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The Five I's: A Framework for Supporting Early Career Faculty

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The Five I's: A Framework for Supporting Early Career Faculty

Engineering Education Research (EER) has developed into a field of expertise and a career pathway over the past three decades [1-3]. In response to numerous reports in the 1990s and early 2000s [4-7], multiple EER graduate programs were established in the mid-2000s and a growing number continue to emerge to educate and train the next generation of EER faculty and policy makers. Historically, many came to EER as individuals trained in other disciplines, but with an interest in improving teaching and learning [8]. This approach created an interdisciplinary space where many could learn the norms, practices, and language of EER as they became scholars. This history combined with the emergence of EER as a discipline with academic recognition; specific knowledge, frameworks, methodologies, and ways of conducting research; and particular emphasis and goals [9], creates a tension for building capacity to continue to develop EER and also include engineering education researchers who have not completed PhDs in an engineering education program. If EER is to continue to develop and emerge as a strong and robust discipline with high quality engineering education research, support mechanisms must be developed to both recognize outstanding EER scholars and develop the next generation of researchers in the field.

The CAREER Award

One of the hallmarks of an engineering field becoming an established engineering discipline is the increase in opportunities for external funding. The National Science Foundation Faculty Early Career Development Program, henceforth called the CAREER program, is a funding opportunity only open to junior faculty in a tenure-line or equivalent position. The program is Foundation-wide, meaning that all of the research directorates can participate. Any area in which a directorate award a CAREER has received public recognition of the validity of the field. CAREER is considered one of the most prestigious research awards for junior faculty and aimed at finding and supporting future leaders in their field who integrate research and education activities. Arguably, NSF CAREER awards in EER is significant external recognition of EER that signals central membership in the community of disciplines. Similarly, the individual receiving the CAREER award has also received a public signal of central membership in the EER community.

While the EHR (Education and Human Resources) directorate had already been making CAREER awards for research on the evaluation and assessment of engineering and science education, the Engineering directorate awarded its first engineering education research CAREER in 2003. Since then, 52 CAREERs have been awarded in the Engineering Education and Centers (EEC) division of the Engineering directorate (as of January 2020).

The CAREER program continues to be a particularly prestigious funding opportunity for early career faculty and the awards are highly sought after by eligible faculty in engineering education research, regardless of institution type. While only a small fraction of CAREER proposals are recommended for funding, former EEC deputy director Sue Kemnitzer frequently reminded applicants that the process of applying for a CAREER award has value in itself. By this claim, she included the self-reflection on a faculty member's research agenda, a plan to integrate the research and education activities throughout the individual's career, and the discussions held between the early career faculty member and their department chair, senior mentors, and, in some cases, deans and other constituencies. These key activities provide many opportunities for faculty development and encouraging growth in all aspects of faculty life. The following sections provide research-grounded advice and tools for faculty developers as they support an early career faculty member applying for a CAREER award. While the following content is applicable to any research area or NSF directorate, the examples provided are from a study of CAREER awardees in the engineering education research and thus will have that particular focus.

Process of Developing a Research-Based Framework

The tools described below were developed through an intensive two-day retreat held in Spring 2019 with 42.2% (n = 19) of the currently funded or previously funded CAREER awardees from the EEC Directorate. The retreat also had the current program officer for EEC in attendance. During this retreat, the group engaged in robust discussions around three central prompts to build set of resources to support early career faculty in the development of competitive CAREER proposals: 1) I wish I had known…; 2) What makes a great CAREER proposal?; and 3) Sharing, finding, and forming resources. The engagement with each of these prompts was facilitated and used collaborative inquiry to build consensus on the topics at hand.

Collaborative inquiry is a process by which individuals work together to identify common challenges around a theme, identify and analyze relevant data, and develop potential countermeasures and interventions for testing. Bell and colleagues [10] derived a set of collaborative inquiry characteristics: orientation/question; hypothesis generation; planning; investigation; analysis/interpretation; model; conclusion/evaluation; communication; prediction. While not all of the collaborative inquiry models and reports of practice they analyzed leveraged each of these characteristics, the majority where present in each example. Additionally, while there are some characteristics that occur earlier or later in the cycle, the characteristics are not a linear progression. The framework for understanding the key components of successful CAREER proposals and faming support for early career faculty is described below.

Dimensions of a Competitive CAREER Proposal

While the particular research and education activity content of a proposal may not be in the bailiwick of the faculty developer, there are three dimensions along which the work of the CAREER proposal needs to find a "sweet spot": value, feasibility, and risk. *Value* is a measure of the potential impact of the proposed research and education activities. It goes beyond the monetary investment from the distribution of funds [11]. Value includes the ways in which society may be improved as a result (directly and indirectly) from this work [12]; when the work is fundamental basic research, it is especially important for the investigator to describe this value in both terms for other scientists / engineers and to politicians and society at large [13]. This emphasis means that applicants are encouraged to consider the value of their proposed work from the perspectives of science, the practice of engineering, the economy, the environment, defense, and public health [14]. Not all of these perspectives will be appropriate for the proposal; however reflecting broadly increases the ability of the investigator to find the key areas of impact. Proposal writers should recognize that bibliometrics and similar citation counts [15] do not include the broader impacts of the work on society [16] and encouraged to use narrative [17] instead.

> *Engineering Education Research CAREER proposals should be potentially transformative work that is connected to an engineering education context and broader impacts beyond the research community.*

The second dimension of a competitive CAREER proposal is its *feasibility*. The objectives, research questions, methods, and integrated educational activities should be clear to the reviewer. Potential "points of vulnerability" [18] should be identified and pivots in response to unexpected results mentioned up front. Further, successful CAREER awards are made to investigators who are likely to be the next generation of leaders in their field. One proxy used to assess potential field leadership is the unique advantage or identity the individual brings that will allow them to push the edges of this particular subfield. The investigator's *unique advantage* is something in their background, experiences, training, current context, or the intersection of these that positions the investigator for success in a way others would not be. It may help the beginning investigator to view their unique advantage as the top of a pyramid, there the steps building to it are one's capabilities, core competencies, and strategic assets [19]. Some of the unique advantages available for CAREER proposals include situating the institutional context (what resources and networks does the investigator have? What are their role expectations?), building on prior research expertise (publications, methodologies, pilot data, theory bases not currently mainstream in the field), and the particular trajectory of the investigator (special feature of the career trajectory or research agenda, vision of what the applicant wants to be known for). The unique advantage is also an opportunity to claim an area that may, on its face, seem like a disadvantage and illustrate to the reviewers how it can be leveraged as a strength. For example, one of the authors (Jen) received her CAREER award while a faculty member in a department without a research-based graduate program. Part of her unique advantage involved describing how her work would build local research infrastructure and involve undergraduates in research at a high level.

> *Alignment of the objectives, questions, methods, and educational plans for the research should be clear. The CAREER proposal should include a persuasive argumentation that the PI is prepared to conduct and accomplish the research.*

The final dimension, *risk*, is another place where CAREER proposals differ from other research proposals. Risk is the likelihood that events will not occur as planned or predicted. Engineers are often trained to think of risk in terms of probabilities [20] or expected loss [as in 21]. In proposal writing, the investigator is encouraged to instead think of risk as uncertainty [22] from the entrepreneurial perspective [23-24]. Not all risks can be predicted ahead of time (e.g., at the proposal stage). Uncertainty encourages reflection that is both interpretive (what are the factors where uncertainty might occur, which factors matter to the results and impacts, how do we determine we need to take action) and predictive (what likely will happen based on our action or lack thereof) [25]. The resulting understanding should be summarized in the proposal, particularly given the five-year timeline of the CAREER program. When considering the risk inherent in a CAREER proposal, the investigator should look for the sweet spot, where there is high enough risk to be potentially transformative, while not so risky that there are serious doubts as to whether or not the work can be completed or the work will not achieve its impacts.

> *The content of the research and education activities should be novel enough to launch a career, not just any five year project. Consider and describe how insights from the integration of the research and educational plans have ability to transform some aspect of engineering education.*

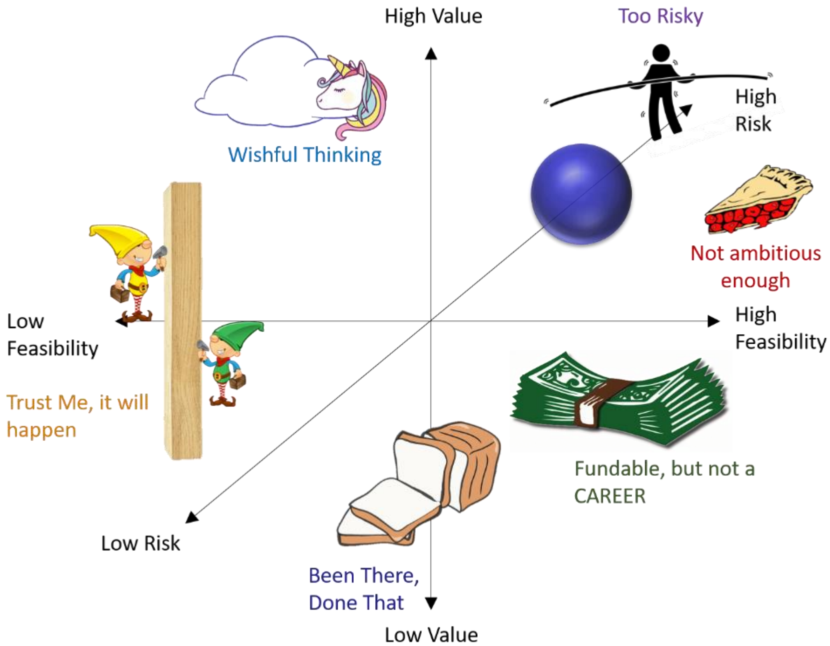

Figure 1. The Three Dimensions of a Competitive CAREER proposal

When we put these three dimensions together, we see there is an area, represented by the ball in Figure 1, where most successful CAREER proposals live. There are pitfalls in the other parts of the three-axis graph that faculty developers can help proposers avoid. We gave each of these areas names with common metaphors to help faculty understand why these areas may not be funded. Proposals that are too risky have value and feasibility, but it is not clear to reviewers that the risk is likely to pay off in terms of impacts (a high wire act). On the other hand, when the feasibility is so high that it is obvious, the proposal is likely to be seen as not ambitious or transformative enough (a small slice of "the pie"). Another proposal may be at a good level of feasibility, but lacking in extra risk or value that sets apart the CAREER program from other fundable work. Proposals with high value while not carrying enough risk and feasibility are considered "wishful thinking," or projects that would be wonderful to occur, however the ability of anyone to make this happen is too low to consider. In contrast, similar projects with low value are obvious given the work that has occurred before (sliced bread). Finally, proposals with low feasibility, regardless of the risk and value, will be viewed very skeptically by reviewers (assumption that someone will complete the work, but is not described in the proposal. The metaphor here refers to the "magical elves" from the Elves and the Shoemaker fairy tale). This framing of how to situate a CAREER proposal within a faculty member's sphere of influence and avoid potential pitfalls has proven useful in discussions of the CAREER program broadly. It also generalizes the main components of successful CAREER proposals rather than focusing on the particular research and education aspects of a project.

Moving Toward "CAREER Ready"

While the previous two sections provide useful advice for positioning one's CAREER proposal, they do not include sign-posts indicating what an individual should be doing or looking for to be ready to write a competitive CAREER proposal and, if successful, thrive while completing the promised work. Recognizing this gap, we developed and honed the 5 "I"s of CAREER readiness. The Five I's are: Ideas, Integration, Impact, Identity, and Infrastructure. As each is described in turn, questions are listed to facilitate the process and spur areas where the individual may need more reflection, more mentoring, or to connect with particular resources.

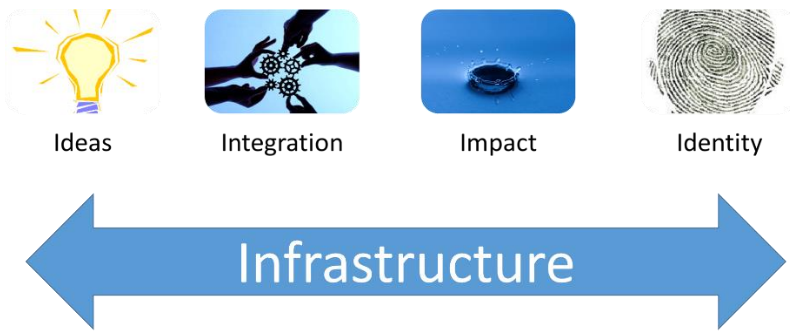

Figure 2. The 5 "I"s of CAREER Readiness

Ideas represents the researchers' innovative and potentially transformative ideas that can make a significant contribution to EER. All NSF proposals are evaluated using the criteria of intellectual merit and broader impacts, and ideas aligned with these goals are essential for funding success. A "CAREER ready" idea should be big enough to be the foundation of a lifetime of leadership in the engineering education field. At the same time, the portion of the idea to be completed in this proposal should fit into the five-year time frame. While the research methods should be of sufficient technical specificity, the idea also needs a "hook" to interest reviewers and others in the field. This is also the part of the framework where the investigator should consider their ability to complete the work and whether or not their idea is the in "sweet spot" for risk.

Describe your big idea in no more than 100 words.

What makes your idea interesting to reviewers?

What makes your plan feasible?

What makes your idea and/or plan risky?

What would you learn if your idea or plan did not work?

The *integration* of research and education is a specific additional consideration of CAREER proposals. Both education and research must inform one another in the proposal process. The integration of research and education activities has long been a standard of the CAREER program [26] and its importance in the proposal should not come as a surprise to applicants. One of the ways the integration of the research and education plans can show the value of the proposal is for the investigator to think broadly about who will benefit from their work and create opportunities to education that population. This includes working professionals (often engineering faculty and/or graduate students, though K12 teachers are also in this category), industry networks, and governmental agencies. Similarly, how will the broader society interact with the results of this work and are their opportunities to train or otherwise inform them?

> Describe your education goals for this proposal in no more than 100 words.
>
> How do your education goals connect to your big idea?
>
> How will your education activities inform your big idea? How will your big idea inform your education activities?
>
> How do both your education goals and your big idea come together to inform your intended career trajectory?

Demonstrating the *impact* of research is essential to convey why research should be funded. This *impact* is essential to address as it directly relates to the NSF criteria of broader impacts as well as why an individual is positioned to carry out that impact. The level of value necessary for an idea to be CAREER ready is greater than the already significant expectations placed the majority of other NSF research programs. Some of this value becomes clearer as the investigator considers the outputs and deliverables, potential uses, and beneficial changes in education and/or society that are likely to occur based on the completion of the proposed work [27]. It is important to note that the focus of research impact in this context is the impact on society [28], not the impact score of a publication or other measure of research productivity [29].

> What is the primary value of the idea to the engineering education ecosystem?
>
> Who is going to receive this value directly? Indirectly?
>
> What evidence (literature, pilot data, information from practice, other subject matter experts, etc.) do you have for the size of this value?

A CAREER ready idea is also tied to the *identity* or the particular research expertise from which a faculty member will be a leader in the field. This identity can be connected to introduction or particular use of a theoretical area; deepening understanding of a particular method, variable type, or component; expertise in a discipline, industry base, or other context; relevance to a particular population or identity; or any other factor that sets the investigator's career path toward leadership. During the collaborative inquiry retreat discussed above, every engineering education research CAREER awadee present described, unprompted, their award focus using a term or phrase that fit into the blank in the sentence: In the engineering education research community, I am the _______ person. Investigators searching for their research leadership identity are encouraged to consider their unique advantage as well as concepts or methods they are drawing from that are common in another field yet novel in EER.

What is your unique advantage in putting together this project? Are there elements of your many personal identities, context, and/or training that impact your ability to collect, analyze, or interpret your data?

Fill in the blank: In the research community, I am the ________ person.

Finally, *infrastructure* includes the people and physical resources from which a faculty member must draw to be successful. CAREER proposals are required to include a letter from the investigator's department chair; this is an opportunity to network with the department chair and other senior faculty regarding the investigator's intended career path and the support, mentoring, and other resources that will be needed. If the proposed work requires particular space, renovation to space, purchasing to using equipment, or facilities, the best time to start those discussions is well before the proposal is due. Items that may seem inconsequential to the investigator may have significant implications to the department or college. Similarly, there are other offices across the university that the investigator should be talking to early on. The sponsored programs office is not only vital to submitting the proposal, they can also help with connecting the researcher to other important groups, like the human subjects review board or IRB, as well as any internal policies or procedures that may impact the local ability to spend allowable costs. This is also a good time for the investigator to consider their personal workstyle and accountability processes. The CAREER is a five-year solo award and the investigator may need to begin developing a network to support their morale, energy level, and timeline accountability.

Does your department chair support your idea and desire to submit it as a CAREER proposal?

Do you have senior faculty mentors (in or out of your department) that your department chair can name in their letter of support?

Do you have the space, facilities, and equipment you will need to complete your plan? Have you talked to your department chair about anything you need to secure from the institution?

Have you started talking to your sponsored programs folks? Have they connected you with any offices or resources that might be vital to making sure the institutional infrastructure is prepared for you needs (e.g. paying participant incentives, submitting an IRB application)?

While you can fund senior personnel in a supportive role, a CAREER award is still a solo endeavor. Do you have access to the post-award knowledge you need for a solo PI role?

Think about your workstyle, do you need an accountability group to keep your energy high while completing a 5-year solo award?

The investigator should go through the "I"s and the question sets in the order provided as they represent a journey through which the researcher is traveling. The area(s) of the model where the individual's ability to confidently answer starts to wane is the starting point for the next segment of building the proposal plan, research agenda, and networks. The faculty developer can facilitate this process of self-reflection, conversation, and further investigation. Key questions include:

- Where do you need to spend more time reading literature and thinking about your ideas and/or plans?
- Who do you need to add to your network? Visit with more?
- Are there folks on other campuses who can help you fill in remaining blanks?

This model and self-diagnostic tool has proven useful in helping early career faculty evaluate their readiness to apply for an NSF CAREER award or highlight the particular areas of their development that could be improved for future success. It has been used successfully in workshops with early career faculty from across the many varieties of engineering education researchers.

Next Steps and Conclusions

CAREER proposal workshops are often framed around understanding the program requirements, grant writing, or a particular aspect of the entire proposal process (i.e., integration of education and research plans). Articles aimed at helping junior faculty become more successful at obtaining grant funding often focus on the process of writing the proposal rather than the necessary work that occurs before the first words are typed [e.g. 30, 31]. This work provides a broader, more holistic framing of the important considerations early career faculty must address in developing CAREER proposals. In addition, it was developed by the EER CAREER community, which is often a large part of the reviewer pool. We have successfully used this framing in several national workshops with engineering education and engineering faculty. Feedback indicates that this way of understanding the larger expectations of how to position one's research and education plans within a unique "sphere of influence" provides ways for large groups of faculty to take their ideas and position them in more competitive ways. Our future work will track the success (i.e., funded faculty or faculty who were recommended for funding by panels) to further provide evidence for this approach.

We are also developing additional tools and curating resources that awardees found in a high quality online archival platform. This platform will provide community recognition of all of the past CAREER awardees as well as host materials that are openly accessible for all early career faculty interested in developing a CAREER proposal in engineering education.

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