Informal STEM Learning at Biological Field Stations
Final External Evaluation Report

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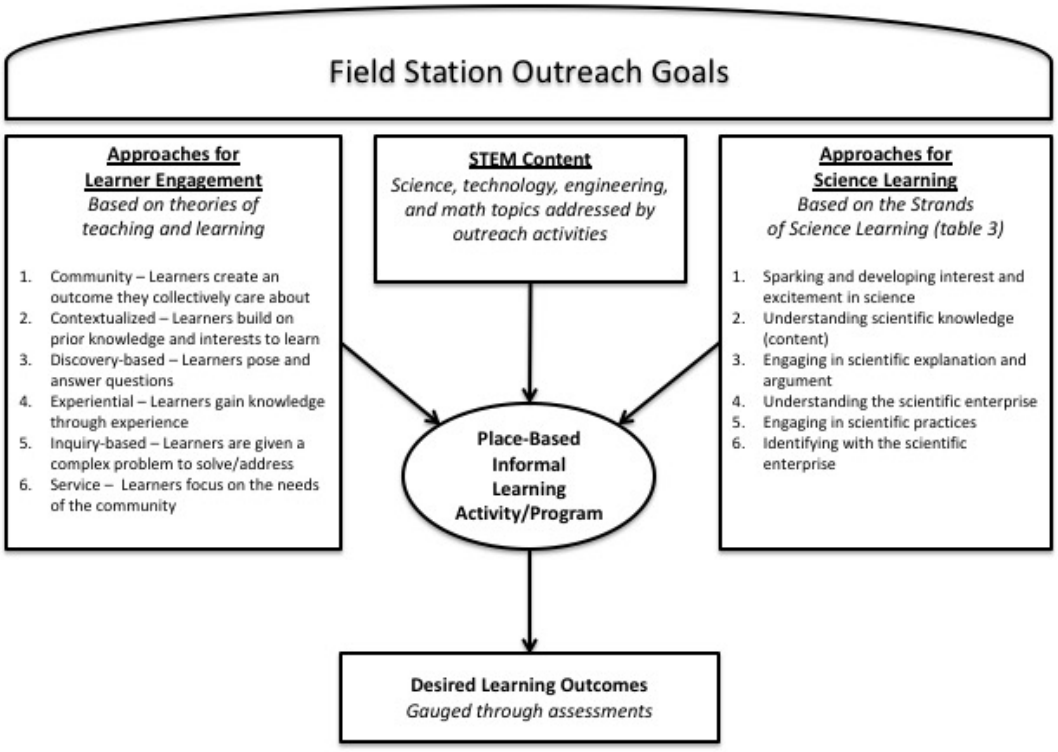
Introduction

Informal STEM Learning at Biological Field Stations, an NSF AISL Exploratory Pathways project, studied the pedagogical and andragogical characteristics of informal educational outreach activities at field stations. The project's conceptual framework (Figure 1) connects theories of learner engagement and approaches for science learning to field stations' place-based activities and desired learning outcomes. The model offers researchers a way to study the kinds of outreach activities undertaken at field stations, and helps field station professionals identify exemplary programs and opportunities for program improvement.

Figure 1. A model for informal STEM learning at field stations



Source: (Struminger, Zarestky, Short & Lawing, 2018, p. 970).

Dr. Kristin Bass, a Senior Research Associate at Rockman et al, an independent research and evaluation firm, conducted the project's external evaluation. She provided rigorous, objective feedback throughout the project to ensure accountability for and reflection on project goals. Her evaluation examined the following questions.

1. Project quality. To what extent were the project's instruments, data collection methodology, analyses, and reporting adequately grounded in theories of learning and supported by empirical evidence?
2. Project accountability. What lessons has the research team learned from the project that have implications for future research and development work on outreach at biological field stations?

This report summarizes the project team's major research activities and the contextual factors that supported that work. It presents findings from: (a) annual team interviews on the project's process and progress; (b) interviews with five representatives from biological field stations; and (c) reviews of instruments, reports, and manuscripts. The appendix contains protocols for the first and last process conversations, and the field station interviews. Descriptions of project activities and stakeholders' reactions are interspersed with literature supporting the research practices. The report concludes with suggestions for future research and outreach with the field station community.

Project Quality

To assess project quality, Dr. Bass held conversations with the project team over the course of the grant, and read research products and annual reports to NSF. She then compared the team's research methodologies to standards from professional societies and literature on recommended practices (e.g., AERA, APA, NCME & JCSEPT, 2014; Cooper, 2011). This section summarizes reviews of the project's instrument, data collection methodology, analyses, and reporting.

Researchers developed their Field Outreach Survey using a systematic, iterative process of construct identification, item creation, and item review (Bass, Drits-Esser, & Stark, 2016). The team translated its theoretical model of informal STEM learning at field stations into questions about the approaches for learner engagement and science learning that field station professionals used in their outreach activities. Researchers minimized educational jargon by focusing on concrete program characteristics. One PI observed that *"we're just trying to pull the heart and soul of those types of activities out where they can rate their activities in a way that is using layman's language to represent these bigger ideas."* The team collected content and response process evidence for the survey's validity. Both types of evidence are appropriate for a measure early in its development (Bass et al., 2016). Researchers gathered content validity evidence through expert reviews from Dr. Bass and four field station representatives. Respondents provided feedback on the relevance of the questions to their field station, and flagged items they didn't understand. Researchers collected response process validity evidence by checking their interpretations of collaborators' outreach program descriptions with the respondents themselves.

Researchers rewrote some questions based on pilot-testers' feedback, and provided additional clarification to individual respondents during the full survey deployment. They also shortened the survey. Instead of requesting background information they could likely find on a field station website or that would be difficult for respondents to recall (e.g., budget allocations), researchers focused their questions around stations' outreach activities. They further clarified that respondents could group those activities (e.g., field trips) rather than describing them individually.

Ultimately, 223 of 400 known U.S. biological field stations (55%) completed the Outreach Survey. The project team felt confident that it had reached all of the "most important players" in field station outreach, including a high percentage of Organization of Biological Field Stations (OBFS) members. Researchers employed seven research-based practices (Anseel, Lievens, Schollaert, & Choragwicka, 2010) to recruit participants (Table 1). Over time, this work yielded information about 316 informal STEM programs representing a diverse array of approaches to learner engagement and science learning (Struminger, Zarestky, Short, Vilen, & Lawing, In Review).

Table 1. Examples of Field Outreach Survey recruitment.

Recruitment practice[1]	Example
Advanced notice	Researchers announced the upcoming survey at a concurrent session during the 2016 OBFS annual meeting.
Follow-up	The project team sent two reminders about the survey. Team members also contacted field station representatives who had started but did not complete their surveys.
Incentives	All field stations who completed the survey were eligible for a drawing to receive one of five $100 gift cards.
Salience	Researchers included their university affiliations, as well as the NSF funding source in their recruitment message and the opening page of the survey. They identified the purpose of the survey and the distribution of its results to make the topic relevant to field station representatives.
Personal connections	22 field station partners on the grant agreed to complete the survey and recruit at least one more colleague at another station. All of the stations that fulfilled these requirements were consequently eligible for a stipend to attend the 2018 OBFS conference.
Personalization	The recruitment message included respondents' names.

[1] Based on practices identified by Anseel et al. (2010).

In the project's first year, researchers established inclusion and exclusion criteria for survey responses, created a code book for their survey, generated aggregated descriptive statistics, and identified questions for additional analyses. This approach is consistent with the transparency and replicability advocated by the American Psychological Association (Cooper, 2011). Later analyses considered the relationships between variables (e.g., approaches for learner engagement and science learning) and employed disciplinary-specific techniques to investigate questions of interest. For example, Short et al.'s, (2020) spatial data research compared the densities of populations and informal learning institutions by county to identify geographic gaps in science learning opportunities for underserved communities. Zarestsky et al (In Review) analyzed the Outreach Survey through the lens of adult education. The authors described the frequency of opportunities for adult science learning at biological field stations, the types of programs and approaches to learner engagement, and the alignment between outreach goals, programs, and assessments. Team members submitted their work to peer-reviewed conferences and journals, enabling them to share their research to varied audiences and frame it within multiple literatures.

In summary, the team's survey development, data collection, analysis, and reporting were grounded in empirically-based best practices. Their dissemination efforts (e.g., posters, presentations, and manuscripts) were further verified through acceptance in peer-reviewed conferences and journals. The next section of this report considers the partnerships that contributed to this success, and the lessons the team learned along the way.

Project Accountability

Team members' reflections about their process and progress, combined with data from field station stakeholders, reveal two factors that were critical to the project's success: (a) responsive partnerships with the field station community; and (b) interdisciplinary research collaboration. This section describes each of those issues in turn.

Community Partnerships

Researchers held a consistent vision for success throughout the project: to establish the relevance of biological field stations as informal learning institutions (ILIs). This recognition should broaden public participation in science. One of the PIs mentioned at the start of the project,

> *Essentially I think what's most important for us moving forward is that we're really setting up field stations in a way that hopefully the public will get more and more access to that is constructive for understanding science and that is beneficial to the*

field station community. That's beneficial to the informal STEM learning community as they see this new exciting resource.

The other PI explained that to fulfill this vision *"we are building a network of collaborators that we are in this project with good reputations in our own fields and with biological field stations."*

The project team maintained close connections to the biological field station community, responding to members' backgrounds, interests and needs around the outreach research. The idea for the NSF proposal came from a desire in the field station community to be acknowledged for doing informal science. As noted earlier, researchers incorporated stakeholders' feedback into their survey and held collaborators' meetings to check their response interpretation.

The team presented its work regularly at annual OBFS meetings. Field station representatives appreciated the efforts. Those interviewed agreed that the team's workshops increased the visibility of outreach at OBFS and gave members a space to exchange outreach practices. One individual said that *"Field stations feel very strongly that this is something we've needed for a long time. We all want to do more, and want to make it more a part of our programs. Nobody says they want less outreach."* She praised the project team for elevating field station outreach through rigorous research (*"from anecdotal to being more quantified*"), observing that the community has *"never claimed this space as a place for informal science."* Another outreach professional mentioned that *"it's nice to have objective reports that you can fall back on"* such as the 2018 Bioscience paper, which *"can help generate more enthusiasm by documenting the value* {of outreach}. *You can then advocate for more support."* Likewise, a third respondent has witnessed a shift in the OBFS community's mindset around outreach from *"Should we do this?"* to *"How do we do this*?" that is due at least in part to the credibility of the survey research.

Field station representatives also praised the researchers' interactive map of biological field stations which showed that "approximately 78% and 98% of the US population live within 60 and 120 miles of a field station, respectively" (Struminger et al., 2018, p. 970). It seemed to provide the validation and recognition that field stations were seeking. *"We are one of the dots* {on the map} *doing this good stuff,"* noted one station professional. Another respondent had used the project's map twice in meetings with other field stations to show the proximity of scientists and their related resources. The map helped her assemble field stations for a statewide pollination outreach initiative. This example demonstrates one of the principles of collaborative educational research with stakeholders, "What Makes Research Valuable Is That It Provides Something of Practical Value to Participants and Their Organizations or Communities" (Penuel, Riedy, Barber, Peurach, LeBouef, & Clark, 2020, p. 651). The recent publication of an analysis using this map (Short et al., 2020) demonstrates another principle, "The Research Should Be of Value to Others Outside the Partnership" (Penuel et al., 2020, p. 654).

The project team acknowledged that its research addressed a longstanding community need. Reflecting on the project's accomplishments, one PI observed,

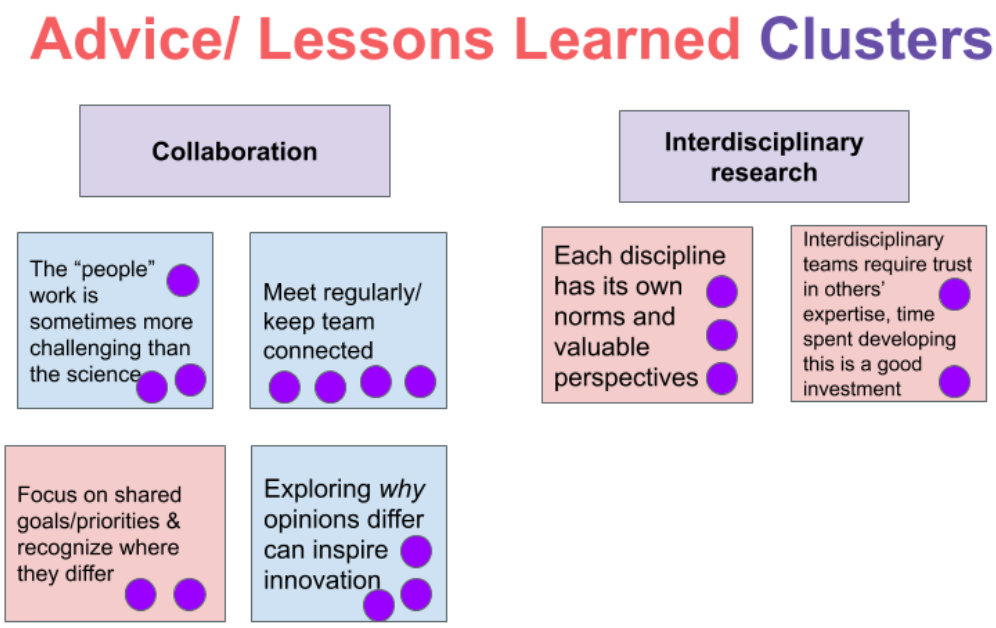
> *I also think that we also tapped into something that the stations are so hungry for. We keep coming back to that and that it's something that they're energized by too. And the importance of the work is seen and recognized by the organization, but the individual field stations as well. … It feels like we have a solid role to play with field stations as a contributor to them and their work reaching the public.*

By the end of the project, team members agreed that they had helped biological field stations attain recognition as informal learning institutions, and facilitated connections between stations. As the team shares survey data through its website, outreach professionals will have more opportunities to learn from each others' outreach experiences.

Interdisciplinary Collaboration

In their final group interview, the research team engaged in a "virtual sticky note" activity to identify the lessons they had learned that they would apply to future work or recommend to other researchers. Before the interview, team members wrote comments on individual "notes" or boxes on a Google slide, and added a dot if they agreed with someone's idea. The external evaluator then clustered those notes for reflection and discussion. As seen in Figure 2, the team's responses focused on collaboration in interdisciplinary research.

Figure 2. Project lessons.



Team-based science has notable challenges, especially among geographically dispersed members from diverse disciplines (National Research Council, 2015). Internal cohesion, including a "shared understanding of team goals and member roles," (National Research Council, 2015, p. 80) can help mitigate these concerns. The team set clear guidelines in the proposal for tasks and roles, and adhered to those roles in their funded project. Thinking about what success would look like at the end of the project, one PI mentioned in the first interview that *"an absolute strength of this team and of our proposal is how clear we were about what tasks we need to accomplish. …I think we thought about what success looks like, and I think we have a plan that will get us to that end goal."* Regular meetings and varying project management strategies (e.g., spreadsheets) kept the team connected and on track.

The team inevitably encountered discrepancies in their disciplinary approaches. They found that shared goals and mutual trust enabled them to work through their challenges. This, however, took time and the ability to identify the source of the conflict. As one of the PIs observed, the team's self-regulatory capabilities improved over time.

> *It's been really useful for us to have to think about why does this feel strange, or why does she want to do something different than the way I want to do it? …. I can't remember anything specific, but I'm certain we had a couple of rocky spots in the beginning when we didn't even realize that that was a tension. And so I think the thing we've gotten so much better at as a team and I'm guessing probably as individuals operating elsewhere is, is being able to identify when that particular disciplinary*

difference in expectation is, is something that's affected affecting the way a team or a project is functioning.

Tensions emerged over differences in language and disciplinary norms. The research team had to learn the language and concepts of each others' disciplines and reach consensus on how and where to apply them. For example, adult education distinguishes between formal, nonformal, and informal learning. Nonformal learning is intentional and structured, but takes place outside of traditionally recognized educational venues. Informal learning is unstructured and occurs within the context of work and leisure activities (Zarestky, Vilen, Short, Struminger & Lawing, In Review). Science educators, by contrast, do not use the term "nonformal" but instead subsume it under a broad header of informal approaches (National Research Council, 2009). Team members also learned about variations in norms for publication and authorship across fields. They tried to stay on the same page when possible, but also had to *"rely on disciplinary strengths of each one of us to focus the particular paper that we're writing, and to mold it to that disciplinary expectation."* (PI, final interview).

The team found that rich discussions of disciplinary norms often generated new innovations. This was apparent since the initial proposal. *"The best example of this exploring why opinions differ can inspire innovation is when we all sat down at that table,"* observed one PI, *"We kept on asking each other, why is this important? Why should we work together? Why do people care? Why would researchers care in our fields and beyond?"*

Researchers also employed creative approaches in their data analysis and reporting. One of the graduate students shared an example.

I was primarily involved in the development and analysis related to the adult education paper. My background and experience is primarily with qualitative research, while Michelle and Rachel have a lot of experience in quantitative analysis. So, having their expertise during analysis of the survey results, coupled with the subject matter expertise of Jill and myself in adult education and pedagogical approaches included in the survey, resulted in a creative approach to analyzing the data that Jill and I would not have been able to do on our own. For example, Jill and I had some ideas about what relationships might be interesting to explore in the data based on educational theory but were unsure if the data we collected would be able to answer those questions. Michelle in particular was a Rockstar at helping us think through the types of analysis we could do with the types of variables we collected data on, and communicating what the results of the analysis could tell us within the constraints of the research design. Michelle and Rachel were also very creative with the visual representation of our data, which is something I don't see as much in education.

One of the PIs found innovation in the team's research questions and target audiences. For that reason, she would recommend that other researchers consider interdisciplinary collaborations.

> *We have very different questions and trying to integrate those together has allowed us to be more creative. I think in the way we are reaching field stations and reaching the public and the different journals that we're getting out to the different audiences we're able to connect to. I think more teams need to be trying to think innovatively about how they're approaching problems. And I think this team has been able to achieve that.*

The project's doctoral students gained experience with interdisciplinary research early in their careers. A recent PhD graduate noted that this had always been her goal: *"This project really let me like focus my career where I wanted to, and be able to have my research in two different fields."* Similarly, an adult education student noted that

> *I definitely think it's expanded my capacity to kind of think about questions from different angles and really learn maybe which research approaches can answer the questions I have, or if it's phrased a different way than another approach would be appropriate. … I've also had some great mentorship from everybody on the team. Getting that from different disciplines has been awesome. I don't know that a lot of my peers are really getting that in the same in my doctoral program.*

In a follow-up email exchange, this individual described the project's impact on her understanding of her own discipline *"I did expand my knowledge base about how informal STEM experiences that occur during PK-16 can influence learner mindsets as they transition into other developmental stages as adults."*

Summary and Conclusions

In short, the evaluation evidence from the *Informal Learning at Biological Field Stations* project demonstrated that researchers had accomplished their four major goals:

1) Identify the field stations in the United States that are engaging the general public with outreach programming,

2) Survey these field stations about their outreach programming to profile their pedagogical and andragogical details, specifically how they engage learners and incorporate science learning,

3) Create a conceptual model of informal STEM learning at field stations that maps the approaches for learner engagement and the six strands of science learning onto place-based activities offered at field stations, and

4) Develop resources for field stations, the informal learning community, and other practitioners to help them network and share ideas to improve outreach efforts. (Struminger, Zarestky & Lawing, 2020).

As befits an Exploratory AISL grant, researchers generated promising evidence for their topic of study, identified new questions for future research, and developed partnerships and practices to continue their work. The project team has identified a variety of new research directions, including long-term studies of outreach impact, the role of place in adult learning at field stations, and the relationships between field stations and their local communities. They also established a need for professional development in outreach, assessment tools to monitor outcomes, and platforms for professionals to share ideas (Struminger et al., In Review; Zarestky et al., In Review). Field station outreach professionals and researchers will have to collaborate closely to prioritize the problems of practice they wish to pursue. Collaborative educational research, and its associated principles, will be essential for these endeavors (Penuel et al., 2020). To that end, it will be especially important to engage community stakeholders traditionally underrepresented in science, such as members of Indigenous groups, to identify and bridge the social and structural barriers to accessing stations' informal learning resources.

Future research will have to address the changes in field station outreach and learning outcomes as a result of the COVID-19 pandemic and recent environmental disasters (e.g., wildfires, hurricanes, floods). Before the pandemic, field stations most commonly offered experiential activities that engaged learners directly in the natural world. Learning was connected to a sense of place and intended to improve participants' knowledge, skills, and attitudes toward their local environmental context (Zarestky et al., In Review). What happens when those experiences are no longer possible? What approaches for learner engagement and science learning do outreach professionals use, and toward what ends? What are the longer term implications for field station outreach? When visitors feel comfortable returning to field stations, why do they go back? It is possible that visitors will find outdoor informal learning experiences to be safer than those at museums and other indoor ILIs. It is also possible that the growing threat of climate change may drive visitors to field stations to learn more. The environmental challenges of the past year have accelerated calls for public outreach, and the need for field stations to exchange ideas, serve communities, and establish their unique role within the ILI landscape.

Finally, the project team has been very conscientious and candid about its learning curve with interdisciplinary research. Its lessons learned are worthy of dissemination through a blog post on their website, a roundtable at a national conference, or a presentation at the CAISE PI Meeting. In future NSF proposals, researchers might list their interdisciplinary

graduate training as an accomplishment in the "Results of Prior NSF Support" section and emphasize it in their postdoctoral mentoring plan. Helping students to developing breadth and depth of knowledge in at least two disciplines aligns with one of NSF's Ten Big Ideas, Convergence (NSF, n.d.). Additionally, researchers might seek private and public funding to embed themselves and their graduate students at a biological field station to conduct ethnographic research first-hand. All of these efforts to share reflections on interdisciplinary research and train early career researchers will serve to broaden participation in scientific research, and generate creative solutions for educating the public.

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Appendix

Project Team Baseline Process Interview

Overall purpose of interview: (a) To get the team's baseline perceptions of the project's evaluation goals and activities; (b) Identify any changes in goals or planned implementation since the proposal.

Note: These questions are meant as conversation points. I'm not expecting to go through them one by one.

Background

(1) What's the elevator pitch for your AISL project? How would you describe it to other researchers? What's unique or special about it?

(2) What motivated you to apply for the grant? What needs did you see in the field station/ informal learning community that this grant was designed to meet?

Project Vision

(3) What are your goals for this project? What do you hope to accomplish by the end?

- How do you hope to advance research on informal STEM learning (aka., intellectual merit)?
- What other benefits could accrue if the project is successful? In other words, what is the potential broader impact of this project?

(4) How will you know if you're successful? What does success look like?

(5) This is an exploratory grant. What is your vision for a Full Scale Development AISL proposal? How does this project relate to that vision?

Collaboration and Activities

(6) You have multiple researchers on this project. What are your major roles and responsibilities?

(7) In the proposal, you outlined an iterative four-step evaluation plan: collecting data, compiling activities, implementing a decision tree, and identifying gaps in the data. Have you made any changes to this plan since the proposal? If so, how and why?

(8) What are your first project tasks? What do you plan to do through the end of the year?

- Who's doing what?
- How will you know you've been successful?
- What challenges do you anticipate? How are you planning to address these challenges?

Field Station Final Process Interview

Interview Purpose: To capture reflections on the activities and outcomes of the grant, such as the key decisions, opportunities, and challenges that informed the project, and lessons learned that might inform future work.

Project Accomplishments (5 – 7 minutes)

Done as a "virtual sticky note" activity so we can visualize this list

What were some of your key accomplishments during the grant, both in terms of intellectual merit and broader impacts? I'll give you five minutes to jot down some ideas on a shared Google slide. If you agree with something that someone else has written, you can mark it with a dot.

Questions to consider

- For example, could you each identify a couple of key findings from your survey and ISL framework that stood out to you?
- Thinking about your dissemination efforts, what message do you hope your colleagues at OBFS took away from your work? What about other communities or audiences?

(1) Thanks so much for contributing to the key accomplishments and lessons learned documents. I've grouped the sticky notes into clusters. Do you agree with them, or have any other clusters to suggest?

(2) Do you have any other accomplishments to add?

Project Processes (15 minutes)

(3) How did you achieve these clusters of major accomplishments?

- Which **activities did you undertake** that were successful in getting to your goals? Why?
- Were there **collaborations/partnerships, tools, resources, or other methods** used that were particularly helpful in accomplishing the project work?
    - *Probe for opportunities and challenges associated with interdisciplinary collaboration, as well as sampling and analytic strategies that may have been especially beneficial and/or innovative*

(4) Were there any aspects of your work that **didn't go as well as you'd expected**? Probes:

- What had you'd hoped to accomplish?
- How did you address these challenges?
- Looking back, what could you have done differently?

Final Reflections and Future Work (10 – 15 minutes)

(5) I've grouped the **lessons learned** sticky notes into clusters. Do you agree with them, or have any other clusters to suggest? Is there **anything you would add** to this list?

- Can you elaborate on the "people work" note, or does that refer to the other challenges in the sticky notes?
- Can you say more about the interdisciplinary norms and perspectives that you brought to the project, and how they enhanced your work?
- What's an example of how differing opinions inspired innovation?

(6) How might people **take action** from your research? There are direct implications for field station professionals. To what extent do you feel your work is generalizable to other learning contexts or communities?

(7) Is there **anything else** you'd like to share about your experience with this AISL project?

Field Station Representative Interview Protocol Revisediujoplm,

A. Introduction [5 min]

Hi, I'm Kristin Bass. I work for an evaluation and research company called Rockman et al, based in San Francisco. I am the external evaluator for the Informal Learning at Field Stations project with Texas A&M University and Colorado State. As a field station outreach representative, I'd like to talk with you about the project's work, including its informal STEM learning framework and wiki, and the contributions this work has made to the field station outreach community.

Participation in this interview is voluntary. You can stop the interview or skip any questions at any time. I'll also ask you at the end of the interview if there is any information that you've shared that you want to be withheld from the program staff.

I will do my best to keep what you say anonymous and will use a pseudonym for any reporting of the information. However, because I'm only interviewing a few people, it may be possible for the project team to identify you. So, I'll ask you at the end of the interview if there is any information that you've shared that you want to be withheld from the project staff.

We'll aim to keep this interview to no more than 30 minutes.

Questions? Thank you very much in advance for your time.

Is it OK if I record our conversation?

B. Background [5 minutes]

(1) To start, can you give me some brief background about your roles and responsibilities with regards to field station outreach?

(2) Based on your knowledge and experience, what are some needs or challenges field stations encounter around doing and improving outreach work?

Listen for ideas including but not limited to, identifying successful outreach practices, sharing resources evaluating outcomes, increasing visibility/ legitimacy, creating a common language, etc.?

C. NSF project contributions (current and potential) [15-20 minutes]

(3) What's your association with the Informal Learning at Field Stations team? How do you know the team and its work?

Answers could address collaborating with the team directly, or otherwise knowing the work.

(4) How would you describe the Informal Learning at Field Stations project to another field station representative?

Listen for information about project's objectives and processes (collaboration, feedback from the OBFS community).

(5) How has the team's work been useful to your station and/or the field station community thus far? Has it addressed any of the outreach needs and challenges you've mentioned? If so, how?

(6) What potential value do you see for this work? How might it help you improve outreach at your station, or support the outreach community writ large? What issues would you suggest the project team address in the future?

For both questions 5 and 6, listen for assistance in doing the work (e.g., technical assistance around outreach) and building/ legitimatizing the field station outreach community.

D. Conclusions and wrap-up [5 minutes]

(7) Those are all of the questions I have. Is there anything else you'd like to say about the Informal Learning at Field Stations project?

(8) Is there anything you've said during this interview that you would like not to be shared? Remember that I'll be using pseudonyms, but it may still be possible for the project team to recognize you.