Ruminations on the NSF Broader Impacts Criterion: A Dialogue with Academic Researchers and Broader Impacts Professionals

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Abstract

The National Science Foundation, a United States federal agency supporting STEM research, puts special emphasis on research impacts in society, and requires each funded research project to have "broader impacts" outside of conventional academic scholarship. As "broader impacts" have become an important part of the STEM research landscape in the U.S., most academic researchers need guidance and support in their broader impact plans. Focusing on a mid-size STEM-focused university, our research identified three major areas that matter to academic researchers: (1) autonomy of the researcher and non-prescriptive nature of broader impacts, (2) impact identity and personal connection to broader impacts, and (3) a critical engagement with diversity and inclusion in research and education. Combining these findings with a broader impacts professional's reflections, we examine the ways in which broader impacts resources such as the ARIS Toolkit can assist academic researchers. We argue that by constructing dialogues between faculty researchers and broader impacts professionals, the research culture in the U.S. can turn into an ecosystem that supports meaningful, inclusive, and transformative STEM practices.

Focusing on Worcester Polytechnic Institute (WPI), a STEM-focused university in Massachusetts, this article examines faculty researchers' perception of the U.S. National Science Foundation (NSF)'s broader impacts criterion (BIC). BIC is one of the two grant-proposal review categories for the NSF, a federal agency that supports fundamental research in science and engineering. The "intellectual merit" criterion focuses on potential contributions to the academic research community, and the BIC addresses potential societal benefits of the proposed research. Centering the faculty researchers' needs and concerns related to BIC, this article identifies areas of success and improvement in research support systems, such as broader impacts consultation services provided by WPI's broader impacts (BI) professional Kathy Chen, a co-author of this article, and the Center for Advancing Research Impact in Society (ARIS) Broader Impact Toolkit (ARIS, 2023), the focus of the special issue of which this article is part.

As McDonnell and Renoe (2024) point out, the conceptualization of BI is evolving alongside the changing culture of academic research in the U.S. The meaning of BI varies; some academic researchers think of BI simply as a proposal-writing requirement for an NSF research grant application, while others see in it the possibility of transforming the world for the better. When a researcher and a BI professional come together, they might need to translate to each other their potentially different understandings of how science contributes to the world outside of a research community. This kind of "translation" that happens in broader impacts consultation is important because it enables a research ecosystem that can benefit from the expertise of professionals who are connected to community partners and other groups that can help with the delivery and enhancement of research impact in society.

The study presented in this article is built on (1) interviews conducted by Yunus Doğan Telliel with 18 WPI faculty researchers, and (2) Kathy Chen's observations from her broader impacts workshops and consultations with faculty researchers. The article aims to bring these two types of "data" into an action research framework (Greenwood, 2015) that seeks to reexamine and reimagine the role and place of the ARIS Toolkit in academic research. These two types of data are also two distinct voices that are in a dialogical relation (cf. Poopuu,

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2020; Wegerif, 2008). The first is the one of faculty researchers; the second is Chen's voice. Chen, as a BI professional, is commenting on resonances and disjunctures between the researchers' vision of broader impacts, on the one hand, and the ARIS BI Toolkit and other BI support systems on the other. The dialogue we construct in this article is inspired by what happens in consultation sessions with BI professionals.

As Iverson et al. (2024) describe, the BI professional "bridges the gap between scientific research and its potential benefits to society [by ensuring that] scientific research serves the public good in a variety of ways [such as] fostering public engagement, enhancing education, promoting diversity and inclusion, and contributing to economic development" (p. XX). In a higher education setting, the BI professional often plays the role of a coach or partner for the researcher's broader impact vision. By mobilizing the synergy between the researcher and the BI professional, new ideas and strategies may be uncovered that can help the researcher build a meaningful and transformative BI plan.

By creating a similar dialogue in this article, we demonstrate that there are multiple points of potential convergence between the support that the ARIS Toolkit and BI consultancies are currently able to offer, and the researchers' needs, concerns, and aspirations related to NSF grants. There are three particular areas of convergence that mattered most to the researchers we interviewed: (a) autonomy, accountability, and non-prescriptive nature of BIC, (b) impact identity and personal connection to broader impacts, and (c) a critical approach to "broadening participation outcome" of research projects. This does not mean that the interviewed researchers all agreed with each other within these areas. Even if they have different—and sometimes opposing—views, they share concerns that bring them together. The scholarship on BI, including articles in this special issue, has shown that while most faculty researchers need guidance and support in their BI plans, there are many who do not take advantage of the ARIS Toolkit. We thus recommend that these three areas of convergence are highlighted and leveraged in reaching out to faculty researchers in the future uses of the ARIS Toolkit in BI professionals' consultations and workshops with faculty.

Context of the Study

Worcester Polytechnic Institute (WPI) is a Carnegie R2 research classified doctoral university that has been placing a greater emphasis on research and growing their graduate programs over the past several years. As of January 2024, 32 WPI faculty members were successful in getting NSF Faculty Early Career Development Program (CAREER) Awards. There has been a 44% increase in research funding from 2018 to 2022, with $47.7 million of sponsored research funding in the 2022 fiscal year. WPI also has a Vice Provost for Research, Office of Sponsored Research, and the Research Solutions Institute (RSI) to help support research activities. Many conversations at the leadership levels and around strategic planning at WPI point towards increasing WPI's research enterprise. Thus, the need to guide and support faculty with their research projects to have beneficial broader impacts for society is essential.

Like many other institutions, the current WPI strategic plan identifies purpose-driven research as one of its key components. The strategic plan states that:

> [O]ur investment in interdisciplinary and creative scholarship is critical, building on WPI's already fast-growing research enterprise. We are committed to growing our investment in research and supporting the innovations of our faculty and students as they seek to address some of humanity's most significant challenges. … We must continually work to increase the relevance and impact of our research and build a strong research infrastructure to support the success of WPI's scholars. (WPI Office of the President, 2021, p. 7)

Sharing this aspiration, the authors of this article have been participating in the ARIS Toolkit research team and are invested in guiding and assisting faculty to authentically examine broader impacts of their research work for the betterment of society and to develop sustainable and meaningful broader impacts plans.

Chen is the Executive Director of the STEM Education Center at WPI, and partners with RSI to facilitate faculty workshops on broader impacts as part of faculty bootcamps or grantsmanship series, in addition to doing individual consulting on BI. She typically does around 15 BI consultations each year and provides letters of collaboration when serving as a BI partner on a grant. She has written and has been principal investigator (PI) and co-PI of numerous NSF grants (e.g., S-STEM, TUES, RET, Noyce), and has served on several

NSF review panels. She has been a Professor and Department Chair of Materials Engineering at the California Polytechnic (Cal Poly) State University, San Luis Obispo, and has extensive experience in engineering education, community-engaged scholarship, and equity and inclusion advocacy. Through these experiences, she brings the disposition of understanding the tenure demands of professors and writing NSF proposals, while also having the developmental approach of enabling others to do impactful and systemic work that broadens participation in STEM.

Telliel is an assistant professor of anthropology and rhetoric, and he facilitates broader impacts workshops for graduate student researchers and teaches an applied ethics course for graduate students with a strong emphasis on the social impact of STEM research. He has been a PI and co-PI on various collaborative projects funded by NSF (e.g., NRT, FW-HTF, CIVIC, NRI/INT, Cultural Anthropology) and the Public Interest Technology University Network. He researches issues related to the public value of science and engineering research.

Methodology

The study presented in this article captures the voices of a group of WPI faculty researchers through qualitative interviews conducted by Telliel over a span of five months from August 2023 to December 2023. In addition, the article draws on Chen's observations on the actual and potential use of the ARIS Toolkit with faculty. The protocols and procedures of this study were reviewed and approved by WPI's Institutional Review Board (IRB).

The semi-structured interviews focused on faculty researchers' perceptions of the NSF's broader impacts criterion. With these interviews, we collected data on:

1. the researchers' current projects and the broader impacts plans they included in their recent NSF applications
2. the researchers' perceptions of "research impact in society" (interview questions included: "What does the idea of broader impacts of research mean to you?" and "What broader research impacts are especially important to you and your work?")
3. the researchers' sensemaking of two major ideas underlying the NSF's broader impacts criterion: the potential for a BI plan (a) to "benefit society and advance desired social outcomes" and (b) to "suggest or explore creative, original, or potentially transformative concepts" (interview questions included: "How do you know when a plan benefits society or advances desired social outcomes?" and "How do you define 'creativity,' 'originality,' 'transformativeness' of BI activities in the grant proposals you have submitted to the NSF and have evaluated as a reviewer on an NSF review panel?")
4. the researchers' views on the role and place of social justice values in their engagement with BIC (interview questions included: "To what extent do social justice values such as diversity, equity, inclusion, and belonging [DEIB] play a role in your research design?" and "To what extent does DEIB play a role in your assessment of a research project's impact?")

The interview data on parts (1) and (2) helped us acquire a deeper understanding of how researchers connect scholarly identity and impact identity to one another (cf. Risien & Storksdieck, 2018). We were interested in part (3) because this interview data generated insights into how the researchers think of the two major ideas of the BIC ("benefitting society/advance social outcomes" and "creative, original, and transformative BI plans"). We were also able to analyze resonances and disconnects between the researchers' views and the ARIS Toolkit's BI Rubric, especially the Rubric's guidance on these major ideas in the criterion. With part (4), we wanted to examine if and how social justice critiques play a role in shaping the researchers' perceptions of the BIC. This was especially important in understanding whether such larger social critiques play any role in the researchers' interpretation of the "broadening participation" or "inclusion" outcome—defined by the NSF (n.d.a) as "increasing and including the participation of women, persons with disabilities, and underrepresented minorities in STEM."

Eighteen WPI faculty researchers were interviewed for this study. In consultation with the Office of Research, Telliel selected potential interviewees due to their experience with NSF grants and/or involvement in various DEIB events and initiatives at WPI. Telliel sent interview requests to 27 faculty members at WPI; because of scheduling difficulties during the period in which interviews were conducted, 9 declined.

Ten of the interviewees were women and non-binary individuals, and eight were men. Our interviewees were from diverse academic

disciplines and career levels. Four were full professors, and the rest were junior and mid-career faculty members. The interviewees were housed in a range of academic departments and programs at WPI: Aerospace Engineering, Biomedical Engineering, Chemical Engineering, Computer Science, Electrical and Computer Engineering, Data Science, Interactive Media and Game Development, Integrative and Global Studies, Mathematics, Robotics Engineering, and Social Sciences and Policy Studies. Some of the interviewees had joint appointments with other departments and programs.

While not all departments and programs at WPI are represented across our interviewees, the researchers included in the study have applied for grant programs across all NSF directorates except Directorate of Geosciences: Biological Sciences; Computer and Information Science and Engineering; Engineering, Mathematical and Physical Sciences; Social, Behavioral and Economic Sciences; STEM Education; and Technology, Innovation, and Partnerships. The interviewees were all knowledgeable about BIC. All except one of our interviewees had served on NSF grant review panels—which involves the review of BI plans included in submitted proposals. Our interviewees were familiar with the vision of the NSF as a federal funding agency as well as with the norms and values represented by the NSF in its guidelines and other communications to the potential grantees.

Eight interviews were conducted remotely via Zoom, and the other ten were conducted in person on WPI's campus or at coffee shops close to WPI campus. Nine of the in-person interviews were recorded on a smartphone's voice-recording app, and in one interview, the interviewer took notes on the interviewee's responses. Transcriptions were done on the Descript software. The necessary corrections were made by Telliel on the automatic transcriptions generated by Descript before the data analysis.

Telliel analyzed all the interview data to identify the frequently appearing themes to help characterize areas of convergence between the ARIS Toolkit and similar BI support systems, and the researchers' needs, concerns, and aspirations related to NSF grant writing. The thematic analysis was done manually using Microsoft Word and Excel. As we wanted to capture the richness of the overall dataset, Telliel preferred an inductive, data-driven approach instead of a deductive approach that relies on already-existing categories of analysis in the study of research impact in society (Terry et al., 2017). The inductive approach privileged a semantic (versus latent) and experiential (versus critical) analysis (Byrne, 2022). It was important for us to prioritize the researchers' articulation of their own experiences of research and its broader impacts, as there is not always a perfect alignment among research stakeholders with respect to how they interpret the concept of research impact.

With this thematic analysis, Telliel identified three overarching themes: broader impacts plans, impact identity, and broadening participation. The first theme was created to capture most of our interviewees' preference for a non-prescriptive approach to BI plans. The interview questions related to the ARIS Toolkit's BI Rubric led to conversations in which most interviewees shared their understanding of what BI guidance and support should look like. The researchers' responses often focused on the non-prescriptive nature of BI plans and their connection to the values of autonomy and accountability. The second theme, impact identity, was created to highlight a common pattern among the responses to our interview questions on the researchers' visions of their project's impact. All of our interviewees highlighted the deep personal connections to their BI plans. The third theme, broadening participation, addresses a concern shared by most of the interviewees regarding the instrumentalization of diversity and inclusion. While our interview questions did not specify broadening participation, many interviewees interpreted our questions about DEIB through the lens of the NSF's definition of broadening participation. Most shared their own critical perspectives on how broadening participation could be accomplished in a more meaningful and transformative way.

The themes and quotes from the interviewees were then presented to Chen for her response and commentary as a BI professional at WPI who works with many faculty that come to her for assistance with their BI plan for proposals or attend BI workshops through the Office of Research. Telliel asked Chen to comment in writing on what she typically encounters at the faculty BI consultations and NSF grant writing workshops with the prompt: "As a BI professional that works with lots of faculty coming to you for assistance with their BI plan on their proposals, what are your thoughts after hearing these words from my interviews with faculty about their perceptions on the BI criterion and their concerns?"

Findings

The three overarching themes identified by Telliel are discussed separately in the following subsections. At the end of each subsection, Chen provides a response focusing on her observations of central issues related to that theme as a BI professional. The findings section concludes with recommendations from the researchers to support BI plans.

Broader Impacts Plans: To Be or Not to Be Prescriptive

While the NSF (n.d.a) "does not want to be prescriptive about the societal outcomes a project addresses," the agency "expects researchers' work to have *broader impacts*: the potential to benefit society and contribute to the achievement of specific, desired societal outcomes." The ARIS BI Wizard in the Project Planning portion of the ARIS Toolkit provides examples of NSF BI priorities and guides the researcher to consider how their research is relevant to society for their NSF proposal (ARIS, 2023).

In exploring faculty thoughts about the BIC, most researchers that Telliel spoke to highlighted that they appreciate that the BIC framework is not prescriptive. The word "creativity" appeared more than other words to characterize the affinity between the research ethos and the openness of the BI criterion. In the interviews, three researchers articulated this affinity as such:

> I like that it's not as prescriptive because it means that we can . . . be creative in our approach … if we're really excited about something.

> I wouldn't want it to be too prescriptive because part of the reason why we become researchers is that we try creative new things that might work.

> Potential great ideas maybe [won't] fit into that narrow[er definition of BIC]. … I like the freedom of being able to say I want to do something that fits this thing on this project and [then] something that's drastically different on a different project.

Another researcher told us that she sees BIC as a license to explore the deeper meanings of what her research means:

> What I appreciate about [the BIC] is that it's almost like a license and an opportunity to really think about [research]. And that's the reason why I like that it's not prescriptive because … when I'm sitting down to … scope something out and I get to that portion … I can [think it through].

The word "breadth" appeared to be the key for another interviewee as they were describing the possibilities of research impact plans that are available for him and other researchers:

> [I'm] all for a liberal interpretation of broader impacts [as long as] it's got to be that you're really impacting. I appreciate the breadth … [it can be] tangible or immediate impact or the kind that builds over time. … That can be through dissemination over time. … [You're] investing in … the new generations of … future scholars … [who] will go and continue … in other types of impact. … I appreciate that the breadth is there because it is less prescriptive.

Yet, other researchers suggested that a well-defined criterion, a higher standard, or more guidance on planning and evaluation is needed. A few of our interviewees thought that this could generate additional motivation for the researcher to create better BI plans:

> I think having something more well defined would … force people to have better developed ideas because they have to fit very specific criteria. … I think it would push people more [towards better BI plans].

> We need better criteria or better evaluation methods. Because … if we tell people that it matters, then there needs to be a standard. Otherwise, you're joking, right? And … there are some people who put a lot of effort into it, and it's outstanding, but it's because they care. The ones who don't care, they just do the bare minimum, and they still go through … and I just don't think that's fair. So, I wish we had more clear criteria. But if you want more clear criteria, then you have to restrict what you're allowing … because the more vague it is, the more hard it is to evaluate.

One researcher thought that a more prescriptive BIC could help with increased accountability with regard to the delivery of BI plans for a funded project:

> I don't think … there is a good feedback loop. … [What] engineering … researchers think about NSF [grants] is [that] you get it and then you don't have to report anything. And you have the money for five years or whatever. … There is much more accountability [attached to research grants by other federal agencies].

The NSF grant administration requires regular and comprehensive reporting on grant activities. While aware of this requirement, this researcher wanted to highlight what she sees as a common issue among her fellow researchers: the lack of a more prescriptive BIC leads to a weaker sense of accountability after a research project receives funding.

We should note that not everyone we interviewed saw the vagueness that may be originating from the lack of a more prescriptive BIC as a problem. For them, openness only becomes a problem when it is not interpreted as a "creative license." Here is how one interviewee put it:

> It's understandable that NSF doesn't want to be prescriptive … but, [it is also possible that] not being prescriptive also … presents some kind of vagueness. And then [some think that] when it's vague, people do not usually necessarily take it seriously [and that] the vagueness also leads … to lack of attention [or] lack of care. No, I don't agree with that [view] because [NSF] specif[ies] very clearly that intellectual merit and broader impact are extremely important. So, the vagueness shouldn't contribute to [applicants] not paying attention. It should just give them a little more creative license.

Chen's Response on the (Non-)Prescriptive Nature of BI Plans. *Oftentimes at the faculty grant workshops sponsored by the university's office for research, I encounter frustrations voiced in terms of not knowing exactly what NSF reviewers are looking for, not thinking that the BI plan is important (and disgruntled about the need to include the BI in the proposal), and wanting concrete examples of BI plans from grants that were awarded. When shown the range of NSF examples of BI priorities, some faculty feel that their research is not represented and feel that it is something extra to do or another hoop to jump through. There is typically a tension between wanting a broader impact to "copy" (i.e., be prescriptive) and to have the freedom and creativity to propose their own idea for BI. And sometimes this tension can even come from an individual.*

A significant number of the one-on-one faculty consultations that I do is about brainstorming appropriate BI plans and figuring out what types of activities they are comfortable (and hopefully excited) to do. The ARIS Wizard and Toolkit can help with ideas, but I've found that faculty often need to know that there is assistance to enact BI plans, otherwise they may dismiss ideas early on. For instance, if they can imagine themselves giving a presentation to the general public at a science museum, they might not know what cultural institutions are in the area or how to go about broaching the idea with the museum. Junior faculty may be new to the region and are so busy with getting their career started that they haven't had the time to be out in the community. This is where the BI professional can assist with sharing their knowledge of the landscape of community partners and connecting them with key stakeholders, as well as supporting the BI plan. The goal of these types of faculty consultations is to relieve the anxiety and feelings of being overwhelmed by showing faculty a path and providing connections to a viable BI plan.

The quotes from the faculty that Telliel interviewed reveal that they are glad there is flexibility and room for creativity with BI, which is interesting, yet not too surprising to me. The other type of faculty consultations that I have are with certain faculty who already have an idea and/or goal in mind, and they might be seeking a sounding board for feedback, connections to others, or a letter of collaboration from the STEM Education Center. There is a definite difference that I sense in their disposition towards broader impacts—as if their motivation for the research grant is so that they can ***also*** *do the BI plan. There is excitement when they describe their BI plan. The ARIS Toolkit and Rubric can help faculty consider different aspects of a BI plan (e.g., budget, ethical partnerships) that they might not have thought to address in their proposal, and we often discuss these different components during our consultation session.*

Impact Identity: Meaning Matters

Since all the interviewed researchers have applied for NSF grants, they already had clear conceptions of BI with respect to their research

projects. Unsurprisingly, the researchers in areas of STEM research that involve human participants—such as science education research, social and behavioral sciences, or human-computer interaction—indicated that their programs have higher expectations with respect to closely aligning intellectual merit and broader impacts of the research. Despite differences across scholarly fields, all the interviewees agreed that the main criterion for picking BI plans is whether they are meaningful to them as educators and researchers. Here are quotations from two researchers who talked about their enjoyment of designing educational outreach plans:

> What my personal values are and what I like to do [matter to me]. … So, for instance, . . . one of the things I like to do a lot is … dissemination to non-technical audiences. I do a little bit of filmmaking. … That to me is really an easy [way] to put the 'broader' into a broader impact. … [It's] dissemination for a broader audience and … involv[es] my own students in media [projects].

> So, in my case, what I really like is [gamification and] the fact that the language of games has this universality that is immediately inclusive. It doesn't matter where you come from, you will likely engage.

While these two researchers enjoy educational outreach BI plans and see them as the most meaningful impact activities, others had different preferences. Some researchers even feel the need to distinguish their authentic BI aspirations from a BI identity that is centered on educational outreach:

> [Educational outreach plans] sound like [the kind of] thing that everybody does and I don't really have … the drive and the motivation to do it. It's not something [I'm] interested in. Good or bad—it's just that it's not the kind of thing that attracts me. [Instead] I like to do broader impact activities that are fun for me and my students.

> Frankly … I would rather lose points on the broader impact section on grants and not have … summer camp outreach or high school class. [If I] say that I will do those things, then [I'll] do it half-heartedly. Because it's not coming from within … I just don't have those types of thoughts about broader impacts. I'd rather think about the students that I'm training and training them well, and that they will go on to impact others based on the good training that they've had.

It is true that perhaps because of the historical success of educational outreach in BI work, some researchers think that educational outreach is *the* broader impacts activity. Furthermore, many faculty shared that they learned how to write a BI plan by reading other faculty proposals, which often had K-12 outreach activities. Even though the interviewees have differing views with regards to what should be included in a BI plan, they all highlighted the significance of developing BI plans that are personally meaningful. One researcher took this a step further and suggested that the personal connection that the BI work enables is an opportunity for personal growth as a researcher:

> Broad impacts is like a good opportunity … to be a better researcher … [it's a] transformation of the self. [Of course] that's not the goal, [but] it is good and probably has some long-running impact. … Anything that transforms us is going to transform the way that we teach and what we do with our students. There's this trickle effect.

Chen's Response on Impact Identity. *In my faculty grant workshops on BI (and for the consultations where faculty don't know where to start with BI), I usually start with an exercise to tap into the researcher's "impact identity." I also ask what they enjoyed as children and what got them interested in doing STEM helps to unlock creative thinking and to shift their mindset to doing joyful work. Another common prompt is to reflect upon what types of "service" or volunteer activities they will always do, even when they don't really have the bandwidth to do so. They are then challenged to imagine doing those activities that could "count" towards their professional review and could possibly be funded or being able to do it more or bigger. Now the BI plan might be something exciting for the researcher to propose! Of course, this isn't always the outcome, but sometimes it does happen. This activity is done before diving into the BI criterion and the ARIS Toolkit.*

Many faculty at the workshops tend to want an off-the-shelf BI activity that they can adapt to fit their research plan. Historically at our institution, many researchers were successful with their grant proposals that had a K-12 education outreach BI plan, and thus the perception that education outreach is the only successful BI may have come about. Furthermore, institutional infrastructure through existing offices at WPI (i.e., Pre-Collegiate Outreach Programs, Touch Tomorrow annual public outreach event, and STEM Education Center) have likely contributed to the success of K-12 outreach activities in grant proposals. Although I direct a center for PreK-12 educators, in my BI professional role, I always purposefully state and reiterate that a BI plan does not necessarily have to do anything with K-12 and that my BI consultations are not limited to K-12. While our university has strong support for K-12 outreach and impact, we might not have as much infrastructure and institutional support readily available for faculty to tap into if they have other types of BI plan ideas (e.g., lack of centralized community-engagement activities).

For those researchers who might be trying to follow a formula of doing BI through K-12 outreach by entering a K-12 classroom to present their research, I will often dissuade them by engaging in a conversation about science communication with different audiences. During these consultations, we are able to inform faculty about K-12 state standards, scope and sequence of topics that teachers follow, standardized testing, teacher and school responsibilities, and protocols for entering classrooms. The STEM Education Center at WPI has many contacts with K-12 teachers and schools, and we are quite protective of those relationships, and we ensure that only those who propose something beneficial to K-12 can receive a letter of collaboration from the Center.

For those researchers who already have a strong impact identity and an idea for a BI plan, they might not feel the need to utilize the ARIS Wizard or Toolkit. However, as a BI professional who is familiar with all the components of the ARIS resources, I can help researchers be more thorough in proposing a robust BI plan, and even help or contribute in appropriate ways as a BI partner (e.g., connecting to local community organizations). There have been several cases where the STEM Education Center has been able to strengthen a BI plan and partner with faculty to have greater or deeper impact.

Broadening Participation: Checklist or Systemic Change?

Among the interviewees, there seemed to be a consensus on the need to "broaden participation" in STEM research and education. Broadening participation in STEM is part of the NSF's merit review criteria. Indeed, in its public-facing communication, the NSF draws attention to its commitment "to expanding the opportunities in STEM to people of all racial, ethnic, geographic and socioeconomic backgrounds, sexual orientations, gender identities and to persons with disabilities" (NSF, n.d.b). The interviewees appreciated the vision of STEM research that the NSF is promoting with its strong emphasis on broadening participation as a societal outcome. Yet, most of our interviewees highlighted the need to move beyond tokenization of minorities and underrepresented groups. Not all, but some researchers were worried that recruiting women and underrepresented minorities is now seen as an end in itself. Critiquing the view of broadening participation as simply a matter of demographic composition of research teams (or "bean counting"), they questioned the extent to which broadening participation BI plans are generating meaningful, inclusive, and sustainable participation. Here are quotations from two researchers:

> "The fact that you have an undergraduate student who happens to be a woman is not a broader impact. It [should] not be. … Yes, [you] can claim as broader impacts … it's just [that] the bar is so low."

> [Sometimes] it's like, 'Oh look, I have two women in my group, so look at me … I'm a gender equity person.' Was that an accident or was that on purpose? How much credit can you claim for that? … [Those students] came to you and said they want to work for you. Okay, so maybe you're not a jerk to women. So you don't have a bad rep[utation]. I don't think you can be particularly proud of that.

The common direction of this critique was to increase both the quality and quantity of participation. Another researcher suggested that broadening participation should shift the focus to a change in research culture:

> We want to make a change, [but] how do we set students up for that change? So, [we need to] talk a lot about how to

> empower students to go into spaces that are traditionally homogenous spaces full of white women or white men … and to really be equipped to become agents of change. And to do that, we [as faculty researchers] have to change [ourselves] as well. … It's really ingrained in our culture to be individualistic, to be competitive, to be always working. Those values don't really align with well-being of our students or … different … cultures and backgrounds.

Some researchers thought that the kinds of behaviors discussed above are mainly about the instrumentalization of diversity. One of the interviewees suggested that this can be seen as a form of extractionism that does not respect individuals from underrepresented minority groups as full members of the research team:

> One thing that [frustrates me] when I read grant proposals is when an old cis-het white dude says [that] you need to give me money because I had X number of women and racial minority PhD students. Oh, so you're giving me a record of how many times you have profited off the labor of [those] people … ergo, that's why you want more money. … It should not be about what you have extracted from people. It should be about what you have put in and what you have produced. So, it is a very different thing to me if somebody says, for example, there was a student club, and I spent the time to give … talks, lectures, mentorships, research, whatever. I took the time to put something into this community versus I have taken this thing out of the community. That is a big difference to me.

While NSF's promotion of broadening participation is generally seen as a positive development, most of the interviewed researchers are aware of the potential challenge of tokenization of researchers with minoritized identities or the instrumentalization of diversity. For them, this challenge negatively affects the delivery of broadening participation as a societal outcome.

Chen's Response on Broadening Participation. *I have similar observations as some of the interviewees who note that researchers sometimes conflate the concepts of DEI and broadening participation, and see it as a means to get a grant rather than fully embracing what broader participation intends or thinking more systematically about DEI issues. However, as a BI professional, if I have been asked to help devise or review a BI plan, I have the opportunity to enter into "difficult" conversations. Several times, I have tried to help faculty become more aware of DEI issues, or at the very least, steer them away from "doing damage."*

For instance, asking questions into what their motivations and intent with certain BI plans can reveal their beliefs about who should succeed in STEM. Deficit (vs. asset) based wording might also indicate a "savior" approach that is worth unpacking in conversation. Sometimes, researchers are not aware of the best practices or strategies to recruit and support people from underrepresented groups in STEM. Rather than providing articles or relying on DEI training, I have found that individual conversations seem to be more effective.

Sometimes, giving blunt feedback as to the quality of the BI plan can push researchers to consider going further with their idea. For instance, a researcher who proposed an event for young women engineers to feature a woman as a keynote speaker might not be enough, and during the consultation, I suggested considering a woman of color as the speaker. The conversation allowed discussion of the intersectionality of identities and a brief history of the outcomes of the civil rights and feminism movements on people of color (cf. Núñez et al., 2020).

Researchers' Recommendations: Overlapping Areas with the ARIS Toolkit

The interviews also inquired about what we could learn from faculty to help support BI activities. The researchers that were interviewed offered recommendations as to what might help with developing more effective BI plans. We have identified nine different recommendations, and we are presenting these recommendations with the quotes from our interviewees in order to clarify their rationales:

1. **A definition of a stronger plan—with what is and what is not:** "[Working on broader impacts] is one of the most challenging, but probably the most meaningful. And I think it's also hard because some people get funding with really bad broader impact sections. … So, I think … if the NSF committee could get together and [define]

what is a strong broader impacts [plan]? Maybe [they would state that] it always includes a dissemination plan that goes beyond the researchers' inner circle."

2. **Setting higher standards:** "If there are [broader impacts] specific to [research under an NSF] program, that specific program [can] take really good examples. So, [they can] set the standard, saying that 'look, these are the ones that we really liked.' They [don't have to] say 'do this, do that,' but … [can suggest that these BI plans] are good in these ways."
3. **BI letter of intent:** "[Researchers often submit] letters of intent … with proposals. … Maybe the letter of intent for broader impacts is … that the first piece [in which you discuss]: What is the path of this research?"
4. **NSF webinars on BI:** "Having some kind of checklist would be helpful or maybe some … slides or something … [like a webinar] you have to … look through before you submit your proposal."
5. **Awareness of different possibilities in the BI space:** "I wouldn't want to standardize the way in which people think about the broader impact components of their proposals, [but] what I think would be helpful is a session … where you get to see a showcase of different ways in which you can develop your own broader impacts."
6. **Requiring more robust assessment plans:** "[What we need is] detailed rubrics or boundaries … or best practices. … [If] broader impacts [are] supposed to be assessed … [these are needed for] more rigorous kind of assessment plan … I hear from [colleagues] that people tend to … repeat each other's successful broad impacts plan. More rigorous assessment plan[s will help with that]."
7. **Stronger connection to outcomes—via backward design:** "First ask … 'What is [this research] actually going to do?' And, then working backwards, [we can ask] 'What is the actual plan?' … Maybe the NSF [can] push out … [guidance focusing on] the foundation for the things that would lead to these [broader impact] outcomes."
8. **Need-based outcomes:** "The boots on the ground [are needed for] understanding actual needs. … The NSF can help us identify those needs because sometimes we have so many different [broader impacts] ideas [and] we … pick the one that is the most comfortable to us. But [what we picked] may not be the most impactful."
9. **New incentives to encourage higher-quality BI work:** "[If] you have a requirement, maybe [you need] an additional incentive. It doesn't always have to be money. … It can be money and maybe the money would make [other things] possible. But sometimes just a recognition, a title, [or] an asterisk that says …you are an [impact] champion [can work]. We need to be thinking about ways to incentivize people to go there and make something that is truly useful. … While money is an obvious incentive, [it] is not always even the best incentive. [Sometimes] time is a better incentive for faculty. Recognition, too. … [Is this] beyond the NSF's purview? I don't think it necessarily need to be. The NSF can give titles [or] can provide a special recognition paragraph. … [NSF] CAREER Awards have a special significance over a standard NSF award. Why is that? Because it's seen as being more selective. So, I think that [the NSF] could provide a fancy fellow title [like] NSF Diversity Champion. … They also could potentially provide an additional stipend [or] get you a course release."

Chen's Response on Researchers' Recommendations. *Some of the recommendations are services that BI professionals already provide in their consultations with researchers. In addition, the ARIS Toolkit provides a checklist, rubric, and a number of resources related to project planning. There is also guidance on how to align BI plans with outcomes. Thus, there appears to be a disconnect with what faculty wish to have and what is already available to them. The WPI Office for Research tries to be proactive with grant proposal support and announces resources, but the messages are not reaching all faculty at the right time.*

Other suggestions seem to be primarily about the mechanisms that can encourage researchers to aim for more robust BI plans. In terms of recognition for stellar BI work, there is the ARIS Champion, Enduring Achievement, and Emerging Broader Impacts Leader Awards (ARIS, 2024). The fact that some of the recommendations call for a higher and well-defined standard for BI indicates that some researchers truly value making a positive impact on society and feel that proposals with poor BI plans should not be funded. The needs-based

outcomes idea is interesting, but it is up to the proposer to make the case why and how their BI plan will be impactful in their proposed context.

Discussion

The NSF review criterion for BI and the grants support infrastructure at WPI has resulted in faculty currently placing greater attention on BI than seen in previous years. Training and support are needed for faculty to thoroughly develop and articulate their broader impacts for society. After focusing on the interviews that elicit faculty perceptions about BI and the observations from a BI professional working with faculty through BI workshops and individual consultations, we (Chen and Telliel) now discuss the findings and propose ways to help researchers with BI.

Broader Impacts Plans

Among the researchers interviewed, there were proponents of the current formulation of BIC and of a revised formulation that is shaped by a more specific set of demands on BI plans. The proponents of the first see BIC through the lens of autonomy of researchers. This is a value that was important to all the interviewed researchers. Indeed, the proponents of a more prescriptive approach did not object to this value. A more prescriptive BIC was primarily an extension of their desire for a culture of STEM research that approaches societal impact as a key component of project conceptualization—not a proposal-writing formality.

Many of the faculty who attend Chen's BI workshops or are referred to Chen as a BI professional think that the BI requirement is too vague and they wish it were more prescribed. Perhaps some of this tension comes from the way most STEM researchers have been trained and the overall culture of STEM itself. The nature of basic research and much of doctoral work has the goal of investigating and contributing new knowledge to a specific field and can result in the narrowing and focusing on very specific research questions, which is often disconnected from societal impacts. The larger goal of the research can connect to societal impacts (e.g., United Nations Sustainable Development Goals), yet what the researcher does in a lab setting typically does not directly or immediately connect to societal impact. Thus, the requirement of BI can seem a bit extraneous, and thus produces some anxiety that manifests as frustrations.

To assist researchers desiring a prescriptive BI plan, providing a range of different BI plans might spark ideas. At WPI we have discussed building our own bank of BI examples from submitted proposals with PI approval. A database of BI examples could include the BI plans and the reviews from proposals (both awarded and those not awarded). The database should be intentional with a range of BI plans, and not just K-12 outreach activities. Such examples would help researchers who might struggle to come up with a BI plan on their own. An additional step would be to pair a scored ARIS Toolkit Rubric alongside the proposed BI.

Impact Identity

Risien and Storksdieck (2018) offered the concept of impact identity to highlight the multiple identities that inform a researcher. In addition to a researcher's traditional role, the impact identity concept refers to a researcher's integration of scholarship with societal needs, personal commitments, and institutional values. This concept has aligned with new approaches to the researcher's positionality (e.g., Milner, 2007). By providing a way of interconnecting multiple forms of identity and belonging in a transformative way, the concept of impact identity has thus become a vehicle to guide faculty researchers as well as to advance their research projects' impact in society (cf. Berkey et al., 2018).

Many of the faculty who were interviewed for this study have strong impact identities that are clear to them, and their BI activities stem from their values about research, education, society, and/or the planet. These faculty are internally motivated to do BI work. When the value-driven engagement and scholarship of faculty is aligned with their university's mission and values, retention of faculty is more likely (Ward et al., 2023). Thus, universities might strategically create more infrastructures to support BI activities that connect to researchers' values and give recognition to researchers doing impactful work through press releases and awards. Furthermore, to parallel NSF's two review criteria of intellectual merit and broader impacts, seed funding for BI plans might be offered similar to seed funding for research. University publications about research can also prioritize promoting BI activities linked to research projects.

BI professionals are also able to redirect well-meaning intentions towards a more appropriate and feasible K-12 impact. As an example from Chen's BI work at WPI, a conversation and

brainstorming session recently resulted in a faculty member developing an augmented-reality game about the nitrogen cycle (integral to their research) with their undergraduate students and the K-12 students at a Boys and Girls Club (BGC) after-school program. Rather than developing something for K-12 students in isolation, the BI plan involved working with the K-12 students and the BGC coordinator to co-design the product together. Furthermore, the proposal budget reflected the commitment to working with external partners by allocating a stipend for the BGC coordinator and travel funds for visits to each other's locations. The faculty member was open to exploring different BI ideas, collaborating with others to shape the plan, and compensating others to make it work for all involved. These aspects are contained in the ARIS Toolkit and provided a pathway to proposing a robust BI plan.

Broadening Participation

The faculty interviewed immediately connected BI with "broadening participation" and voiced the concern about token diversity. While broadening the participation in STEM is recognized by faculty, further conversations are sometimes required to understand asset-based (vs. deficit) approaches, as well as developing ethical and mutually beneficial relationships with K-12 educators and community-based organizations (O'Meara, 2021; Santana et al., 2023; Tryon et al., 2023). These conversations can happen in individual consultations, but also are effective as group dialogues in BI workshops.

We have discussed institutional policies and cultures that lead to barriers for broadening participation, and how faculty can inadvertently contribute to inequities by being complicit with the status quo. Exploration of the ways researchers can be agents of change despite systemic challenges can lead to more sustainable and systemic methods of advancing DEI goals and broadening participation. An example that is within control of PIs is the recruitment and selection of project participants. For instance, some PIs select students with prior research or project experience for consideration of research programs, without any consideration of low-income students who had to work to pay for tuition rather than being able to volunteer to work in research labs to gain experience. Having different recruitment and selection protocols (and a more developmental mindset) are possible, and thereby result in more diversity and equitable processes (Fine & Handelsman, 2012). Ensuring inclusive environments (Villa et al., 2013) is also important to emphasize with researchers, and providing training through our university can help nudge faculty to embrace best practices for DEI that results in broadening participation.

Recommendations from Academic Researchers

As with many higher education institutions, faculty are often valued in the promotion and tenure process for large research grant awards, while "service" is an afterthought; thus, the message heard is that technical expertise in research laboratories to churn out publications is what matters most. We wish to disrupt that message and guide faculty in developing their unique BI identities and help them find meaningful ways to have positive societal impacts with their research.

While the ARIS Toolkit's Wizard and Rubric may be shared with faculty or used in workshops, we have found that faculty oftentimes don't have the time or patience to fully utilize these resources, thus hindering their success with BI plans. However, the BI workshops and consultations have been informed by the ARIS resources and the BI professionals might be viewed as the transmission mechanism. When appropriate, specific targeted parts of the ARIS resources (e.g., partnerships, budget) have been provided to individual researchers for their grant proposals. Providing a breadth of BI examples and exemplar projects by BI award-winning researchers could also help. Through brainstorming and review of BI plans, BI professionals can encourage (and sometimes subtly educate about) broadening participation activities and procedures, as well as ensuring ethical engagement with K-12 students, teachers, and community organizations.

Conclusion

The NSF broader impacts criterion compels researchers to connect their research to societal benefits, and we are seeing a greater need for faculty to be guided and supported in their BI plans. This article presents dialogues between BI professionals and academic researchers about their thoughts and experiences developing BI plans. This method of dialogue located areas of convergence between academic researchers' needs and concerns with what the ARIS Toolkit and BI professionals currently offer to researchers. We identified three areas of convergence: (1) autonomy of the researcher and the non-prescriptive nature of broader impacts,

(2) impact identity and personal connection to broader impacts, and (3) a critical engagement with diversity, equity, and inclusion in broadening participation. By putting researchers' voices and BI professionals' voices in a constructive dialogue, these areas of convergence can be leveraged for productive ways for researchers, BI professionals, and ARIS to support research impacts for society.

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