From Educator to Broader Impacts Professional: A Case Study Analysis of the BI Toolkit Approach

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Abstract

Increasing emphasis is being placed by granting agencies on the need for specialists who support the translation of research into societal benefits. This societal benefit is often referred to as broader impacts (BI), and BI is important for acquiring grant funding and fulfilling land-grant university missions, among other benefits. However, few career paths lead directly to becoming a BI professional, so individuals moving into BI work need to transition from another career, which requires learning about BI. This case study examines the experiences of four former classroom teachers making the transition to both teacher educator (a teacher of teachers) and BI professional, and the ways in which their transition was supported using the Center for Advancing Research Impacts in Society (ARIS) BI Toolkit. Implications for onboarding using this toolkit are described and recommendations are made for how to use the ARIS BI Toolkit for transitioning BI professionals.

Agencies that fund science and technology research in the United States are increasingly requiring researchers to demonstrate that their projects will contribute substantively toward benefiting society, in addition to contributing to their field. For proposals to the National Science Foundation (NSF), these benefits, referred to as broader impacts (BI), are required to be included in each proposal and can include outcomes related to broadening participation in STEM and diversifying the workforce, improving STEM education, national security and the well-being of individuals in society, increasing economic competitiveness, public engagement with science/technology, and enhancing infrastructure for research and education (NSF, 2023a). Other federal agencies, foundations, and nonprofits are following suit, expressing their interest in funding projects that connect science and society (Civic Science Fellows, 2023). With an increased emphasis on the societal benefits of research, the work of BI has grown into a new professional field that requires expertise in working with scientists and engineers to develop ideas for and conducting the work of translating research into societal benefits.

As the contests for funding become more competitive, research institutions and other organizations have begun to invest in infrastructure to support researchers in the proposal development and implementation of BI activities connected with technical research projects. Additionally, organizations intended for professionals working in broader impacts, like the National Alliance for Broader Impacts (NABI) and the Center for Advancing Research Impacts in Society (ARIS), have continually grown in membership since 2014. However, few people who work as BI professionals are formally trained for their roles. Many find themselves in BI positions through circuitous career paths. Some came into the field through science, others through education, and still more came through community engagement, communication, grant development, or other paths. Ultimately, most BI professionals needed to make a transition from a field other than BI.

Onboarding for any new position is often wrought with challenges, and in broader impacts this is no different. Few understand the nuances of grant proposal writing, particularly when the proposals include programs in education, public engagement, and/or workforce development. The ARIS BI Toolkit, a suite of resources and tools for preparing a proposal that successfully implements effective BI principles, is one potential way for

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

new BI professionals to become more acquainted with BI expectations and get more comfortable in their role. The ARIS BI Toolkit is comprised of the Guiding Principles, a Planning Checklist, the BI Wizard, and the BI Rubric. This article describes how the ARIS BI Toolkit was used as an instrument to onboard former elementary and secondary science teachers into positions in BI.

Context of this Study

The Center for Science and the Schools (CSATS) at Penn State University is housed in the College of Education and, for the past 20 years, has supported researchers from STEM colleges in proposing K-12 teacher education programs connected to technical grants to have beneficial societal impact. When those projects are funded, CSATS faculty co-develop and co-teach workshops and other professional learning experiences with the researchers, creating impact by merging best practices in STEM education with cutting-edge research projects. The work of CSATS is informed by the Next Generation Science Standards (NGSS), which call for K-12 teachers to engage their students in the knowledge-creating practices of scientists and engineers (NGSS Lead States, 2013). CSATS emphasizes these practices by helping STEM researchers create experiences for K-12 students like professional research projects that both simulate authentic work and provide a vehicle for teaching content included in the state and national science standards.

CSATS also focuses on recruiting program participants who are teachers in schools that serve high percentages of student demographics that are typically underrepresented in STEM fields. The paucity of African Americans and Hispanic Americans in many science and engineering fields is well documented (Trapani & Hale, 2022). This underrepresentation is highly correlated with poverty. Aschbacher, Ing, and Tsai (2014) found that middle school students' aspirations to enter a STEM field varied depending with SES, but not gender, ethnicity, or STEM field. Consequently, rural communities are also underrepresented in these fields due to the correlation between low socioeconomic status and rurality, which contributes to their underrepresentation. (Harris & Hodges, 2018). Moreover, many of the under-resourced schools in urban and rural communities educate potential first-generation college graduates; CSATS's targeted recruitment of teachers in these schools to science and engineering professional development programs contributes to potentially increasing precollege students' participation in STEM fields.

The lead authors of this paper are the director and associate director of CSATS. Each has degrees in science and experience in research and professional practice. They also have teaching degrees in secondary science teaching and have taught in the classroom for 13 years combined. They also have a combined 22 years of experience in BI work. They have been involved in the writing and submission of over 250 proposals, most of which were submitted to NSF. Both learned about BI through co-writing with a more experienced colleague and through participation in NABI.

CSATS tends to consist of fixed-term faculty who have training and experience in K-12 classroom teaching. To accomplish the goals of CSATS, former teachers need to make two important but distinct transitions: from teacher to teacher educator (a teacher of teachers) and from teacher to BI professional (who must collaborate with science and engineering faculty in preparing grant proposals). The director and associate director of CSATS made use of the ARIS BI Toolkit as an onboarding tool for four faculty in CSATS who are developing, proposing, and implementing K-12 teacher programs to enhance the BI plans of technical grants with faculty from the five STEM colleges at Penn State University (engineering, science, earth and mineral science, information science and technology, and agriculture). This study is the result of examining the approach of utilizing the BI Toolkit for onboarding individuals hired for BI positions at CSATS.

Study Participants

Each of the four study participants were former classroom teachers. At the time of the study, each had worked at CSATS from less than one year to up to four years, and each has had experience in consulting with STEM faculty on anywhere from zero to 11 proposals. This was a self-study, so the four participants played a large role in data analysis and writing. Their voices provide first-person accounts into their experiences, and for this reason, no Institutional Review Board protocol was required for this project.

Amber was a high school science teacher for five years. She taught biology, physical science, and marine science. She became interested in professional learning through participation in a university's outreach program in molecular modeling and

now leads the professional development programs for several life science grants, helping teachers understand the connection between structure and function in biological systems.

Tiffany was a high school teacher for eight years and taught biology, general science, and forensics. At CSATS, she works with faculty from the main campus, Penn State Harrisburg, and Penn State College of Medicine. She is also primarily in charge of the logistics and a workshop series associated with the Research Experience for Teachers (RET) program run each summer over seven weeks. She became interested in working for CSATS after participating as a teacher in two summers of the RET program.

Jeff was a middle school science teacher for 35 years and was an adjunct instructor in a STEM education program at a local college. He is a STEM teacher ambassador, participated on the committee for writing the state's science standards, and won several teaching awards. At CSATS, he is responsible for establishing and maintaining relationships with school districts and other educational entities and disseminating our programs.

Stephanie was an elementary classroom teacher for eight years after beginning her education career in museum education. She developed and taught a course called IDEA Lab (Imagine, Design, Experiment, Apply), was a robotic and technology instructor, and started a school hydroponics lab. She has won multiple teaching awards and completed an Albert Einstein Distinguished Educator Fellowship with the Carderock Naval Surface Warfare Center where she developed an elementary curriculum based on Department of Defense careers and engineering solutions work in the Navy. It was through this experience translating Navy research into K-6 curriculum that she came to work at CSATS.

Literature Review

Broader Impacts and Broader Impacts Professionals

In 2023, the NSF provided over nine billion dollars to researchers in competitive grant programs (NSF, 2023a). Funding agencies like NSF expect technical research to have a positive impact on society (APLU, 2019; NABI, 2018). Since most investigators require support in translating their research into societal benefits, it is important for organizations to invest in centralized infrastructure focused on BI to develop, implement, disseminate, and evaluate BI (Renoe et al., 2023). While some view this support as essential only for the purposes of increasing the competitiveness of grant proposals in the eyes of funding agencies, others suggest researchers have a civic duty to engage with the public (Christopherson et al., 2018). Further, land-grant institutions are expected to improve lives and serve society locally, regionally, nationally, and globally (APLU, 2019).

These institutions are increasingly hiring specialists in BI to perform this translational work, yet there is a broad range of positions within BI as a field. On one end of the continuum are BI practitioners, and on the other are research development professionals (Altermatt, 2020). According to McNall and colleagues (in press), BI practitioners connect researchers with community partners and collaborate to develop and implement BI activities, while research development professionals support researchers in the development of BI statements for inclusion in their proposals but rarely participate in the development or implementation of BI activities. However, neither BI practitioners nor research development professionals typically set out to end up in that role, nor do they receive degrees in this work—so they almost always transition from a different (but often related) profession.

Table 1. Participants Onboarded Using BI Toolkit

Participant	Years of Teaching	Years at CSATS	Prior BI Sections of Proposals	Specialty
Amber	5	4	11	Secondary-level education
Tiffany	8	3	9	Secondary-level education
Jeff	35	1	0	Liaison to schools
Stephanie	8	0	0	Elementary-level education

Transitioning into Academia and Research

Typically, individuals are largely in charge of managing their work tasks—and to overcome social and work-related insecurity, they have to develop a career identity in which they link their own motivation, interests, and competencies with acceptable career roles (Meijers, 1998). This identity is not a fixed trait, but can be seen as dynamic and as a resource that people use to make sense of themselves and their relation to others (MacLure, 1993), and this professional identity necessarily undergoes challenges when transitioning to a new career.

Of particular interest is the transition from practitioner to academic. These "pracademics" often face struggles during such a transition: struggles with their concept of themselves, struggles with the new role, struggles with the new culture, and struggles with the future (Kinsey et al., 2006). These individuals often come from a field that is vastly different, and they encounter an unfamiliar culture with its own codes, rituals, and politics. Having a mentor often can help with this acclimation (Mullen & Hutinger, 2008).

Teachers are one subgroup that transitions from being practitioners of teaching to practitioners of BI. Teachers are well suited to engage in teacher education programs that are BI components of projects, and have credibility with other teachers because they have authentic work experiences (Dickinson et al., 2022). They are also well-positioned to positively impact STEM education because they understand academic standards and can translate the work of scientists to those learning targets in meaningful ways (Johnson & Hill, 2023; in press).

Yet teachers making the transition to teacher education often develop negative self-views about their abilities and identities (Izadinia, 2014). Many describe the *imposter phenomenon*, first described by Clance and Imes (1978) as high-achieving women reporting the pervasive feeling that they are ill-equipped for their jobs and being constantly afraid that fact will be discovered. Over the years, it was found this phenomenon was not isolated to high-achieving women, and that men are equally affected by it (Matthews & Clance, 1985). Imposter syndrome is particularly common in academia, and Hutchins (2015) attributed this feeling in part to the highly competitive and stressful work environment, and as well as the personality types drawn to academia—including those who are conscientious, achievement oriented, and have perfectionist expectations.

Onboarding Employees

Organizational socialization, or *onboarding*, is a process by which new employees go from being organizational outsiders to becoming organizational insiders (Bauer & Erdogan, 2011). The importance of efficient onboarding of new employees cannot be overstated. Effective onboarding drives productivity, accelerates the delivery of results, and improves talent retention (Bradt & Vonnegut, 2009). Onboarding is both a formal and informal process (Klein & Weaver, 2000). The formal aspect includes the coordinated policies and procedures to help an employee learn about the job and organization; the informal aspect is the process by which the employee learns about the job without an explicit plan (Ibrahim et al., 2022). The responsibility then falls on the leaders of the organization or workplace to support the outcomes of role clarity, social integration, perceived fit, task mastery, work-group integration, and political knowledge (Becker & Bish, 2021).

According to a study by the Society for Human Resource Management and TalentLMS (2022), employees can make learning and development more effective by having tasks that are more relevant to job responsibilities, up to date, more social, and more self-driven. Training programs should recognize that new knowledge is built on learners' prior knowledge. Learning is an active process; it is constructed through a process of change based on experiences and interactions with ideas and phenomena, and it should be situated in meaningful and relevant contexts (Bransford et al., 2000). In order to become proficient in new trainings, learners must acquire skills, practice integrating them, and know when to apply what they have learned (Ambrose et al., 2010).

BI Onboarding Procedure

Our ARIS BI Toolkit onboarding sessions took place over four two-hour sessions to provide time for practice and reflection. Each of the four participants attended each session. The first session utilized the framework used by ARIS for introducing folks to BI through a presentation called "BI 101." This presentation covers the history of BI within NSF, describes the merit review criteria, discusses why BI matters, gives examples of successful BI programs, and introduces the ARIS BI Toolkit. We then discussed some of the types of proposals CSATS has submitted, and looked at key elements of three previously submitted proposals.

The second session investigated two of the ARIS BI Toolkit instruments: the ARIS Guiding

Principles and the Planning Checklist. Embedded in the Guiding Principles is a list of ten goals for broader impacts set forth by the NSF in their Proposal and Award Policies and Procedures Guide (PAPPG). Our group discussed the different goals and considered how various examples of projects could contribute to these goals. We then discussed each of the questions included in the Guiding Principles, how they align with the merit review process, and how addressing these questions can improve the quality of the proposals being submitted. We then used the Planning Checklist to examine an example proposal co-developed by CSATS. Each participant went through the proposal and used the Planning Checklist to check items that they agreed were addressed in the proposal. The group discussed their decisions, and we debated items where consensus was not achieved.

The next session involved using the BI Wizard. The BI Wizards is a website designed to help researchers and educators develop and articulate the broader impacts of their work. It guides users through a series of questions and prompts to identify potential societal benefits and to create a comprehensive broader impacts plan. Prior to the meeting, participants explored the tool independently. During the session, we went through each section dealing with partners, target audiences, budget, and evaluation. We also discussed how we could use this tool as we work with researchers and in what ways it might be helpful to have researchers use the tool prior to our consultation meetings.

During the last session, we used the BI Rubric to evaluate example BI plans provided by ARIS for use with the BI Rubric . The breadth and variety of these samples enabled us to consider different qualities of proposals and see differences in partners, methods, and audiences. We then discussed the use of the BI Rubric during the end of the proposal process to ensure the reviewers would not be able to easily critique the project due to missing key aspects described in the merit review process.

After these four sessions, which were held in spring 2023, the CSATS director assigned each of the participants to lead the consultation, collaboration, and writing of education plans for two Faculty Early Career Development (CAREER) grants. They were each asked to use the BI Toolkit in any way that made sense to them as they met with researchers, developed budgets, and wrote, edited, and submitted these proposals. The director and associate director were always available for support if and when needed.

Methods

After the proposals were submitted, each of the participants responded to a series of questions in a semi-structured interview. The interview protocol was designed to involve discussions about the participant's background as a teacher and what motivated them to work in BI; the experience of transitioning from teacher to BI professional; the ways in which they used the BI Toolkit; experiences with grant writing; reflections; adaptations they would make; and future plans. See Appendix 1 for the interview protocol.

Interviews were held on Zoom and recorded. Recordings were transcribed verbatim using the transcription feature on Zoom and manually cleaned up. We chose to present the analysis and findings using a qualitative case study approach (Yin, 2018). Each case represents a unique use of the BI Toolkit, a unique story of the transition from teacher to BI professional, and a unique opportunity to better understand the development of BI professionals learning to collaborate with researchers on proposals. Then, the co-authors discussed similarities and differences to synthesize the findings to present in this article. Participants of the interviews are also co-authors on this article, and contributed to the writing to ensure their stories are accurately told and their recommendations are heard.

Case 1: Amber

Transition and Grant Writing

When discussing her transition from teaching to CSATS, Amber admitted she did not know anything about BI. She was motivated to enter teacher education by her own experiences of participating in a teacher professional development program with researchers at a university. "I really love thinking about ways to teach kids biology that are kind of cutting edge and different than the traditional route," she said. The fact that she would eventually be drawn into grant writing was a surprise to her. At the time of the interview, Amber had written 11 grant proposals—the most out of all four participants.

When asked, her experience in grant writing came from collaborating with the director on two major projects, of which the director was principal investigator. One was a National Institutes of Health (NIH) Science Education Partnership Award; the other an NSF Discovery Research in PreK-12

Education project. After those experiences, the director assigned her to collaborate with scientists on BI plans. Although Amber was assigned to collaborate on two proposals in the summer of 2023, she actually completed the education plans of two CAREER proposals and the BI section of a single-investigator proposal.

When asked to describe the process when she started working with researchers, Amber mentioned the importance of the initial meetings, and how she relied heavily on using prior proposals as the basis for planning the budget, the program structure, and the language for the new proposal. She emphasized the importance of seeing a draft of the project description so she could attempt to weave the education component into the narrative in a way that was consistent with the writing style of the research faculty. Initially, she relied on the director to edit her work, but as she gained experience, the need for such approval decreased.

For the BI section that she developed, she integrated the technical research of the faculty, an electrical engineer, into a newly established solar competition for middle and high school students. These students would enter the competition after their teachers learned about it through a professional development workshop taught by Amber. This proposal was a resubmission, so she read the reviews related to the BI section from the previous year, and she and the director discussed potential changes.

On multiple occasions throughout the interview, Amber mentioned having imposter syndrome (Clance & Imes, 1978). She first used the term when talking about the challenges she faced in transitioning to BI professional. "I think one of the biggest challenges is feeling like you don't belong in a room of PhDs and sometimes as teachers and as educational specialists, our expertise is overlooked or not appreciated." She also mentioned those feelings when working with a researcher not in her content area of life science. "Like it's not in my wheelhouse, in my area of expertise, and it's just very foreign, so it's harder for me to draw on my expertise as a teacher."

BI Toolkit Usage

When asked about her approach to utilizing the BI Toolkit in collaborative grant work, she explained that she did not actively employ it with the researchers. Instead, she shared the link and provided a brief overview, but noted a lack of interest among the researchers. However, in her own personal workflow, Amber found the Planning Checklist to be the most beneficial tool. During the review of the proposal, she meticulously examined each point on the checklist to ensure comprehensive coverage in the text of the proposal. One specific point, regarding the scalability of the project and its relevance to regional/national scale efforts, stood out. Amber then considered this point, and acknowledged that not every project is scalable depending on its niche nature and alignment with K-12 science standards. She deemed this aspect irrelevant to the researcher's proposal and didn't perceive it as a necessary inclusion. Amber expressed a strong preference for the Planning Checklist, emphasizing its effectiveness in ensuring that all necessary components were addressed in the proposal. To her, it provided a valuable means of verification, allowing her to confirm the inclusion of crucial elements and avoid overlooking any aspects.

However, while attempting to incorporate the BI Rubric into her process, Amber found it more discouraging than helpful. She conveyed a sense of frustration in distinguishing between different scores, describing the process of "splitting hairs" on what counted and what didn't count as a challenging aspect of using the BI Rubric. At another point in the interview, she admitted experiencing a bit of imposter syndrome when faced with the task of choosing between scores, particularly when they fell in between categories.

Reflection and Future Plans

When asked to share her reflections on her experiences through her development as a BI professional, she mentioned that the process was slow and that it requires watching and following people who have written grants before and determining what approach works for the individual. She again mentioned that the "imposter syndrome feeling is totally normal" and is something you must learn how to persist in working though, despite having these feelings.

Participating in a pilot program testing the Broader Impacts Certification Program at a pre-conference workshop before the 2023 ARIS Summit was also influential to Amber. She also found it helpful to attend sessions, learn from speakers, and speak with other BI professionals at the summit. She felt like these two opportunities of learning and connecting have increased her understanding of BI and given her more confidence. She indicated that she would become increasingly more comfortable supporting researchers with BI as she continues

engagement with other ARIS members and gains additional experience working with science and engineering faculty.

Lastly, when asked about suggestions she has for onboarding new faculty at CSATS, Amber suggested that the BI Toolkit be introduced in phases. First, the Guiding Principles should be employed to think about the main goals for BI. The next step should be going through the process of re-writing a proposal; the Planning Checklist should be used to help the BI professional interact effectively with a proposal in development, but it's not as useful to show the researcher. According to Amber, mentorship from a more knowledgeable BI professional at CSATS is the most important aspect of onboarding.

Case 2: Tiffany

Transition and Grant Writing

Tiffany began working at CSATS three years before this study, after being a teacher in a biology classroom for eight years. Her first introduction to CSATS was through her participation in the RET program, where she completed two research placements: one in hydroponics and the other in cancer-focused molecular biology. She was motivated to participate in these programs because, "I never had science education professional development in my experience as a high school teacher, so I sought out that opportunity." After those two experiences, she applied for a CSATS open position because she felt so strongly about the importance of understanding what science researchers *actually do*—something that was unknown to her even during her training to become a science teacher. She went on to say:

> [I] never really realized that in grants there had to be some sort of thing that impacts society. I didn't really know that, and I also would have never understood how grants actually work if I didn't get out to the side of BI. When you're in the classroom, you're really focused on yourself and what you're doing and how that's influencing students. But in the BI world, it's all about collaborating and reaching out to people, and who does this, who does that, and then bringing them together to make a more beneficial impact to society.

Tiffany knew nothing about BI when starting this position. As a teacher, "writing grants is a completely foreign idea to us. And for the first six months, I probably struggled with what 'broader impacts' actually means." She strived to be a teacher educator and understood that aspect of CSATS but, admittedly, she did not know how to fit that work within a grant. Ultimately, she became a BI professional "because I was intrigued by the thought of understanding what scientists and engineers do and translate it back to the classroom through teachers."

At the time of the interview, she had collaborated on nine grant proposals, all of which were K-12 teacher education programs proposed as BI components of NSF grants. She also relied heavily on using existing grant proposals written by CSATS as a basis for developing new ones, and spoke about the importance of mentorship. She stressed that having a mentor walk new faculty through a proposal was critical to understand why certain components were added and the rationale for structuring the program in particular ways.

Despite initially having two grant proposals to work on in the summer of 2023, one faculty decided to end their CAREER proposal. As such, Tiffany only worked with one researcher using the BI Toolkit.

BI Toolkit Usage

Tiffany used the Guiding Principles when working with a researcher in earth and engineering sciences. During the interview for this study, she referenced an email that she had sent to the scientist prior to their first consultation meeting that included the Guiding Principles. She asked him to read it and told him that during their meeting they would be working on question 3, which asks: *Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?* Within that question, there are guiding questions about justification, intended audience, social impacts, citing appropriate literature, clearly defined goals and objectives, and evaluation.

During the writing process, she also encouraged the researcher to use the BI Wizard when she edited the education plan of his proposal. The education plan of a CAREER proposal must be integrated with the research, and while it may include K-12 teacher programs, it also needs to be clearly connected to the technical aspects of the research. Tiffany suggested that he make individual justifications about the educational components of graduate/undergraduate education, course

development, K-12 education, mentorship, and more. She pointed him to the BI Wizard to help him better articulate the rationale for each.

The education plan that resulted from her collaboration included placing a teacher from an underfunded school serving students underrepresented in STEM for two consecutive years in CSATS's RET program. The RET program was justified using literature on STEM education, and the plan explicitly stated how the goals of the RET program are well aligned with NSF's call for full participation of women, persons with disabilities, and underrepresented minorities in STEM, and to improve STEM education and educator development at all levels. The education plan also described evaluation methods.

Tiffany found the most value provided by the BI Toolkit was in helping her raise questions about the activities being proposed, the goals of the project, and partners that could be collaborators. She explained how the BI Toolkit "helped prompt me to ask certain questions to get at the details of what I was proposing so I could actually communicate it."

Reflection and Future Plans

Tiffany has noticed a shift in the importance of BI in grant proposals. She has participated in the ARIS community through participation in the annual summits and online webinars and learned about updates on BI, which opened her eyes to its further significance. She feels that more emphasis is being placed on BI in the past four years, and the NSF is trying to put more focus on having better BI plans. Tiffany believes that having a strong BI plan is crucial for a grant to be competitive.

When asked about how the BI Toolkit influenced her understanding of the impacts of research grants, she mentioned learning about BI outside of the K-12 teacher education sphere. She referred to the Guiding Principles and identified only two goals addressed with K-12 education programs, and therefore got a broader scope of the kinds of BI that can be included in a project. She feels as though she is better able to navigate this field now.

Tiffany suggests using the BI Toolkit in a phased approach for onboarding. First, she recommends working through a BI plan with an experienced BI professional. Then, she feels she would have been able to examine a proposal draft and use the BI Toolkit to work backwards and critique an existing proposal rather than starting from scratch. This progression, coupled with participation in ARIS and having a more experienced mentor, would be extremely helpful in increasing the abilities of a BI novice.

Case 3: Jeff

Transition and Grant Writing

Jeff began working at CSATS as an outreach liaison a year and a half before this study. He transitioned to BI work after a 35-year career teaching middle school science. He was not familiar with BI when he applied for the job at CSATS but thought it might "scratch an itch" for him. The most challenging aspect of the transition for Jeff was a lack of confidence; he had been in the classroom for 35 years and then he had to interact with faculty with doctoral degrees. He remembers thinking:

> What in the world do I have to contribute? PhDs are awesome and brilliant, but they're brilliant at very specific isolated areas. And I feel like teachers are really gifted at thinking on their feet and being creative problem-solvers, being system-approach people, and being generalists.

Prior to this project, Jeff had not participated in any grant writing. During this project, Jeff collaborated on two CAREER grants; one was about the nanomanufacturing of graphene, the other was about AI and controlling systems. For the first education plan, Jeff supported the faculty in planning a teacher workshop. For the second, Jeff integrated a teacher placement in the RET program in the faculty member's lab. Jeff was able to connect the researcher's idea about *convergence research* and the White House Office of Science and Technology Policy's call for *convergence education* (National Science and Technology Council, 2022). He was able to identify state and national standards related to this work and justified the program on the value it would bring to students.

BI Toolkit Usage

Jeff found the entire BI Toolkit helpful, except for the BI Rubric. He spoke in his interview about how he used the Planning Checklist to prepare for the first consultation meeting with the researchers. He said it "helped me start the conversation and keep the conversation going, because I found it's not just a one-hour session. It's going back and forth, and those things seem to have helped me sort of reverse-plan the proposal."

He also mentioned that he felt the BI Toolkit gave him more credibility in dealing with the researcher even though he was relatively new to the profession:

> What experience do I have to bring to the table as far as helping write a grant proposal? But this [BI] Toolkit comes from professionals very experienced across the country … many institutions and other places in ARIS that have created [these resources] with a lot of intentionality and relevance, so I figure that this gives me a little bit more credibility to interact with the professionals and say, "It's not just something I've come up with. This is a highly vetted resource from highly respected professionals around the country." So, I feel like that was a really valuable asset to me.

As he progressed through the process of writing with the two researchers, Jeff switched from using the Planning Checklist to the BI Wizard. He mentioned its strength being that it helped him figure out specifically what the relevance was, and who the target audience would be in relation to the researcher's goals in the project. He reiterated that the BI Wizard facilitated an ongoing discussion with the researcher. Jeff says he:

> under-utilized the [BI] Rubric, just because my brain didn't have the capacity for it at this time. But now that I've a better understanding of how the [BI] Toolkit and [Planning] Checklist works, I'm looking forward to the next time I use [the BI Toolkit] to add the [BI] Rubric in there as part of my own new lens.

Jeff did not feel like he had enough of a grasp about BI quality to be able to judge proposals, even with the highly detailed BI Rubric.

Reflection and Future Plans

A key aspect Jeff referred to on multiple occasions during the interview was the importance of looking at previously written grant proposals. He found it particularly helpful to reflect on aspects of the prior proposals that related to the elements of the Planning Checklist and/or the BI Rubric. He also mentioned the importance of participating in a community of practice like ARIS and their professional learning opportunities to learn from and with other people working in BI.

Jeff's unique position as outreach liaison gave him a bit of a different perspective from the other three specialists who do more of the programming for CSATS. When reflecting on the grant-writing process, Jeff suggested the importance of taking every opportunity to engage and connect with people and build relationships, because those relationships can be leveraged in future projects. He also felt like the experience gave him a refined lens with which to view his position within CSATS, because he had talked to several people about what CSATS does, but he hadn't really understood BI until engaging in the grant-writing process with the BI Toolkit.

When asked what advice he had for the director and associate director for onboarding, he stressed two aspects: First, he described the value of being able to use previously developed proposals as a starting point. Second, he mentioned the BI Toolkit as a method to critically review previously-written proposals and help write new ones. He also felt he would not have been able to keep the sections of the proposals he wrote focused enough and be able to fit them in a limited amount of space without the BI Toolkit to "keep me in my lanes."

Case 4: Stephanie

Transition and Grant Writing

Stephanie was hired to be an elementary education specialist with CSATS and is the newest hire, with only one year of experience when this interview was conducted. She had spent eight years in elementary classrooms, teaching science, math, and STEM. She then was selected for an Albert Einstein Distinguished Educator Fellowship and worked with researchers in the Department of Defense to develop curriculum for elementary students based on their work at Carderock Naval Surface Warfare Center. After serving in this position, she felt she could have an impact on more students if she helped teachers learn new and exciting ways to teach concepts in STEM.

As a teacher, Stephanie had written some small grants for classroom materials, but felt completely unprepared for the grant work performed at CSATS. As a new hire, she did not have experience helping support large grant proposals, and she did not understand how to budget for people's salaries and supplies and materials and overhead, particularly in multi-year projects. For the purposes of this study, she collaborated on the writing of two proposals. One was an engineering project that used biomimicry to create underwater robots that moved like fish; the other was a

collaboration with Penn State's Department of Special Education to work on an AI tool that could support accommodations for learners.

Stephanie, too, expressed feelings of imposter syndrome, because she felt pressure to be the expert on BI with scientists expecting her to deliver even though "I don't even know how to do it right. It can be very daunting and confusing. And honestly, you could give wrong information, meaning like wrong information about budgeting, timeline, goals."

BI Toolkit Usage

Stephanie found the BI Wizard to be helpful, particularly in developing a budget for the BI program she developed. She used the guiding questions in the budgeting sections to ensure she was considering all the things that would need to be included and how many days of time would be required to budget. She was very pleased when the PI appreciated her work, did not question it, and included it in the project.

Stephanie reported that both the BI Toolkit training session at CSATS, as well as participating in a pilot program testing the Broader Impacts Certification Program at a pre-conference workshop before the 2023 ARIS Summit, helped her immensely. The pilot program "was a game changer. I honestly said to myself, 'Why didn't I get this like the first week [that I started working at CSATS]?'" She felt she knows more about what NSF looks for and how the proposals are reviewed. She felt that for someone experienced in BI work the BI Toolkit might seem basic, but for a novice the BI Toolkit "was really helpful and it was very nice to see black-and-white statements."

When working on the biomimetic fish robots, she used the BI Wizard with the faculty who wanted to have students build the robots and have a competition in a swimming pool. Initially, the researchers wanted to hold the competition for grades K-20. Stephanie was able to focus their target audience on third- to fifth-grade elementary students, particularly because the science and engineering standards are more compatible with those grades. In addition to the challenge in designing a competition and requisite teacher workshops for such a wide age range, the BI Wizard helped her focus the researchers on who they wanted to involve.

Stephanie also found the Guiding Principles useful in communicating to the researchers that NSF has goals they value for BI. She was able to help the researchers understand that their focus on impacting students with disabilities was important to NSF (i.e., "full participation of women, underrepresented minorities, and persons with disabilities") (NSF, 2023b) and should be emphasized in the BI statement.

She also found the BI Wizard helped her connect the goal with a target audience by leveraging the proposed research as context for developing and delivering impactful programming. The BI Toolkit gave her confidence to interact with specialists in fields such as special education and mechanical engineering, which enabled her to make contributions that strengthened those proposals.

Reflection and Future Plans

Stephanie was adamant that the BI Toolkit was very influential in helping her learn about BI and in collaborating with faculty on their research grants. On multiple occasions she mentioned that she would have loved to have had access to the BI Toolkit earlier in her time with CSATS. She said:

> I know there's a lot of onboarding whenever you start any job, but there's a lot of articles that can be shown to you, or like, basic procedures and stuff. And Penn State sent me a lot of onboarding stuff, so believe me, I was bombarded. But it would have been nice to have something like this to understand anything about broader impacts, because I really didn't.

At another point in the interview, she reiterated this point:

> But I would highly suggest, if there's another specialist like me that comes along or is in an office like CSATS anywhere in the U.S., that they would use this tool to help onboard people, because it really does give you an understanding of the basics of NSF grants and BI.

She is also excited about how her career will continue to be impactful. She said:

> It's cool to think that cutting-edge science is happening right now, and I get to help deliver that new and exciting science content, especially to elementary students. I feel like elementary is always on the backburner, and I think it's exciting that I finally get an opportunity to not only be an advocate, but to help teach that content. I think there's a great

> opportunity, because I've never had the opportunity before to be that advocate for those people, but I obviously changed the mind of some research scientists to start thinking that elementary is important.

Cross-Case Analysis

All four participants in this study were transitioning from being successful and highly decorated teachers to a new career path at CSATS in the area of BI, which involves translating technical research to K-12 education. Jeff and Stephanie won state and national teaching awards, and Tiffany and Amber were selected for spots in well-respected teacher education programs from talented pools of applicants. Each of them joined CSATS because they wanted to have an impact on education through teacher professional development. However, none of them knew about BI or grant writing when they started, and each found that aspect of the job daunting.

Tiffany and Amber, both of whom had some grant-writing experience prior to this study, seemed to find less utility with the BI Toolkit than Jeff and Stephanie, who had no prior grant writing experience. Tiffany found the Guiding Principles most helpful to justify the BI plan's goals and to use the guiding questions, especially question number 3 (*Is the plan for carrying out the proposed activities well-reasoned, well-organized, and based on a sound rationale? Does the plan incorporate a mechanism to assess success?*) to frame the conversation with the researcher. Jeff and Stephanie both found the BI Wizard to be highly useful for them to work through examples of previously written grants and to help them address the aspects of BI program development that addresses goals, partners, audiences, budget, and relevance. None of them found the BI Rubric to be a useful tool, and Amber and Jeff expressed that they did not feel capable of distinguishing between the different ratings for the components of the BI plans.

Along with the daunting nature of learning about grant writing and BI, each expressed the feeling of anxiety that comes with interacting with experts in science and engineering. Jeff and Stephanie both expressed that they felt empowered by the BI Toolkit because it was developed by experts in BI, and it gave them some authority with which to speak confidently about their contributions to the proposal. Tiffany and Amber agreed, though to a lesser extent, that the Planning Checklist and Guiding Principles gave them points to address with the researchers to make sure they included enough description about their plan and that the budget was adequate.

The other commonality among each of the participants was the importance of using previously written proposals as tools to reflect on using the BI Toolkit, and as a basis for writing new proposals. They also all expressed the importance of one-on-one mentorship from a more experienced BI professional and did not feel the BI Toolkit would have been as useful without that mentorship. All agreed that the BI Toolkit should be used by CSATS leadership during the onboarding process to help introduce new hires to BI and grant writing. And each found tremendous benefit from belonging to and participating in ARIS Summits and professional learning opportunities.

Limitations of this Study

This study is limited by the small number of participants included and by the fact they were in different stages of onboarding; therefore, we do not intend to generalize. We feel our method was useful in investigating the complex issue of teaching novices in BI about how to support researchers in developing BI plans. This study gives insight into how it worked for us and is intended to start the conversation about how best to develop BI practitioners.

Discussion

Outcomes

CSATS is situated such that most of the education faculty must serve in two distinct but overlapping roles. The first is that of BI practitioner, who must understand the current best practices related to STEM education, how to identify the epistemic practices scientists and engineers use to create knowledge (Kelly & Licona, 2018), and how to adapt that knowledge and activity to be useful for classroom teachers (Altermatt, 2020; Johnson & Hill, 2023; in press). The second role is that of research development professional, who must interact with researchers and help them develop and propose BI plans in research grants to increase impact and make them more competitive (Altermatt, 2020; McNall et al., in press). In other words, teachers who come to work at CSATS must go through two transitions: from classroom teacher to teacher educator, and from teacher to BI professional. While most teachers have interacted with teacher educators, few have any experience in research development. While it is well established that practitioners moving to academia are prone to experiencing imposter syndrome, it was notably

experienced by each of the BI professionals working at CSATS. The BI Toolkit was demonstrated here to be supportive in decreasing imposter syndrome when interacting with researchers, because the users felt it provided legitimacy to their role in the process. Interestingly, the use of the BI Toolkit may also support scientists who also experience a lack of confidence in translating their work to the public (Nadkarni et al., 2019).

In addition to onboarding for teacher education roles—including how and why we hold workshops in certain ways, what technologies we have access to, and useful systems and approaches for conducting high-quality programs—there needs to be a systematic onboarding process to support CSATS faculty in learning about BI and grant writing. Consistent with Bradt and Vonnegut (2009), effective onboarding of those new to BI prepared them to be productive in supporting BI plans, enhanced the competitiveness of proposals, and developed their familiarity with the field. Both formal and informal learning are critical in training new employees (Becker & Bish, 2021), including BI professionals. While the BI Toolkit provided a formal approach to both reviewing and crafting BI plans, the in-house training provided informal learning about the context and culture of our institution such that these new employees learned about their role as BI professional and how it is operationalized in their specific workplace.

Conclusion

With the current trends of federal agencies increasing the importance of societal benefits of research, and institutions of higher education creating positions that support BI, more people will be making a career transition to become BI professionals. This transition often involves a shift from being a practitioner (e.g., K-12 teacher) to being a translator of research. Based on the study here and the advice of the study participants, the BI Toolkit should be used in a more formal process of onboarding novice BI professionals. The systematic use of the BI Toolkit can facilitate the development of novice BI professionals, enabling them to iteratively reflect on proposals, conduct consultations with researchers, and strengthen BI plans. Coupled with effective mentorship practices and participation in a community of practice of other BI professionals (e.g., ARIS), early onboarding with intentional use of the BI Toolkit can lead to better-prepared BI professionals who are equipped to support faculty in developing robust plans for impacting society with their research.

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Appendix 1

BI Interview Protocol

Introduction and Background:

1. Can you briefly describe your background as a teacher and what motivated you to transition into a novice BI professional role?
2. Could you provide an overview of the BI Toolkit and its components that you've been using?

Transition Experience:

3. What were the key challenges or obstacles you encountered when transitioning from being a teacher to a BI professional?
4. How has the way you perceive the role of the broader impacts section in grant proposals changed since you started at CSATS?
5. Could you share some insights into your unique motivations for making this career transition?

BI Toolkit Utilization:

6. Can you describe how the BI Toolkit, particularly the BI Checklist, Guiding Principles, BI Wizard, and BI Rubric, have influenced your understanding of the broader impacts section in grant proposals? Let's go one by one with these.
7. How have these tools aided you in collaborating with STEM professionals to write grant proposals targeting K-12 education?

Grant Writing Experience:

8. Please provide more details about the grant proposals you worked on this summer.
9. How did the BI Toolkit specifically contribute to the writing of the broader impacts section in these proposals?
10. Were there any specific instances or examples where you found the BI Toolkit particularly helpful in translating technical research into benefits for K-12 education?

Reflection and Adaptations:

11. Reflecting on your experiences, can you share any valuable insights or lessons you've learned during your development as a BI professional?
12. Have there been any adaptations or modifications to the BI Toolkit based on your feedback or needs?

Impact and Future Plans:

13. What positive outcomes or successes have you experienced as a novice BI professional working on grant proposals targeting K-12 education?
14. How do you envision the insights from your experiences and this study influencing future training and collaboration efforts at CSATS?
15. Are there any plans to expand the use of the BI Toolkit or similar resources in your work with researchers?

Research Process:

16. Could you describe the process of integrating the BI Toolkit into your training and daily work routines?