The ARIS Broader Impacts Toolkit: An Online Guide to Support Broader Impact Project Development and Evaluation for Researchers and BI Professionals

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Abstract

The Center for Advancing Research Impacts in Society (ARIS) Broader Impacts (BI) Toolkit is a collection of online, interactive tools focused on the generation of broader impacts activity plans that satisfy the criteria of proposals submitted to the National Science Foundation (NSF). The BI Toolkit includes a set of ARIS Guiding Principles, a Planning Checklist, the BI Wizard, and the BI Rubric. Over a three-year period, the ARIS BI Toolkit was pilot-tested with BI professionals located within ten institutions geographically distributed across the United States. The participating institutions represented a range of R1 and R2 institutions, Land-Grant Institutions, and Minority Serving Institutions with BI professionals serving in centralized and decentralized capacities within the institutions. This paper discusses the development of the ARIS BI Toolkit, its evolution through usability testing, a description of the BI Toolkit as it currently exists, and goals for future expansion.

As part of federal funding accountability requirements, proposals submitted to the National Science Foundation (NSF) are evaluated on both the broader impacts (BI) and intellectual merit (IM) of their work. While IM refers to the potential for the project to advance science, BI refers to the project's potential to benefit people and communities. According to the current NSF Merit Review Criteria published in the Proposal and Award Policies and Procedures Guide (PAPPG), the NSF values the advancement of scientific knowledge and activities that contribute to the achievement of societally relevant outcomes. Such outcomes include, but are not limited to, broadening participation; diversity, equity, and inclusion; improving STEM (science, technology, engineering, mathematics) education; public engagement in STEM; societal well-being; STEM workforce; partnerships with industry; support of national security; increased economic competitiveness; and enhanced STEM infrastructure (NSF, 2024). These target areas are suggested as relevant and important for supporting societal benefits.

However, there are a variety of issues with respect to proposed BI plans. Proposers can struggle to craft substantive BI plans as guidance for creating BI statements is often not provided for researchers. During the proposal review phase, the BI portions of proposals are often subjectively evaluated by review panels, with little guidance beyond NSF's five reviewer questions in the PAPPG (NSF, 2024). In the post-award phase, there are inequities in the level of support researchers receive from their academic institutions in enacting BI activities, impacting the implementation, evaluation, and sustainability of BI projects.

The ARIS Broader Impacts Toolkit was designed to guide and support the development and assessment of BI plans by addressing proposal preparation (the BI Wizard) and effective practices for BI review (the BI Rubric, the BI Planning Checklist, and the Guiding Principles). In 2021, a three-year project began to assess the impact and usefulness of the ARIS BI Toolkit with 10 partner universities and colleges (McDonnell et al., 2024). Each partner university was tasked with pilot testing the BI Toolkit, documenting how their institution used the BI Toolkit, along with other instructional resources, to build their intuition's BI capacity. To reach further into the community, in 2022 a series of interviews and usability testing was conducted with BI professionals and researchers.

Toolkit Origins: The COSEE NOW BI Wizard

In 2002, the NSF created the Centers for Ocean Science Education Excellence

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

(COSEE), which established a network of over a dozen regional and thematic centers with 270 partnering organizations across the country. Each center focused on developing programs and partnerships to engage ocean scientists and educators in outreach efforts to extend the reach of research and promote ocean literacy (Scowcroft et al., 2021). The COSEE network codified its experience in educator-researcher partnerships and BI by developing entry-level guidance for researchers focused on how to create and build effective BI projects (Franks et al., 2006). The *Education and Public Outreach (EPO): A Guide for Scientists* document included simple tips on how to develop EPO proposals, including finding partners and communicating effectively. The guide was updated and expanded in 2018 (McDonnell et al., 2018).

Networked Ocean World (NOW), one of the funded COSEE centers, identified a need to operationalize the guidance on BI project and proposal development and provide exemplars of EPO projects, thus developing the COSEE Broader Impact (BI) Wizard. Launched in 2012, the COSEE BI Wizard is an online interactive website that walks users through a series of steps to develop a viable BI plan for a research proposal. Based on user-selected criteria, users produce an outline of key elements of a BI project plan. The BI Wizard utilized a five-step process, including identifying the audience, establishing a budget, selecting an appropriate activity, defining the project goals, and how to include an evaluation plan. The output of the BI Wizard was not designed to create "drop-in" text for a proposal. Rather, it provided researchers with a suggested project idea and a list of questions they could then review with a BI or EPO partner to develop a complete BI plan for a proposal.

Challenges and Limitations

The COSEE BI Wizard was a significant step in developing a resource that could guide researchers on the elements of a BI project, but it did have several limitations. First, some users found the list of possible activities provided in the "selecting an appropriate activity" step too generic. Second, the COSEE BI Wizard was principally designed to support the ocean research community. While many of the project examples could easily be adapted to other research areas, some researchers felt the tool was not relevant to their field. Third, the COSEE BI Wizard had a bias toward K-12 focused projects, reflecting the experience of the initial development team. As the BI community has grown, there is now a greater interest in projects that can support other audiences, like government policymakers, homeland security, or technology transfer. However, these projects tend to be specific to individual communities and researchers, and hard to capture as generalizations, which make examples for use in a widely used tool difficult to design. Finally, as an online web application, there are always technical limitations, such as cybersecurity and software upgrades, which require constant technical support.

While COSEE NOW and the COSEE Network have since ended, a new network was formed soon after that would focus its efforts on developing new tools and collaborations to support researchers with their broader impact projects.

The ARIS Toolkit

In 2018, with the support of NSF, the University of Missouri-Columbia established the Center for Advancing Research Impact in Society (ARIS) Network. The goal of the ARIS was to develop a collaborative network of BI professionals across the United States. During early meetings of the ARIS network, the COSEE BI Wizard was discussed as a tool for training BI professionals and engaging researchers in the BI project-development process. With ARIS support, a revised version of the COSEE BI Wizard was launched in 2021 as part of a larger ARIS BI Toolkit to meet the needs of the ARIS community. The new ARIS BI Wizard features a new interface, updated research field–agnostic videos, a reformatted question flow, and an expanded set of tools (see Table 1). Collectively, the ARIS BI Toolkit (including the BI Wizard, BI Planning Checklist and BI Rubric) is designed to provide increased support in creating effective partnerships, as well as additional guidance on designing projects that support NSF's target outcomes.

ARIS Toolkit Audience Goals

Many BI professionals are new to their role and lack formal training or previous experience writing or developing scientific research grants. The BI Toolkit not only provides assistance with BI development, but also helps establish common vocabulary, and effective work practices. The BI Toolkit can also directly serve researchers with the development of BI activities, as their experience leading or developing BI projects can be limited.

The BI Toolkit aims to minimize the

Table 1. Comparison of COSEE Wizard and ARIS Toolkit Features

	COSEE Wizard (2012)	ARIS Toolkit (2023)
Target Audience	Researchers	BI professionals and researchers
Tools	Wizard only	BI Wizard (planning guide and planning tool) BI Planning Checklist BI Rubric Guiding Principles
Key Wizard Features	98 example EPO activities Guided questions to select appropriate activities Backwards design guidance to develop project plan and goals Login accounts to save multiple plans References for various audiences	Streamlined guidance on BI project planning Checklist and rubric to assess project proposals Expanded guidance and questions for developing BI projects All data stored in user's browser Expanded audience reference list
Videos	BI Introduction (ocean science focus) Potential Audiences for Scientists Program Evaluation for EPO	Toolkit Intro BI Introduction (general focus) Collaborative Partnerships
Research Focus	Ocean sciences	All sciences

Note. The COSEE BI Wizard included videos developed by Josh Kurz, Tilapia Films, and an evaluation video developed by Ari Daniel and Chris Parsons. The new ARIS BI Toolkit contains updated videos developed by Josh Kurz, Tilapia Films.

gap between academic research and public understanding by providing researchers with resources and strategies to communicate their work effectively to a broader audience. The intent of BI projects is to provide greater awareness, understanding, and support the application of research findings in real-world contexts. By providing researchers with tools and guidance, they can better contextualize the relevance of their work and foster trust and transparency by communicating their methods, findings, and implications, contributing to a positive relationship between science and society.

Key Toolkit Elements

The ARIS BI Toolkit features four key components, each of which can support different phases of the proposal-development process (see Table 2).

ARIS Guiding Principles

The *Broader Impacts Review Document for National Science Foundation Proposals* was created by the ARIS predecessor, the National Alliance for Broader Impacts (NABI) working group, to assist BI professionals and their research collaborators with addressing the five NSF questions from the PAPPG in 2015. It was updated in 2020 by ARIS leadership to reflect changing language in the PAPPG and to clarify some of the recommendations. The Guiding Principles provide a common framework for effective BI projects advocated by the ARIS community.

BI Planning Checklist

The BI Planning Checklist is an interactive worksheet providing proposal developers with a short list of components that should be included in a BI plan. It provides a quick assessment to help writers gauge the completeness of a drafted BI plan in addressing the NSF PAPPG.

BI Wizard

This tool helps researchers and BI professionals develop a plan that will satisfy the NSF BI requirements and support community

Table 2. Recommended Tools to Support Each Phase of the BI Proposal Development Process

	Guiding Principles	Planning Checklist	BI Wizard	BI Rubric
Introduction to BI concepts/ planning for new researchers and BI professionals	X		X	
Project/proposal development		X	X	
Pre-submission proposal review		X		X
Formal proposal/panel review				X

engagement and effective communication of NSF-funded research impacts. The BI Wizard contains two parts: 1) a **Planning Guide** that provides background information and resources on the key components of an effective BI plan, and 2) a **Project Planning Tool** that interactively walks users through a series of steps to help the user define their BI project. Each step includes several questions with fillable fields to help the user record "personal notes" as they think through their project and learn about the essential components of a BI plan.

BI Rubric

BI Rubric utilizes the NSF guiding questions and provides metrics to evaluate to the BI criteria. The BI Rubric can assist BI professionals and researchers assess the rigor of their BI plan and to help build capacity and consensus on effective practices in BI plan development. The BI Rubric also can be used by reviewers participating in the panel review process to assess the rigor of a proposed BI plan (Iverson et al., 2024, in this volume). Included in this tool is an interactive **Rubric Tutorial** that provides an example BI project plan, and then walks users through each question. As users rate each metric, the tutorial provides a "suggested answer" and rationale. This approach encourages users to think about how their score compares to the suggested score, with the goal of building a common baseline for understanding the BI Rubric questions and scores.

Sharing the Toolkit with the BI Practitioner Community

To better understand the utility of the ARIS BI Toolkit across a spectrum of institution types, a professional development (PD) series was designed to promote collaboration between BI professionals and researchers within partner institutions using the BI Toolkit. The overarching objective was to build BI capacity and infrastructure by 1) improving faculty, staff, and graduate student training in BI; 2) increasing communication and coordination to broaden the overall culture of BI through community engagement; and 3) creating a community of practice (CoP) among BI professionals to partner and learn from each other.

Through interactions with representatives of the ten collaborating institutions, the project team engaged in discussions on what constitutes effective practice in BI plan preparation and implementation; iterated on the utility of the tools to help engage researchers and university support staff in meaningful conversations about BI; and shared these lessons learned with a broader audience.

The ARIS BI Toolkit team provided coaching, mentoring, and consultation to the university collaborators to evaluate:

- What contextual factors do participants (researchers, BI professionals) perceive as influencing their implementation of the ARIS BI Toolkit?
- How do the collaborators characterize their use of the ARIS BI Toolkit concurrently and over time?
- To what extent are institution-level outcomes related to the BI capacity associated with the ARIS BI Toolkit use?

Project Partners

Ten institutions participated in the project within two cohorts. Cohort 1 included Penn State University, University of Nebraska Lincoln, and University of Texas at Dallas. Cohort 2 included Michigan State University, City University of New York (CUNY), University of New Mexico,

Table 3. ARIS BI Toolkit Cohorts I and II

Institution	Description	Case Study Approach
Michigan State University	Land-Grant R1 Institution Decentralized BI Services	Testing with internal university partners to enhance the quality of BI services
Penn State University	Land-Grant R1 Institution Decentralized BI Services	Testing the BI Toolkit as a staff professional-development onboarding tool at the Center for Science and the Schools
University of Nebraska - Lincoln	Land-Grant R1 Institution Centralized BI Services	Testing as a component of the UMN-Lincoln Career Club for early career researchers
University of Texas at Dallas	R1 Institution Centralized BI Services	Working with North Carolina State University to develop a consulting protocol for supporting researchers using the BI Toolkit
City University of New York	R2 Minority-Serving Institution Decentralized BI Services	Conducting focus groups with faculty and staff on BI resources
University of New Mexico	R1 Institution Decentralized BI Services	Conducting a needs assessment on the BI Toolkit with university partners
University of Oklahoma	RI Institution Centralized BI services	Conducting a baseline study using the BI Rubric to understand patterns of previous BI plans followed by focus groups with staff and researchers supporting BI planning
North Carolina State University	R1 Institution Decentralized BI services	Working with University of Texas at Dallas to develop a consulting protocol for use in engineering education programs
Montana State University	R1 Institution Office of Research Development	Conducting needs assessments of BI Toolkit resources with community partners
Worchester Polytechnic Institute	R2 Institution Decentralized BI services	Conducting focus groups with faculty on crafting BI plans

Note. The ARIS BI Toolkit was tested with two cohorts (n = 10) over three years of the project. The schools were selected because of their existing participation in other ARIS programs and their extensive BI programs and experience, as well as because they represent diverse institution types (Hispanic-Serving Institutions, Established Program to Stimulate Competitive Research). Cohort I worked collaboratively with the project team and evaluator to develop case study exploratory research protocol. Several Cohort I participants stayed with the program to engage with Cohort II participants.

University of Oklahoma, North Carolina State University, Montana State University Bozeman, and Worchester Polytechnic Institute. The participants in the pilot project provided insight into the factors that can promote or deter successful implementation. Two cohorts were selected to pilot test the ARIS BI Toolkit (Table 3).

BI Toolkit Professional Development

As the timeframe of the program stretched through the COVID-19 pandemic, the planned PD pivoted to a primarily online synchronous and asynchronous model. During the PD sessions, participants used the tools (BI Wizard, Planning Checklist, ARIS Guiding Principles, and BI Rubric) in the ARIS BI Toolkit to generate sample BI plans

and learn to apply the Planning Checklist and BI Rubric to their sample plans to model how they might implement the tools with their faculty.

Online PD provided the opportunity for materials to be used by local implementers of the ARIS BI Toolkit with their faculty and provide a platform for long-term sustainability. This feature is important, as the ARIS community has a high degree of turnover in the evolving BI profession. It is important that the ARIS BI Toolkit PD remain accessible and online to promote seamless sustainability within university infrastructure.

In addition to providing the online BI Toolkit training for BI professionals, the project team provided online coaching and mentoring to support local implementation of the BI Toolkit through discussions during bi-monthly check-in Zoom calls. The sessions, in addition to one-on-one conversations, determined how the progress of the cohorts and helped to solve implementation issues and adapt the tools to their specific use.

The university partners worked with the ARIS team and the evaluation team to document both the BI professionals' and researchers' views about the usefulness of the BI Toolkit. At the project start, university partners were asked to self-assess their current level of interaction and support of researchers in BI plan construction in order to benchmark the current state. In each of the cohorts, university partners formatively documented their use of the tools over their year-long engagement in the project. The results of these efforts are reflected in the content of this special issue.

Community Usability Study

To understand the value and usability of the revised and new tools with the broader community, ARIS conducted a reliability and validity study of the BI Rubric (for results, see Iverson et al., 2024, in this volume) and a think-aloud test of the ARIS BI Toolkit website (O'Connell et al., 2022).

Methods

Website usability tests are typically designed to identify user issues with the design, navigation, or functionality of a website. In the fall of 2022, the Science Education Resource Center (SERC) gathered input from ARIS community members to better understand how users interact with the ARIS BI Toolkit website, assess the needs and expectations of the intended audience, and determine areas for improvement. To begin the evaluation, SERC conducted a series of website think-aloud interviews, a type of usability test. This method asks users to verbalize their thoughts as they work through realistic scenarios, which allows the observers to identify misconceptions and directly observe what parts of the interface are working well and those that cause problems (Nielsen, 1993; Nielsen, 2012)

Ten participants completed website think-aloud interviews, with 5 of 10 new to the ARIS BI Toolkit website. During the walkthrough interviews, participants completed two scenarios while sharing their screens remotely with the evaluators. One scenario focused on initial exposure to the BI Toolkit in service of the development of a BI plan, and the second scenario asked that they specifically consider using the Toolkit to strengthen a BI plan. As they navigated the site, participants were asked to think out loud to explain their choices. Participants were asked to start on the BI Toolkit home page, which is a realistic starting point based on the website analytics. Following the scenarios, participants were prompted to specific pages of high interest if they had not explored them during the interview. Finally, participants were asked a series of closing questions about their experience with the BI Toolkit website as well as their professional role and BI experience.

The participants represent the target ARIS audience, holding a range of positions at higher-education institutions and education-focused organizations, including positions in education outreach as well as BI professionals, researchers, and university administrators. Participants' experience with broader impacts, formally and informally, ranged from 3 to 40 years. Participants' prior experience with the ARIS BI Toolkit website varied from first-time users (n = 5), those with some limited prior use (n = 3), and those who were familiar with the site and have made use of the tools in the past (n = 2).

The think-aloud study was designed to maximize internal validity by reducing social desirability bias by being conducted by a neutral party (SERC) who aggregated and anonymized the data and explained to participants that the study is testing the website and not the user -noting that there is nothing the user can do wrong and that any confusion will help highlight needed changes. The interview protocol utilized scenarios that were realistic to the ARIS BI audience. Saturation appeared to be reached, where new themes were not emerging across user types in the final interviews. Quantitative measures, such as order of pages visited during a

given scenario, were recorded and crosschecked by two SERC evaluators. Qualitative measures include observation of the session, participant narrative, and responses to follow-up questions, coded for emergent themes and triangulated between two SERC evaluators and with the quantitative measures.

Results

The interviews uncovered several cross-cutting themes, including the following successful elements of the BI Toolkit:

- All participants reported positive views of the BI Toolkit and all reported that they would use the BI Toolkit in the future. Participants reported a range of intended uses, including as a guide to align their BI plans with NSF requirements, as a tool to check that their BI plans are strong and complete, as a helpful path to get started with BI, and as a resource to share with colleagues and graduate students.
- Participants reported that the concise and clean pages aided their ability to view the content quickly.
- Despite challenges encountered with the site, participants reported that the content was useful and worth further exploration. As they completed the two walkthrough scenarios, participants continued to note the value of the content as they explored, had minimal observable frustration, and persisted in completing the scenario tasks.
- Participants identified two categories of users to whom they would recommend the BI Toolkit: 1) beginners getting started with BI planning and NSF proposal writing (inclusive of BI professionals and researchers), and 2) experienced practitioners assessing whether their BI plans are strong, complete, and aligned with NSF requirements. Participants reported that they would introduce the site differently to these audiences, pointing beginners to the Planning Checklist, Introduction, and Guiding Principles pages, and more experienced practitioners to the BI Rubric and BI Wizard.

The interviews also uncovered several challenges users faced while working through the provided scenarios. Namely:

- Participants occasionally struggled with orienting themselves to the content and intended use of the BI Toolkit website. While the Index page provided a brief overview of the tools, it was insufficient to orient participants, and additional time was spent to gain a mental model of the website and the purpose of its tools before participants attempted to complete the scenario tasks. This time spent orienting led to shallow site use (e.g., more breadth across overview pages than depth). This behavior is also reflected in website analytics, where the Index and Overview pages have much higher use than the detailed BI Wizard pages.
- Participants reported a desire for more guidance on when to use each tool in the BI planning process and how to best leverage the various tools while developing BI plans and writing proposals.
- Participants had difficulty wayfinding (using visual cues to build a mental model of the website to support navigation) due to differences in naming conventions and ordering between navigation elements.
- While the fill-in boxes were viewed as potentially useful, participants hesitated to use them when working through the planning elements.

Discussion

As a result of this study, and additional feedback from BI Toolkit project partners and other users, the BI Toolkit site was redesigned and updated in the spring of 2023. The newer version includes updated top-level navigation and consistent use of tool names throughout the site to better support user wayfinding. The BI Rubric was improved with functionality to make usage clearer (including adding tabbed navigation so users can quickly jump between questions and the summary, and checkbox circles so users understand what scores they have selected). The most significant changes were made to the BI Wizard. The new design separates the BI Wizard into two separate and distinct sections: the Planning Guide section, which is a workbook to provide relevant background on BI, while the Project Planning Tool provides fillable fields to guide researchers in the development of an outline for their BI plan. Collectively, these two sections are still referred to as the BI Wizard.

Some users expressed the desire for local information or the ability to customize the BI Toolkit for their institution. Currently there are no plans to create custom-made iterations of the BI Toolkit for individual institutions, nor develop an

application programming interface (API) to blend the existing BI Toolkit with any locally developed applications. There are no funds for such an initiative and no perceived gains from taking such an approach. Individual institutions can link out to the BI Toolkit from an internal BI resource page and include local resources to support researchers within the institution.

Some participants suggested including more case studies of successful BI proposals and projects, or a database of specific opportunities or partners, even more detailed than the original COSEE BI Wizard provided. While these features are possible, they would require substantial and sustained effort by a dedicated team to support their implementation.

Based on feedback collected through formal evaluation with BI professionals, future expansion of the ARIS BI Toolkit will include the development of resources to facilitate connections between community partners and researchers. These resources will focus on assisting researchers with understanding the challenges and opportunities of working with community-level partners, and methods for developing co-designed and insightful BI projects.

More significantly, BI is still an evolving concept for many researchers and institutions to navigate. The priorities of NSF and other agencies will likely continue to evolve, as they respond to the goal of ensuring research impacts are broadly effective and communicated beyond the research community to other stakeholders.

Conclusion

The ARIS BI Toolkit is evolving. As the ARIS Network and larger broader impact–focused community of researchers, educators, community partners, and professionals has grown, the BI Toolkit has served as a "watering hole" to bring communities together. It provided the community with common touchpoint, helping to establish common terminology, consider processes, and set expectations for resources that are possible to develop. As noted by other ARIS BI Toolkit project papers in this volume, the BI Toolkit has helped other BI professionals engage and train researchers and other partners at their institutions. It is because of these conversations that the BI Toolkit has expanded to meet some of those needs, while also helping the BI community learn and grow.

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