identity for researchers participating in UNL's CAREER Club.
2. Existing categories of the BI Rubric inform the development and review of an integrated research and education program for NSF CAREER proposals, despite the absence of an explicit Rubric category to assess integration.

Methods and Results

We used various data modalities and instruments to investigate our hypotheses, as summarized in Figure 1. To test Hypothesis 1, we conducted surveys and interviews with CAREER Club participants. To test Hypothesis 2, we utilized the BI Rubric and a mock panel review, followed by in-depth discussion of very integrated proposals (VIPs). We also conducted follow-up interviews with the principal investigators of VIPs to gain additional insight into both hypotheses. Written informed consent was obtained from all survey respondents, and verbal informed consent was obtained from interview subjects prior to participation. This study was approved by UNL's Human Research Protection Program (approval no. 20230522661EX).

Hypothesis 1: Engagement with the BI Toolkit promotes the creation of an integrated impact identity for researchers participating in UNL's CAREER Club.

Process for Surveys and Interviews

Surveys. As detailed in Table 1 below, we administered anonymous pre- and post-program surveys to CAREER Club participants to assess: 1) whether and how engagement with the BI Toolkit influenced participants' perceived self-efficacy and attitudes about broader impacts, and 2) how participating faculty viewed the relationship between research and education before and after the program. The survey, which was administered online through Qualtrics, was adapted from an instrument originally developed by ARIS (NSF grant #2140950) and the Science Education Resource Center at Carleton College to evaluate researchers' experiences creating BI plans.

Table 1. Survey Structure

Assessment Object	Survey Structure		
	Prompt	*Survey Question*	*Response Options*
Self-efficacy around broader impacts	Please indicate to what extent you agree or disagree with these three statements.	I am confident in my ability to write a broader impacts statement that aligns with NSF values.	Four-point Likert scale with options of *disagree*, *tend to disagree*, *tend to agree*, and *agree*; in addition, respondents could explain any of their ratings via open text box.
		I am confident in my ability to successfully develop a broader impacts plan.	
		I am confident in my ability to develop an integrated research and education plan for the NSF CAREER proposal.	
Attitudes toward broader impacts	Please indicate to what extent you agree or disagree with these two statements.	Education and impact activities are important to my identity as a researcher.	Six-point Likert scale with options of *strongly disagree*, *disagree*, *tend to disagree*, *tend to agree*, *agree*, and *strongly agree*; in addition, respondents could explain any of their ratings via open text box.
		The societal impacts of my research are important to my career goals.	

The pre-program survey was administered at the CAREER Club kickoff event, and the post-program survey was administered following proposal submission at the final CAREER Club meeting, both via QR code. To mitigate survivorship bias, both surveys were also distributed via email to all faculty accepted into CAREER Club, regardless of whether they actively participated in the program's activities and whether they submitted a CAREER proposal in 2023. Thus, survey respondents include several faculty members who decided to strategically delay their CAREER submission or determined over the course of the program that a different funding mechanism was more appropriate for their long-term career goals.

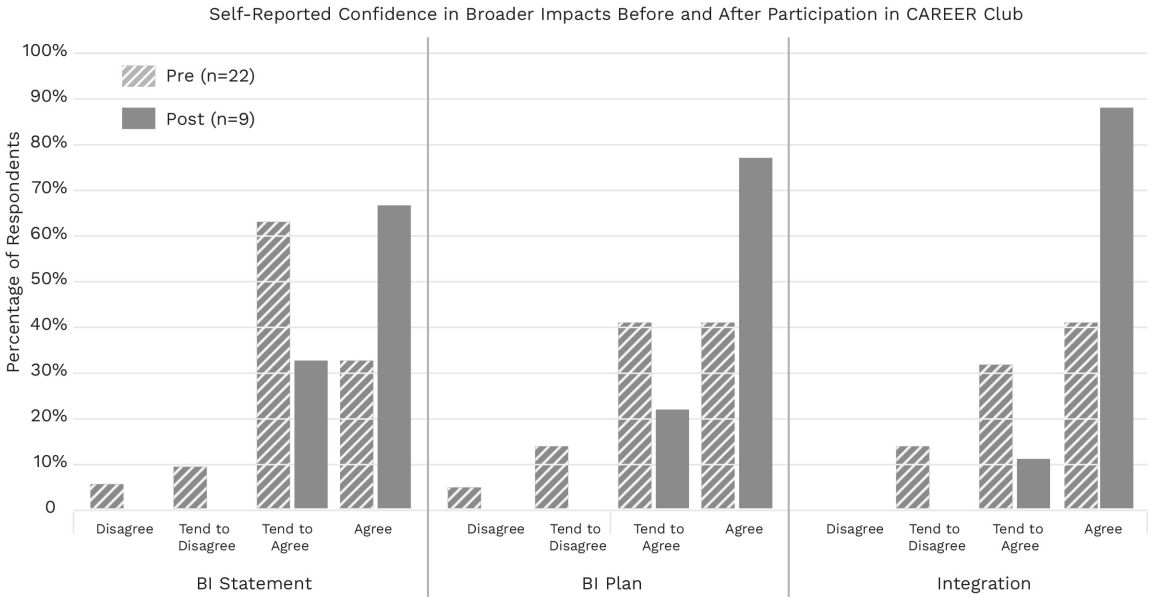
Interviews. To supplement the aggregate survey data and gain additional insight into how engagement with the BI Toolkit influenced impact identity, the 2023 CAREER Club participants who submitted proposals were invited to participate in one-on-one interviews. During open-ended conversations conducted and recorded via Zoom and lasting between 19 and 39 minutes, faculty were asked to reflect on their experiences using the BI Toolkit; their approach to integrating research and education generally; and whether and how the BI Toolkit helped them to integrate research and education for their CAREER proposal.

Results from Surveys and Interviews

Surveys. The pre- and post-CAREER Club surveys received 22 and nine responses, respectively. Results were compiled in Qualtrics and then converted to percentages to enable comparisons across pre- and post-program data.

As summarized in Table 1 above, one section of the survey instrument was designed to assess participants' self-efficacy with several aspects of broader impacts, specifically their self-reported confidence in 1) writing a broader impacts statement that aligns with NSF values, 2) successfully developing a broader impacts plan, and 3) developing an integrated research and education plan for the NSF CAREER proposal. The survey data, summarized in Figure 2, show substantial gains in faculty's self-reported confidence in each of the three areas.

Figure 2. Pre-Program and Post-Program Measures of Self-Efficacy Around Broader Impacts



Although the differential response rate of the pre- and post-program surveys (n = 22 vs. n = 9) places some constraints on the interpretation of our data (see Limitations and Challenges below), we can still compare the confidence gains for integrating research and education with those measured for other aspects of broader impacts. As shown in Figure 2, pre-program respondents were overall less confident in their ability to develop an integrated research and education plan for CAREER than they were in writing a broader impacts statement or developing a broader impacts plan. Only 73% *agreed* or *tended to agree* that they were confident integrating research and education, compared with 87% for writing a broader impacts statement and 82% for developing a broader impacts plan.

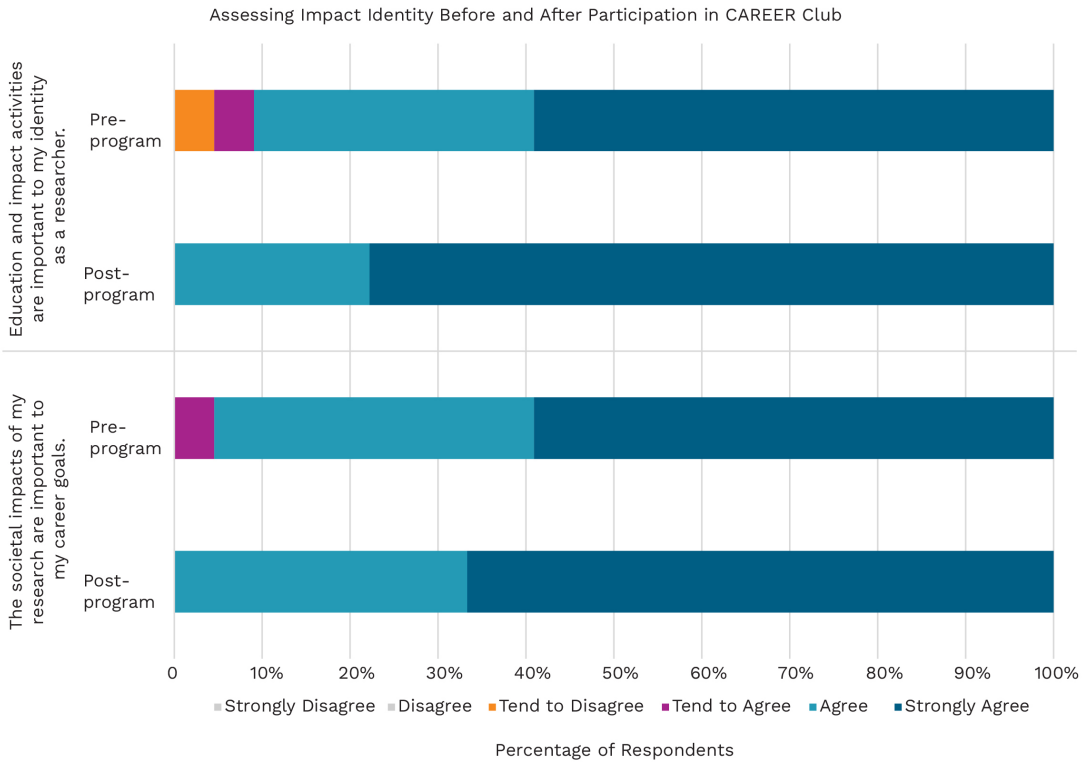
In the post-program survey, 100% of respondents *agreed* or *tended to agree* with all three statements, but the split toward *agree* was most pronounced for developing an integrated research and education plan. Even considering the differential characteristics of the sample populations captured in the pre- and post-program surveys, the observed confidence gains in research and education integration outpaced those in other areas, which speaks to the program's success in helping faculty achieve greater self-efficacy around integration.

The survey also assessed participants' attitudes toward broader impacts before and after the program. As shown in Figure 3, most participants *agreed* or *strongly agreed* that broader impacts are important to their career goals and to their identity as a researcher, with more than half of pre-program survey respondents *strongly agreeing* with both statements. In the post-program survey, that majority was more pronounced: those who *strongly agreed* that the societal impacts of their research are important to their career goals increased from 59% to 67%, and those who *strongly agreed* that education and impact are important to their identity as a researcher rose from 59% to 78%.

Interviews. Of the 16 CAREER Club faculty who submitted proposals in 2023, seven consented to be interviewed (n = 7). We employed narrative analysis to understand how participants conceived the relationship between research and education and how CAREER Club programming affected participants' impact identity.

We found that researchers who already placed a high value on impact beyond the academy were attracted to CAREER specifically because of its integrated approach. Explained one participant, "I thought it was a unique opportunity to say, not only do I want to answer some questions through this research, but I have a chance to do something with those answers to make a cool change." Another noted that, in her work, research and education are already highly integrated. This made CAREER a natural and comfortable fit, enabling her to express and further develop a professional identity

Figure 3. Pre-Program and Post-Program Measures of Attitudes Toward Broader Impacts



organized around both research and education goals. "For the most part, I actually prefer that. And it's easier for me to write that [way] than it is to do mostly research and tack this [education] on at the end," she said, adding that she wished all NSF programs emphasized the integration of education as much as CAREER. Another researcher with a history of funding from the National Institutes of Health said:

> One of the reasons I wanted to apply for a CAREER was because of the integration of research and education, because the topic[s] that I work on are considered hot topics, if you will. And so I think it's essential, if you're going to make a research program on these things like I am, that there is some component of outreach or education, and the CAREER is somewhat unique in that.

The fact that some faculty sought out the CAREER program specifically for its emphasis on research and education integration may partly account for the relatively high proportion who identified education and outreach as important to their research identity, even among pre-program survey respondents.

Others found the experience more transformative. One participant explained:

> There was a huge transformation that happened within me in terms of thinking about the impact of my work. I should be thinking in terms of the impact when I develop my research. When I started, there was no connection between the broader impact and my research. There was no integration. There was no organic relationship. My thinking has been shifted. So now I think, or at least try to think, from the perspective of the broader impacts.

Another experienced a similar shift, which has informed his mentoring philosophy: "While I conduct public policy research, my training and exposure have focused on its technical aspects," he noted. "My graduate students will participate in training and town hall events to provide them with

public engagement experience, which I did not receive through my graduate education."

Hypothesis 2: Existing categories of the BI Rubric inform the development and review of an integrated research and education program for NSF CAREER proposals, despite the absence of an explicit Rubric category to assess integration.

Process for Completing BI Rubric and Panel Discussions

BI Rubric. The BI Rubric consists of five general questions, each containing two to five specific criteria. For each of the 16 total criteria, reviewers are asked to rate a proposal as *Excellent*, *Very Good*, *Good*, *Fair*, or *Poor* (Iverson et al., 2024). To understand how the existing categories of the BI Rubric relate to the integration of research and education in CAREER proposals, we first used the BI Rubric to evaluate all CAREER proposals submitted by UNL faculty in July 2023. There was variation in how the principal investigators engaged with CAREER Club: 16 were 2023 CAREER Club participants, three had participated in a past CAREER Club cohort, and five had never participated in CAREER Club. Each of the 24 proposals was assigned to two case study team members who independently completed the BI Rubric for that proposal; for 2023 CAREER Club participants, the primary CAREER Club point of contact served as one of the two BI Rubric reviewers.

Panel Discussions. We then convened a mock review panel to assess the integration of education and research in each of the 24 proposals. Five case study team members served as reviewers, while the sixth facilitated the panel discussion. In a process loosely modeled on NSF peer review, each proposal was assigned a primary, secondary, and tertiary reviewer. In each case, the tertiary reviewer was one of the proposal's two BI Rubric reviewers; for the 2023 CAREER Club proposals, this was the principal investigator's CAREER Club point of contact. This served to reduce the total number of proposals each team member was tasked with reviewing while still offsetting potential bias, since reviewers never served as the primary or secondary panel reviewer for a proposal where they also served as a BI Rubric reviewer.

Prior to the panel discussion, reviewers individually scored their assigned proposals as *Excellent*, *Very Good*, *Good*, *Fair*, or *Poor* based on *how convincingly the reviewer felt the proposal presented effective and integrated education and research plans*. Individual rankings were not shared ahead of the mock review meeting, nor did we come to a consensus on *how* to assess proposal integration prior to convening the panel, since this is precisely what we hoped to learn through the panel discussion. During the 90-minute in-person meeting, the primary reviewer of each proposal shared their rating and a brief explanation of how and why they arrived at this rating. If the secondary or tertiary reviewer had the same rating as the previous reviewer(s), they shared only their rating without further explanation. If there was variance in the ratings, the three reviewers discussed the proposal until a consensus rating was reached.

Following the mock review panel discussion, each of the five panelists individually reviewed all six proposals for which the panel had reached a consensus score of 5 (*Excellent*) for integration—proposals we define as *very integrated proposals*, or VIPs. The panel convened a second time for a one-hour discussion (hereafter referred to as the VIP panel) to consider in more depth how integration was conceptualized and demonstrated in these six proposals. During the VIP panel, each proposal was discussed in turn, with each team member sharing their observations on what made the proposal very integrated. To close the discussion, the VIP panelists shared general observations around the topic of integration.

The same case study team member facilitated both panels and was tasked with ensuring that all panelists were engaged in the discussion; that a similar process was followed for each proposal under discussion; and that each proposal was discussed within the allotted time. Both meetings were recorded to enable subsequent analysis of the discussions.

Interviews with VIP Principal Investigators. To supplement the VIP panel findings, we conducted follow-up interviews with each of the six VIP principal investigators to gain additional insight into how they approached the integration of research and education. The VIP interviews lasted 18 to 31 minutes and, like the first round of faculty interviews, were one-on-one, open-ended conversations conducted and recorded via Zoom. Each VIP principal investigator was asked to reflect on the strategies and mechanisms they use to integrate research and education in their CAREER program; where and how they demonstrated the integration in the proposal itself; and what advice they would give other faculty thinking about developing an integrated research and education plan for a CAREER proposal.

Results from BI Rubric and Panel Discussions

Integration Scores. During the mock review panel, six of the 24 proposals received a consensus score of 5 (*Excellent*) and were designated as VIPs, or very integrated proposals. While only two-thirds of the 24 proposals came from 2023 CAREER Club participants, all six VIPs belonged to this group. Significantly, no proposal submitted by a principal investigator who had never participated in CAREER Club scored higher than *Good* for integration. Past CAREER Club participants fared better on integration than never-Clubbers, but not as well as 2023 Clubbers. Figure 4 shows the distribution of the mock review panel's consensus integration scores across these three groups.

The panel's greater familiarity with the 2023 CAREER Club proposals does not appear to account for the higher integration scores in this group. In fact, for proposals submitted by 2023 Clubbers, the CAREER Club point of contact was often more critical of the proposal than the other two reviewers during the mock review panel. For five of the 16 proposals submitted by 2023 CAREER Clubbers, the three panel reviewers were unanimous in their initial integration scores; for nine of the remaining 11 proposals, the CAREER Club point of contact assigned the lowest integration score across the three reviewers, and in no case did the CAREER Club point of contact assign the highest integration score across the three reviewers.

Previous cohorts of CAREER Club had access to programming and support for developing their education plan, but only the 2023 group benefited from systematic engagement with the BI Toolkit. Thus, while numerous factors may have influenced the distribution of integration scores, our data suggest that engaging with the BI Toolkit in CAREER Club played a positive role in promoting the integration of research and education.

Statistical Analysis of the BI Rubric and Integration Scores. Proposals scoring high on integration tended also to score high across all BI Rubric criteria, while proposals that scored low on integration had consistently lower scores across BI Rubric criteria. It is instructive to consider two proposals that did not fit this pattern. Of the VIPs, one averaged a score of 3.78 across all BI Rubric criteria, placing it below the mean (4.03) and median (4) BI Rubric scores for all proposals and well below the mean BI Rubric score (4.52) for VIPs. Conversely, another proposal only scored a 3 (*Good*) for integration, placing it in the bottom third of proposals reviewed, but averaged a score of 4.31 across BI Rubric criteria—well above the mean for all proposals. These two proposals illustrate that a high-quality education plan need not always be well-integrated with the research plan, and vice versa. We anticipated, however, that certain BI Rubric criteria would be more significant than others in contributing to a model that predicts stronger research and education integration.

Figure 4. Integration Scores for Proposals Evaluated by the Mock Review Panel

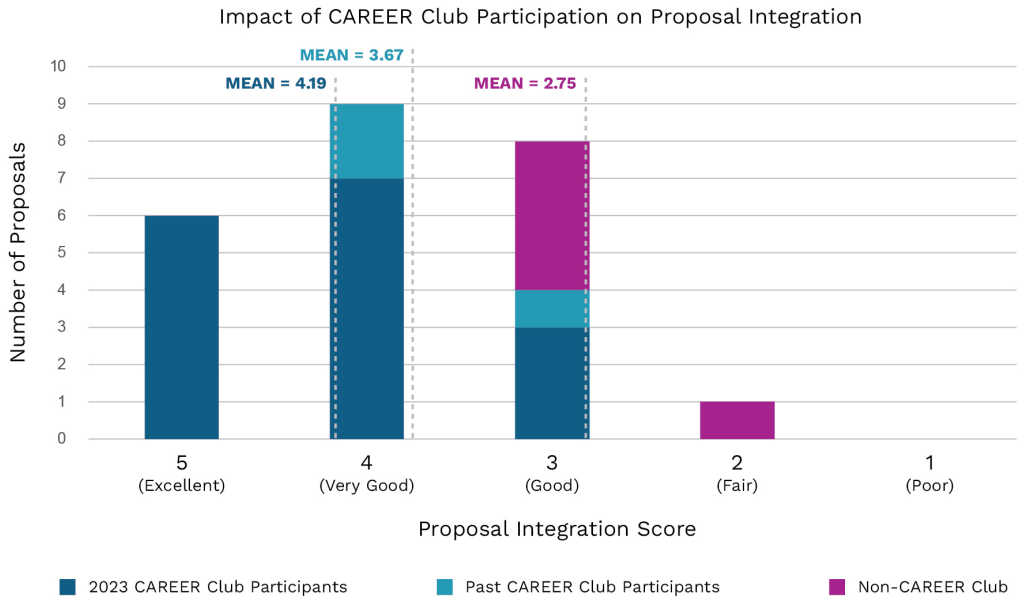


Table 2. Spearman Correlations Between Integration Score and BI Rubric Criterion Scores

Rubric Category	Rubric Criterion	Correlation with Integration Score
Target Audience (Question 1)	Characteristics (1a)	0.445
	Engagement (1b)	0.362
	Alignment (1c)	0.454
Proposed Activities (Question 2)	Research-based (2a)	0.124
	*Evidence-based (2b)	0.395
	***Innovation (2c)**	**0.481**
Goals and Outcomes (Question 3)	***Objectives (3a)**	**0.576**
	NSF outcomes (3b)	NA
	Evaluation (3c)	**0.100**
Project Management (Question 4)	Team (4a)	0.395
	Partners (4b)	0.330
	Partner needs (4c)	0.443
	Timeline (4d)	0.410
	Checklist (4e)	0.453
Resources (Question 5)	***Infrastructure (5a)**	**0.500**
	Budget (5b)	0.606

Note. Shaded criteria are those moderately or strongly correlated with integration. Bold denotes criteria kept in the regression model, and asterisks denote those with strong odds ratios.

In our data set, the mock review panel's integration score was the dependent variable and the reviewer scores for each of the BI Rubric criteria were the independent variables. We used regression to predict integration based on the 16 Rubric criteria. To ensure the assumptions of our regression analysis were met, we first examined the frequency patterns of the variable scores. Addressing group size challenges that could arise with the Hosmer-Lemshow test, we removed the single proposal that scored lower than 3 for integration so that no group had less than 5% of the total observations. Further, to ensure that all categories had frequencies greater than zero, we collapsed both the integration score and the BI Rubric scores from five possible categories (*Excellent*, *Very Good*, *Good*, *Fair*, *Poor*) to two (*Excellent-or-Very-Good* and *Good-Fair-or-Poor*). While this re-categorization permits less granular analysis than would be possible with a larger sample size, it does approximate how proposals are assessed by review panels, where *Excellent* or *Very Good* proposals are often considered competitive for funding while proposals rated *Good* or below typically are not competitive.

We ran Spearman correlations across all variables for the re-categorized dataset. As shown in Table 2, nine of the 16 criteria had moderate (0.40–0.59) or strong (0.60–0.79) correlations with the integration score. For one criterion, *NSF Outcomes*, all 23 proposals analyzed scored *Excellent* or *Very Good*. Because this score was constant across proposals, the correlation to the integration score could not be computed, and this criterion was not included in the regression model. To meet the multicollinearity assumption of regression, we also examined correlations among the independent variables and calculated variance inflation factors (VIFs) for each BI Rubric criterion. We found that *Characteristics* and *Alignment* had moderately high VIFs (6.362 and 7.053, respectively), so we removed them from the regression.

Using cross-tabs and Chi-square tests, we then identified 1) patterns of complete separation, where a particular BI Rubric criterion score was in the same category as the integration score for each of the 23 proposals, and 2) instances where observed or expected counts for a particular Rubric criterion score were almost zero. The following BI Rubric criteria fell into one of these patterns and were omitted from the regression: *Engagement*, *Research-Based*, *Evidence-Based*, *Team*, *Partners*, *Partner Needs*, *Timeline*, *Checklist*, and *Budget*.

Finally, we ran the binary logistic regression with the remaining four BI Rubric criteria: *Innovation*, *Objectives*, *Evaluation*,

and *Infrastructure*. To measure the strength of the relationship between the dependent and independent variables in the model, we calculated the Cox and Snell and Nagelkerke R^2 values, which were 0.476 and 0.657, respectively. In other words, 48% or 66% of the observed variability in the integration score is explained by the four BI Rubric criteria in the model. The overall predictive accuracy of the model is 82.6%, suggesting it is useful for predicting proposal integration.

Of the four BI Rubric criteria in the model, three had odds ratios (OR) well above 1, indicating that the scores for these criteria had a particularly large impact on the integration score. These three criteria are listed below with accompanying text from the BI Rubric:

> **2c) Innovation (OR = 8.01, p = .012):** *The proposal provides an original and creative BI plan to align with the proposed research and partner needs.*
>
> **3a) Project Objectives (OR = 20.56, p < .01):** *The project objectives are specific, measurable, achievable, relevant, and time-bound (SMART).*
>
> **5a) Infrastructure (OR = 21.95, p < .05):** *The infrastructure is appropriate for supporting the proposed BI activities.*

While our small sample size militates against generalizing too far from statistical analysis alone, this analysis does point to one very important conclusion: the criteria most important for predicting research and education integration are not clustered under any specific BI Rubric question but are distributed across multiple questions. The evidence for integration thus appears in various forms and aspects of a proposal. Put another way, integration is itself integrated throughout the proposal.

Analysis of Panel Discussions. The mock review panel and subsequent VIP panel discussion afford additional insight into how particular aspects of the CAREER education plan work together to promote integration with the proposed research. Thematic analysis of the two panel discussions yielded these key takeaways:

- **The reciprocal feedback of education into research, not just research into education, is critical.** The panels noted it was significantly more common to find evidence that the research objectives would inform the education objectives than it was for education objectives to inform the research in turn. Therefore, demonstrating the reciprocal feedback of education into research tended to make a more compelling case for integration. This was true for the VIP with lower BI Rubric scores mentioned above; it lacked detail for some education objectives but made a strong case for how other education objectives would inform the research plan. Conversely, the less-integrated proposal with high BI Rubric scores had a well-developed education plan, but the evidence for integration flowed mostly from the research to the education plan.
- **Student training in education and engagement bolsters integration.** The panels found that involving students in the proposed research was a typical way to show reciprocal benefit between the education and research plans. VIPs went beyond this by mentoring students in *both* research and education, which the panels found to be a powerful strategy for heightening integration in these proposals. Four of the six VIPs included students—from courses, research trainees, or both—in their outreach and stakeholder engagement initiatives. Two of these proposals also referenced specific programs students would participate in to gain training in effective outreach and engagement (Tamarack Institute, 2024; UNL Institute of Agriculture and Natural Resources, 2024), and one employed the responsible innovation framework (Stilgoe & Guston, 2016) to articulate a rationale for an integrated approach to student training. Another principal investigator utilized human-centered research design (Hanington, 2010) to involve students in both the research and education objectives, inviting students in her course to serve as research subjects and then incorporating data from the research into their coursework.
- **Proposals leveraging natural points of integration scored highly.** Not surprisingly, mechanisms for successful integration varied with the nature of the proposed research. Some proposals engaged research stakeholders as education audiences and/or participants. Others leveraged research sites or facilities to create and deliver educational programs. Crucially, the panels noted that

while some fields and topics may offer more straightforward paths to reciprocal integration than others, intentional development of these opportunities is still needed to achieve high integration. For example, two of the reviewed proposals focused on discipline-based research in engineering education, where research and education are already closely aligned. While one of these proposals scored 5 (*Excellent*) for integration, the other only scored 3 (*Good*). The more integrated proposal distinguished itself by clearly articulating how the research objectives advanced the education plan and how the education objectives operationalized the research findings.

- **Integration can be a mark of and means to innovation.** The panels noted an intriguing connection between integration and innovation in proposed CAREER programs. Several proposals with relatively well-developed education plans had activities that felt commonplace and generic; these proposals scored lower on integration, since the education plan appeared parallel to rather than motivated by and responsive to the research plan. Conversely, the panels found that effective integration can *itself* be a compelling form of innovation, adding a novel dimension to standard activities by meaningfully connecting them with the proposed research. These observations amplify the results of our statistical analysis, where the BI Rubric *Innovation* score strongly predicted the integration score.

While it is possible for a well-integrated proposal to come up short on various aspects of the education plan, the panels noted that a desire to learn from and through both research and education activities makes a compelling case for integration. As one panelist put it, "It's the passion for both [research and education] and how they have to operate together to make change that gets you to buy into the proposal."

Analysis of Interviews with VIP Principal Investigators. The six VIP principal investigators came from different disciplines and programs, and their strategies for integrating research and education varied accordingly. Nonetheless, using a combination of narrative and thematic analysis, we identified several cross-cutting themes.

*Who***.** Four of the six VIPs leveraged the education plan to engage audiences who are natural stakeholders in the research, emphasizing reciprocal engagement and mutual benefit (Dostilio et al., 2012).

- The centrality of relationships was raised by several researchers. "I feel like that's kind of what I'm trying to achieve with that part of my education plan [because] it's another opportunity for building relationships that can hopefully promote the impact of the research," explained one. "[The key] for me," another observed, "is focusing on relationships [more than] the activities."
- Other researchers explicitly considered the role of reciprocity and the added value diverse audiences could bring to their projects. "For me, I think it was important to make that connection to research with different groups of stakeholders, who have life experiences and expertise in other areas," said one.
- Several VIP principal investigators drew a more direct line between stakeholders and their research programs. "How do we learn from the stakeholders? And how do we implement? How do we improve our research plan from the input of the stakeholders?" one commented. Another described his approach to developing his education plan as follows: "Who benefits? Who's involved? Who are we talking with? Whose input are we getting? And who is then a guiding force in the research?"

*Why***.** In four VIPs, researchers identified a common purpose or framework under which they developed their research and education objectives.

- One described his approach this way: "I kind of started a list with the things I wanted to accomplish with the research plan and the things I wanted to accomplish with the education plan, not really thinking about the integration yet. And then I went back and started to figure out, OK, how can I link the two together?"
- Another utilized his education plan to share with students the motivation behind his research: "I included a [freshman honors] seminar, which is based on a book that I actually had read that sort of inspired the research. And then so I thought, well, if I can integrate this same book into a course, then maybe that will inspire students to pursue research."
- A third looked to the responsible innovation framework (Stilgoe & Guston, 2016) to

understand how her education plan could inform her present and future research: "Because we definitely don't want to create solutions that nobody will use. We definitely want to first educate broader stakeholders [about how they can] benefit, and we also have the feedback from the stakeholders."

- Another articulated a specific mechanism by which her education plan would enable her to innovate within her research program: "I also included a little treat for myself as part of the education program—I gave myself three years to learn more about data art. I'm hoping this will allow me to branch out a bit [and] use that to get more people interested in statistical graphics, all at the same time."

*Where***.** In two VIPs, specific lab and field locations were central to both the research and education plan. These place-based initiatives (Kuttner et al., 2019) became sites of physical as well as conceptual integration.

- Explained one researcher, "A part of my education plan is creating the field course. And it seems kind of obvious that, like, I have these field sites that I'm developing for my research, I'm developing a field course—develop those two things together."
- Another principal investigator recalled, "I started to think about how to utilize the testbed to serve as the center point to integrate my research and education, because the testbed is not only a critical tool to help with my research tasks to be fulfilled, but also very important [to] train the next generation of engineers and scientists."

Interestingly, the question of *what* education activities to do, while clearly important, did not appear to be a driving force behind the VIPs' successful integration of education with research. Rather, VIP principal investigators focused first on opportunities to leverage the research objectives and infrastructure to engage audiences for the education plan. This finding closely mirrors the results of our regression, where two of the three BI Rubric criteria most strongly predictive of integration were *Project Objectives* and *Infrastructure*. The third criterion, *Innovation*, considers education activities in the context of their alignment with both the proposed research and the needs of BI partners. VIP researchers also prioritized alignment and mutual benefit in their education plans, selecting partners appropriate to their target audiences and identifying opportunities to co-create activities that would meet the partners' needs as well as the principal investigator's goals.

Reflections and Outcomes

Limitations and Challenges

As discussed above, our small sample size warrants restraint in interpreting statistical relationships between specific BI Rubric criteria and proposal integration. By supplementing our statistical analysis with qualitative data, however, and especially by attending to patterns that emerged across data modalities, we were able to identify key factors that contributed to the effective integration of research and education and indicate where and how the BI Rubric captures these factors.

Further, we noted that the differential response rate to the pre- and post-program surveys limits the comparative aspect of our study. This difference likely reflects a self-selection bias: while the survey data are anonymous, we suspect participants who engaged with CAREER Club activities for the duration of the program are disproportionately represented among post-program respondents. Moreover, in comparing pre- and post-program survey responses, it is difficult to parse which gains resulted specifically from using the BI Toolkit and which would have occurred anyway through participation in CAREER Club programming or through additional research development supports to which UNL faculty have access.

Our study does not attempt to delineate the effects of content (the BI Toolkit) from context (the CAREER Club program at a research-intensive R1 institution) but rather suggests ways in which the BI Toolkit can be utilized by early-career faculty to promote and operationalize the integration of research and education. Given the multiple forms effective integration can take, individuals using the BI Toolkit in many different contexts can likely apply at least some of our findings to their roles, projects, and environments. Future work examining the use of the BI Toolkit across institutional settings will enrich our understanding of how organizational supports influence the implementation and impact of the BI Toolkit.

The mock review panelists' role in developing and implementing CAREER Club programming also complicates the interpretation of our results. All six proposals identified as VIPs were submitted by active 2023 CAREER Club participants. Several past CAREER Club participants scored a 4 (*Very Good*) on integration, while the highest a never-Clubber scored on integration was 3 (*Good*). This may reflect the beneficial effects of interacting with

the BI Toolkit during CAREER Club, as discussed above; since the panelists assessing integration for this case study also coached the 2023 Club cohort on the development of well-integrated proposals, however, it is not surprising that proposals from this group aligned more closely with the panel's collective expectations. This potential bias may be partially offset by the tendency we observed for individual panelists to be more critical of proposals for which they had provided one-on-one support—where, we can surmise, they were especially attuned to possible shortcomings. A future case study with panelists who were not directly involved with developing the proposals under review may shed light on whether and how far our findings can be generalized.

Pathways to Integration

The panelists' expertise and involvement with CAREER Club was helpful to our case study in other ways. During the panel discussions, we found it instructive at times to differentiate how integration was *conceptualized* in the research and education plan from how this integration was *demonstrated* in the proposal. Typical reviewers can make no such distinction; they can only assess what is described in the proposal. Because our panelists worked with faculty throughout the proposal development process, they had additional insight into how these faculty had approached and achieved the integration of research and education.

Coupled with participants' own reflections on the development of their proposals, the panel discussions uncovered a variety of potential pathways to integration, from "roots" (opportunities to explore and develop points of contact between research and education objectives) to "flowers" (ways to demonstrate integration of research and education in a proposal). In Figure 5, we summarize these "roots" and "flowers" of integration.

We found that the "roots" of integration can include target audience selection (e.g., engaging audiences who are potential stakeholders or intended beneficiaries of the research), specific activities (e.g., community science or crowdsourcing), and even evaluation (e.g., education plan evaluation may suggest directions for future research). For all pathways, cultivating mutually beneficial partnerships (e.g., co-creating tools and programming with education partners) is critical to enhance research value for and uptake by target audiences.

These "roots" closely mirror the modules of the BI Wizard, the BI Toolkit's comprehensive interactive tool to assist proposers with developing broader impacts plans. The BI Wizard Project Planning Tool includes modules on *Audience* (containing questions about target audience and partners), *Project Goals* (containing questions about planned activities), and *Evaluation*. Based on the results of this case study, we recommend the *Relevance* module as a natural starting point for faculty developing an integrated research and education plan for a CAREER proposal. This module has two prompts:

1. What are the research/science questions in your proposal? And what elements of the scientific questions do you want to highlight in your BI project?
2. What are the potential benefits of sharing this information with your audience?

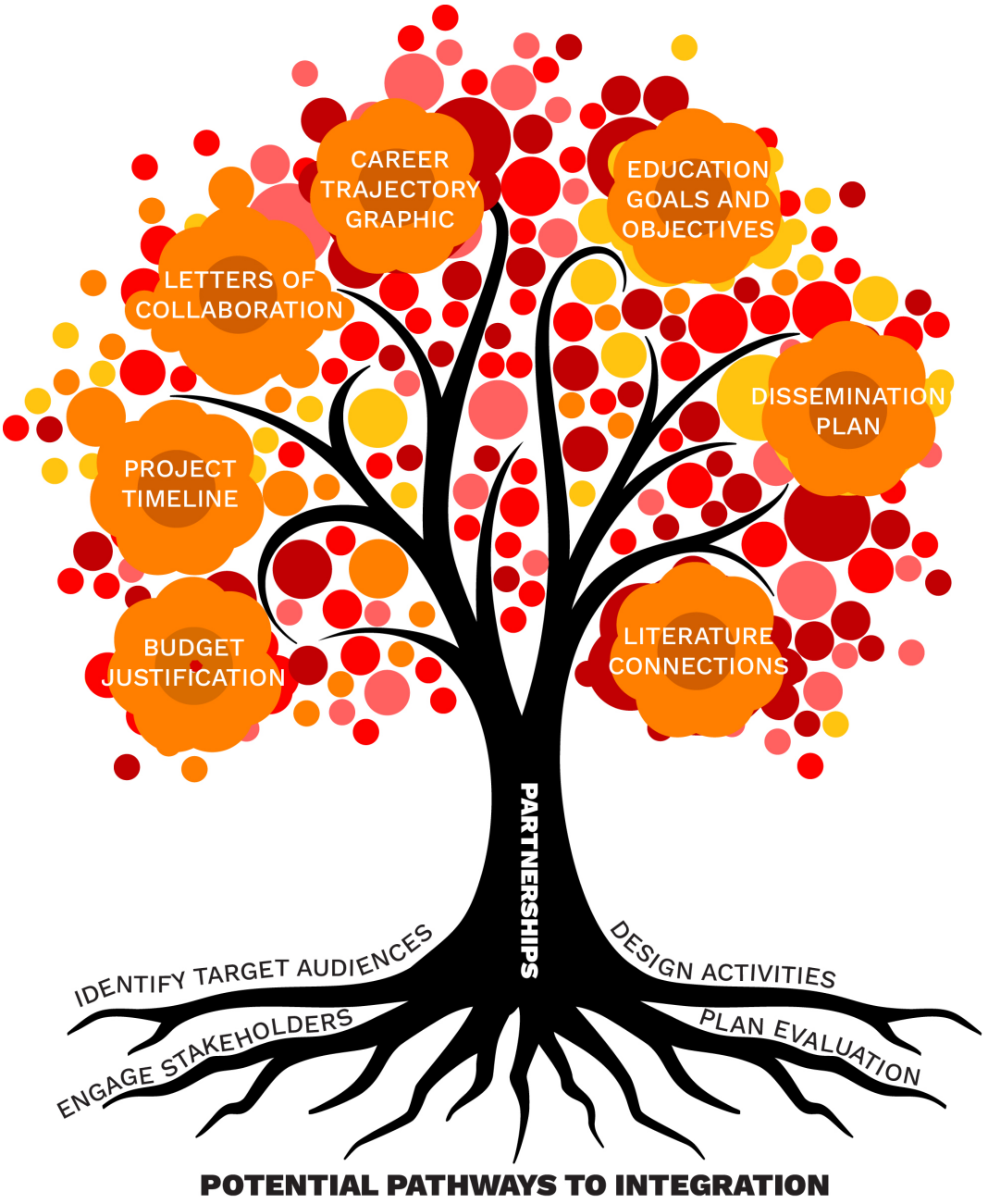
We also suggest an intermediate question 2a: What audiences might benefit from engaging with these aspects of your research?

The BI Rubric captures many of the same pathway elements. Rubric criteria corresponding to the "roots" and "trunk" of integration include: *Target Audience Characteristics* (1a), *Engagement* (1b), and *Alignment* (1c); *Evaluation* (3c); *BI Team* (4a), *Partners* (4b), and *Partner Needs* (4c). Other BI Rubric criteria are closely related to our "flowers" of integration, including: *Research-Based* (2a), *Evidence-Based* (2b), *Project Objectives* (3a), *Timeline* (4d), *Checklist* (4e), and *Budget* (5b). Additional proposal elements (e.g., a career trajectory graphic showing research and education milestones) have no direct correlate in the BI Rubric, but help to place the education plan on equal footing with the research plan, promoting effective and reciprocal engagement.

The BI Toolkit and NSF Broader Impacts Merit Review

Our quantitative and qualitative data indicate there is no single "best" pathway to integrate research and education in CAREER proposals. Integration is, by definition, multidimensional. Thus, the BI Toolkit—and specifically the BI Rubric—serves CAREER proposers well by *not* identifying integration as a distinct criterion. Indeed, our mock review panel observed that referencing education aims throughout the proposal tends to strengthen integration, so considering integration within multiple aspects

Figure 5. Potential Pathways to Integrating Research and Education in NSF CAREER Proposals



of the BI Rubric is itself a strategy for crafting a well-integrated research and education program. Moreover, the flexibility offered by the BI Rubric may help to accommodate differing expectations across NSF directorates for integrating education with research.

The findings of this case study also point to some additional questions BI Toolkit users may consider to bolster the integration of research and education for CAREER proposals. In Table 3, we present these in the context of the five NSF Broader Impacts merit review elements around which the BI Rubric and other BI Toolkit components are organized.

Preliminary Relationship to Funding Outcomes

The results from UNL's 2023 CAREER proposals are encouraging. At the writing of

this article, all 24 principal investigators in our case study have received notification of either award or decline, with nine of these awarded or negotiating award. The likelihood of funding appeared to increase with higher BI Rubric scores: funded proposals had an average BI Rubric score of 4.34 across all 16 criteria, compared to 3.88 for unfunded proposals. While there was no obvious correlation between proposal integration scores and funding outcomes, the NSF panel reviews closely mirrored our mock review panel's assessment of integration in both funded and unfunded proposals. Additional tracking over multiple cohorts is needed to determine whether and under what conditions the degree of integration between research and education, as determined

Table 3. Questions ARIS BI Toolkit Users Can Consider When Assessing Integration of Research and Education

Area	NSF Broader Impacts Merit Review Element	Questions to Bolster Integration
Societal Impact	What is the potential for the proposed activity to benefit society or advance desired societal outcomes?	Will the impact of the education activities strengthen the impact of the proposed research—and vice versa—in the near term and/or long term?
Innovation	To what extent do the proposed activities suggest and explore creative, original, or potentially transformative concepts?	Rather than running parallel to each other, do the education and research activities integrate in novel ways that enhance overall project impact?
Activities and Evaluation	Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?	Do the proposed education activities inform the research activities, in addition to research informing education? Does the proposal incorporate student mentoring in designing and implementing education activities as well as in research? Will the evaluation of the education plan yield data that might inform research integration?
Personnel	How well-qualified is the individual, team, or organization to conduct the proposed activities?	Does the principal investigator convey their unique impact identity (one that values both research and education) in the proposal through their passion, motivation, prior experience, and/or career goals?
Resources	Are there adequate resources available to the principal investigator (either at the home organization or through collaborations) to carry out the proposed activities?	Are natural stakeholders in the research involved as collaborators in the design and/or implementation of the education activities? Do the Facilities, Equipment, and Other Resources document; budget and budget justification; letters of collaboration; and departmental letter demonstrate the feasibility of proposed education as well as research activities?

by our case study team, increases the likelihood a proposal will compete successfully for funding, and how particular pathways to integration are reviewed in specific NSF programs. We anticipate a future study systematically comparing our mock panel reviews with actual NSF panel reviews of the same proposals.

Conclusion

Like the hypothetical overwhelmed early-career faculty member with whom we began our story, the researchers in this case study care a great deal about the broader impacts of their work but lacked the training and tools to develop robust and meaningful impact plans. One reflected:

> Whenever I see an obituary [for] a faculty or staff [who] passed away, I kind of try to see myself in that person's position. Maybe I've done some research, some publication, some grants. But would that be satisfying? Is that how I would like to sum up my life? Or do I want to leave some, you know, real impact on people's lives? I always had this question. I just didn't know what's the best way to address [it].

Our data show that engaging with the BI Toolkit positively affects impact identity and self-efficacy in early-career faculty (Hypothesis 1), positioning them to effectively integrate education with research in CAREER proposals (Hypothesis 2).

The relationship between our two hypotheses is richer and more multifaceted than we imagined, however. Principal investigators of VIPs sought to learn and grow through the implementation of their education initiatives, mirroring the approach they took to their research. In this way, the process of integrating research and education for a CAREER proposal may help to galvanize an early-career researcher's impact identity. Conversely, we found that an authentic, consciously cultivated impact identity could be a lodestar for faculty developing an integrated CAREER program and a powerful means to demonstrate this integration in the proposal. For our study participants, the integration of research and education was at once motivation for, means to, and expression of a meaningful impact identity.

Because the integration of research and education appears closely bound with a researcher's identity, it is helpful and appropriate that the BI Toolkit captures multiple pathways to conceptualize and demonstrate integration. By equipping researchers to chart a unique course toward a holistic and well-integrated professional identity, this case study suggests that—and positions a future study to investigate whether—utilizing the BI Toolkit in the development of CAREER proposals may contribute to long-term grant-writing and research program success over the career spectrum. Since the BI Toolkit is freely available and accessible to *all* researchers, this would be of particular consequence for those who lack strong institutional support for proposal development.

Our results also present an exciting opportunity to consider the development of a well-integrated research and education plan in the context of community engagement models. We noted that CAREER proposals scoring higher on integration tended to include robust, reciprocal engagement between researchers and their education audiences. Anchoring this observation to specific engagement metrics—for example, the IAP2 Spectrum of Public Participation (International Association for Public Participation, 2018)—would afford greater insight into how various engagement practices inform and are informed by an integrated approach to research and education. This work would create an important bridge between research impact professionals and community engagement scholars and practitioners, including those in the service- and experiential-learning, student volunteerism, and Cooperative Extension fields. While these roles are too often siloed by their institutional locations, conceptual frameworks, and specialized methodologies (Beere et al., 2011), cross-learning and collaboration are vital to build the institutional and community capacity to catalyze, support, and sustain meaningful connections among researchers and stakeholders (Ozer et al., 2023). The present volume is an important step in this direction, positioning the ARIS BI Toolkit as a potential boundary object to facilitate knowledge exchange and innovation (Caccamo et al., 2023; Grant et al., 2024).

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