Challenges in study design for characterizing the informal physics landscape

Julia Willison, Dena Izadi, Issac Ward, and Kathleen Hinko
Department of Physics and Astronomy, Michigan State University, 567 Wilson Road, East Lansing, Michigan, 48823

Claudia Fracchiolla
School of Physics, University College Dublin, UCD O'Brien Centre for Science, Belfield, Dublin 4, Ireland

There are many informal physics education programs across the country. However, the available information about these programs varies widely and can be difficult to find. Without this knowledge, it is difficult for individual informal physics efforts to be understood as part of a broader national landscape of physics learning outside of the classroom. In this paper, we describe the development of study design and implementation to map the complex landscape of informal physics in the United States. We seek to determine the best ways to collect meaningful and comprehensive data from the wide-ranging and diverse formats of informal physics programs facilitated by academic institutions. Data was obtained from initial web searches for programs, surveys and interviews of program facilitators, and site visits of program events and activities. This data was analyzed along with participants' feedback to produce iterations of the survey and interview protocol. We report on challenges and outcomes from our attempts to collect information about programs in Michigan as a test case for the national landscape. These methods can also be used in other informal education studies to gather program information.

I. INTRODUCTION

Informal physics programs are events, activities, and environments for learning that occur outside of traditional classroom settings - these activities often overlap with what physicists call "outreach". It is likely that informal physics education activities exist at and are supported by most of the over 750 physics degree-granting institutions in the United States as well as our national labs and centers. The physics community expends significant resources, time and effort on these activities; however, there is not a comprehensive catalog that documents the scope of these efforts nationwide. Since physicists directly interact with the public through these efforts, we need to know more about who these programs reach, what physics content is involved, and how they involve physicists and physics students in engaging with the public.

Furthermore, practitioners could use this information to situate their local programs in the context of national efforts, improve existing programs, and inform new programs, especially with regard to inclusivity and accessibility. This information could also be used to leverage additional funding or support from administrators and funding agencies.

Thus, the broad goal of this project is to collect data on informal physics programs so as to compile a national landscape. We believe that this landscape can go towards helping programs collaborate, discovering new formats and content, and helping audiences find programs. In this paper, we discuss the processes we have used to begin characterizing this complex landscape. The data collected are in the forms of surveys, interviews, and site visits, all of which will be used to create a taxonomy of informal program characteristics. In our complimentary proceedings paper, we present in depth analysis of one program, looking at the factors and challenges that are most salient to the program [1]. As our data set grows, our analysis will expand accordingly.

II. BACKGROUND

The APS Forum on Outreach and Engaging the Public (FOEP) conducted a short survey of members' outreach efforts in 2015 [2]. This survey, composed of seven multiple choice questions and one box for comments, was taken by 350 people from the 1800 person FOEP database [3]. Respondents selected from 20 categories of types of outreach they did, with public talks and lectures being the most prevalent category, followed by K-12 classroom visits, open houses, and lab tours, with smaller categories of social media, books, and videos. This survey provided a snapshot of some of the efforts of APS physicists; however, it was not able to provide more concrete details on key programmatic features for individual programs nor lead to a deeper understanding as to the systemic nature of informal physics efforts.

Two studies have provided more robust approaches on documenting outreach efforts. Elyse Aurbach's Conceptualizing the Public Engagement (CPE) series was a series of meetings at the University of Michigan which aimed to create a framework under which public engagement activities can be organized and to create a landscape of the university's public engagement efforts [4]. The result of this work was a comprehensive framework that establishes characteristics of program stakeholders, their relationships, and the context they exist within [5]. Another study we draw from is The Mapping Out-of-School-Time Science (MOST) report to the Noyce foundation that [6]. This study details characteristics of out of school STEM programs, utilizing document and web site reviews, interviews of program facilitators, and a questionnaire to gather basic information on many programs. They also employed snowball sampling as a technique to increase their number of subjects, asking each participant to recommend additional participants.

The path to mapping the discipline-based informal physics national landscape is challenging to navigate due to the diversity and complexity of informal physics activities, as evidenced by the FOEP survey. Therefore, we need to develop systematic methods to obtain the information we need for the next steps of this study and future studies. The questions we want answer include:

- How do we become aware of existing informal physics programs, events, and activities?
- How do we recruit informal physics practitioners to participate in this study?
- How do we obtain comprehensive and insightful information about existing programs and events?

The stages of our study constitute the structure of this paper: 1) preliminary web review, 2) survey and interview design, 3) communication, and 4) survey and interview response. Due to the iterative nature of our methods, some of these stages happened in parallel. Our intent is by providing the details of these processes, future projects utilizing similar techniques can avoid some of our mistakes and make use of our successes. For instance, these techniques may be useful for projects looking at how different programs for undergraduates or curricular adoption are taken up nationwide.

III. PRELIMINARY WEB REVIEW

Before a survey and interview protocol could be designed, we needed to gather basic information on existing informal programs. This information would give us a better understanding of the landscape of programs to aid in our protocol design and allow us to confirm whether our survey for program information was necessary. We created a database of programs and filled in data as it was collected. Eleven categories of basic logistical information were chosen to help our survey design and landscape understanding. The categories included program frequency throughout the year, fees, scholarships, funding sources, age advertised to, audience demographics, program type/format, description of volunteers (undergraduates, graduate students or faculty), size of staff, and whether the content was strictly physics.

We developed a strategy to be as comprehensive as possible with identifying potential informal physics programs in the state of Michigan. Michigan was chosen as a test case for this phase due to its wide variety of physics degree-granting institutions and our ability to easily attend program activities as site visits. For the scope of this project, we defined informal physics programs as out of classroom education programs sponsored by, related to, or including physicists and physics students at academic institutions and national facilities. During this stage, we focused on programs associated with universities. Websites of universities with known physics departments, such as the University of Michigan and Michigan State University, were scoured for outreach information, both at departmental and university levels. Other universities were found through Google searches for Michigan physics departments and the Society of Physics Students chapter list. If this information was insufficient or difficult to find, Google searches with keywords (such as "outreach," "physics," "informal," etc) and school names were utilized.

It was challenging to find these programs online. Many informal STEM programs exist, but whether these programs include physics content, are supported by physicists, or are connected to physics departments is often not explicitly stated on websites. Informal STEM programs which stated to have a focus other than physics, such as programming or mathematics, were excluded from this study. In the interest of inclusivity, programs that were vague on how much physics content they present were included. For these programs, the facilitators we connected with were not necessarily the physicists associated with each program, which had its own set of challenges, as we will discuss in Section IV. Due to the many connections between physics and astronomy, including shared resources in many institutions, informal astronomy programs, including planetariums, were included in this study.

Because of the challenges above, we are not able to report an exact number of informal physics programs in Michigan. This result is not necessarily unexpected, but important nonetheless. Moreover, collected data showed many gaps in the current and available information on physics outreach programs. This lack of meaningful data made it clear that data collection from program facilitators was necessary and further drove the need for a survey. Additionally, the variability of the information, in part due to the differing formats of programs, made it clear that the language used to obtain the information would need to be both precise and open-ended, as described further in Section IV.

IV. SURVEY AND INTERVIEW DESIGN

A. Development Process

We chose to take an iterative three phase approach toward developing a survey and interview package to obtain comprehensive information from programs, as shown in Figure 1. The first phase of this project, Phase 0, used only facilitator

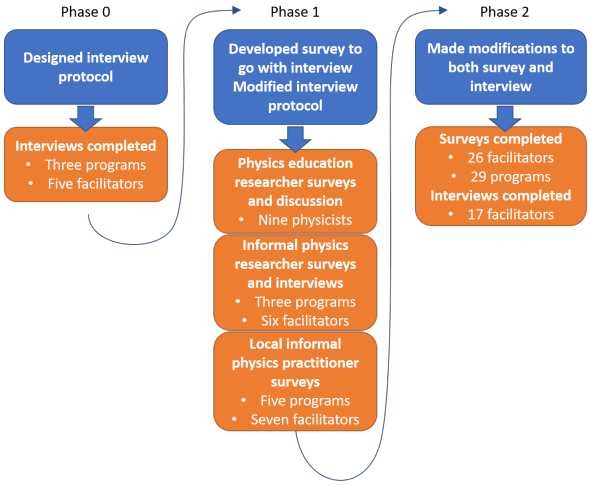

FIG. 1. The phases of the survey and interview development process.

interviews to gather information on the informal physics programs [7]. The interview for this phase asked basic questions about the programs' format and content along with in-depth questions to obtain an understanding of their culture, stability, and goals. Five facilitators completed interviews about three different programs.

These interviews were analyzed using a framework for effectiveness in non-profit organizations [8]. From our analysis we found that the interviews were useful in understanding the nuances of cultural and structural aspects of the programs. However, they did not provide sufficient details about basic program features. For example, when asked directly about number of volunteers, interviewees got carried away in descriptions about volunteer training and experience in the program without answering the question. This situation was difficult for the interviewer since it would interrupt the flow of the interview to ascertain exactly how many volunteers they had. Additionally, since it was only reasonable to ask for 90 minute interviews, when interviewees spoke at length about certain aspects of their program, questions about other aspects were truncated for time, limiting the usefulness of the interview for obtaining basic program information.

After Phase 0 we determined that a survey of this basic program information was needed as a secondary data collection tool and also to reduce the weight and length of the interview. The addition of the survey allows the interview to skip basic questions and spend more time on in-depth questions that are harder to answer in writing.

For the next phase of the project (Phase 1), we had a starting point for the survey from the web based data collection and the Phase 0 interview protocol. The breadth of programs found online made it clear the questions would need to be open-ended. Unlike the FOEP survey, which was all multiple choice [2], we made the decision to have text box options for every question, even multiple select questions, allowing programs to define themselves in their own words. We also made

the decision to focus on programs that had in person content, such as summer camps, lectures, and demonstrations. This decision to exclude other forms of media like radio programs and web sites was made to simplify the survey.

The Phase 1 survey was distributed to 20 people in three stages, as shown in Figure 1. The first stage consisted of six respondents who are involved with informal physics education research. Three of these respondents are facilitators for the same program. The second stage consisted of nine respondents from our institution who are involved with physics education research but who are not currently involved in an informal physics program. This stage allowed us to get feedback from physics education experts. The final seven respondents were local informal program facilitators who we know personally, three who were surveyed about the same program.

The most recent phase of this project, Phase 2, was the widest distribution of the survey and interview. A total of 65 people were contacted for this phase and 35 people responded (26 surveys completed; 17 survey/interview packages completed). These respondents consisted of interested facilitators who saw our presentation at American Association of Physics Teachers Conferences, facilitators from our updated list of informal physics programs in Michigan, and other program facilitators we were put in contact with.

B. Feedback

The addition of the survey allowed the interviews to avoid basic questions and contain more thoughtful questions that are harder to cover in writing. Similarly, the interview allowed the survey to stay shorter, keeping with basic questions about the organization, format, and content of the programs. The MOST Report chose a similar method of data collection, with program facilitator interviews for robust program information and surveys to gather basic program information [6]. Additionally, the survey, which was taken prior to interviews, allowed interviewers to familiarize themselves with the programs and conduct a more effective and robust interview.

The language of the survey was carefully chosen. With each new phase, a new iteration of the survey was developed, with better choices of language and clearer definitions of those choices. For example, in Phase 1 of the survey design, responses from three facilitators of the same program were compared to find differences in their answers. Most of the discrepancies between their answers came from their understanding of our definitions of personnel and audience. This particular program, like many, utilized undergraduate volunteers to work with the K-12 students attending the program. The facilitators were not sure whether to consider these volunteers personnel or audience. As one of the facilitators said, the undergraduate volunteers "are nominally also 'recipients' of [our] programming in that they are meant to gain experience with scientific communication," but that defining them as a part of the audience would significantly change the audience activities for the program. To rectify this confusion, the survey now has examples of "personnel" to distinguish any volunteers from the audience.

The survey contains text boxes and options to write in additional responses to multiple choice questions. Since we found a wide variety of informal physics programming online, the survey needed to be designed to accommodate all of these types of programs. At times, the open-endedness juxtaposed the idea of keeping the survey short, as multiple choice and multiple select questions are generally easier to answer. However, we wanted to allow the programs to define themselves in their terms. Ultimately, the open-ended questions have given more benefits than the cons associated with the length of the survey. Although several respondents have made note of the survey length in the feedback section of Phase 1 and Phase 2, most respondents who started the survey have also completed it. One respondent in particular wrote in the feedback section, "I appreciated that this asked more philosophical and foundational questions. This seems more meaningful than a collection of statistics."

V. COMMUNICATION

Our database helped with the survey design and allowed us to contact programs, often via cold emailing. This was done in three phases (Phase 0, Phase 1, and Phase 2) to allow for feedback on and improvement of our survey and interview design, as shown in Figure 1. In Phase 0, we contacted physicists within our research group, people familiar with the language of informal physics education. In Phase 1, we contacted friends from other research groups who were familiar with physics education, and local program facilitators. In Phase 2, we contacted programs in Michigan. We made some initial contact with facilitators at the Michigan American Association of Physics Teachers (MIAAPT) group meeting in January 2019, and finally cold emails were sent. These emails were designed to explain how the project connected to them, and introduce the survey and interview package. They also included a link to the survey. While we received some responses, there were quite a few programs that did not respond. Other programs responded via email but never completed the survey. Upon receiving two declines due to the length of the interview, we chose to not mention the expected length of the interview in the initial email. We sent reminder emails to those who did not respond. We sent all emails in the beginning of the work week, when people are more likely to be in their offices. We kept a log of our most recent contacts, which allowed our team to work together on email responses.

Two programs were contacted by phone, as they were Societies of Physics Student chapters, to confirm whether or not they conducted outreach. Both calls were answered and both confirmed that they conducted outreach. The survey and interview package were then emailed to them. One of them forwarded it to their SPS officers, who filled out the survey, and the other did not respond, despite email reminders.

VI. SURVEY AND INTERVIEW RESPONSE

A. Declines and incompletes

Overall, we received a 60% response rate for Michigan. This included declines and responses that did not end up with a completed survey or interview. Our number of declines overall were low. Only two facilitators declined the survey and interview package. One cited a lack of time on their end, and the other said the interview was long and that their program does not do much physics overall. The second respondent mentioned here forwarded our information onto another program facilitator at their institution, however, when we contacted them directly this second facilitator did not respond.

We had several responses that required extra analysis, which will not be used in our final analysis. Two of these respondents completed the survey in part, but did not respond to requests to finish the survey. Two other respondents were from two different Society of Physics Students chapters that claimed to foster outreach programs. However, from their survey responses, it seems that neither chapter engages in informal physics or physics outreach activities apart from their normal SPS meetings, which is not a type of outreach we are including in our sample. One respondent seemed to answer survey questions for two different programs at once and their interview was also difficult to understand.

B. Programs that completed the survey/interview

Previously known contacts for informal programs were some of the best respondents for us. Requests from friends and colleagues were generally answered and allowed us to collect a significant amount of data. We had a 100% response rate from these contacts in Michigan, and seven out of eight respondents completed the entire package.

One facilitator, who did not have a background in physics, required extra communication to explain our study and help them complete the package. They did not consider their program an informal physics or physics outreach program, and retook the survey, as they initially put that they were not involved with any informal physics programs.We explained our view of the program as an informal physics program based on the content and connections to the physics department and requested that they retake the survey, which they did, and they completed an interview. This extra communication helped us learn to adjust our language when discussing the study with facilitators without a physics background.

So far we have collected data about programs from six different institutions, out of fourteen institutions contacted. The responses were from predominantly white institutions, all universities. Michigan's three largest universities were a part of our survey data. The two largest respondent pools were from the University of Michigan and Michigan State University. The large populations and large physics departments at these universities allow for more outreach programs from faculty. Additionally, each of their locations, at large urban centers, allow them to have programs that advertise to the local population, not just a population from out of town.

In general, responses were positive, with some respondents thanking us for our work and wishing us luck with our project. Some were clearly excited to have this kind of research going on, with the hope that the research can help their programs, as we are also hoping. For example, one respondent wrote, "Thanks so much for your email - it sounds like a terrific project from which [we] could well benefit."

VII. DISCUSSION

There are limitations to our current process. The main limitation is that our current survey and interview design are made for a certain set of informal physics programs. The questions are worded for in-person programs and do not allow for proper analysis of media-based programs, such as radio shows, television shows, and websites. Many institutions contain online resources and media as a part of their outreach efforts. This kind of outreach can have a wider reach than in-person programs and is an important part of informal physics. However, these types of programs would require significant changes to the survey and interviews. As we move forward to map the national landscape, our hope is to design a survey and interview package for these types of programs, using a similar process as our current package.

Another limitation is the reliance on updated websites for contacting informal physics programs. Most of our research was conducted on the web and was done in the hope that the information on the programs' sites were up to date. Programs with out of date websites or with no information available on the internet are thus not a part of this study. A way to help this limitation would be to call physics departments directly and ask for information on any outreach being conducted. At our own institutions, we found programs through prior knowledge and word of mouth from other participants. We also found some programs via suggestions and forwards from other respondents. Part of our hope is that by contacting more programs, we can continue finding smaller programs in this way; programs that may not have a website or have out of date websites that we would not otherwise be able to find.

Further work on this study will broaden its scope. In addition to university and college-based programs across the country, the study will include informal physics programs based out of national labs, NSF Physics Frontier Centers, and NSF physics centers and facilities. Using the methods from the current phase of this study will allow the expansion of this study to be smoother and faster. Our communication to participants has improved over the course of this study, as has our survey design and interview protocol. Additionally, the techniques for improvement of communication and interview and survey design described here can continue to be used as needed for the rest of this study and other future studies with similar goals.

[1] D. Izadi, J. Willison, C. Fracchiolla, and K. Hinko, Developing an Organizational Framework for Informal Physics Programs, 2019 Physics Education Research Conference Proceedings PER Conference, accepted with revisions (2019).
[2] APS Forum on Outreach and Engaging the Public (FOEP) (2015).
[3] Results: Survey by APS Forum on Outreach and Engaging the Public (2015).
[4] E. Aurbach, Recapping the Conceptualizing Public Engagement series: Part One (2019).
[5] E. Aurbach, Recapping the Conceptualizing Public Engagement Series: Part Four. The Draft Michigan Public Engagement Framework – Academic Innovation (2019).
[6] H. Thiry, S. Laursen, and T. Archie, *Nuts and Bolts: Organizational and Program Characteristics of Youth Out-of-School-Time Programs focusing on Science, Engineering, and Technology*, Tech. Rep. October (University of Colorado Boulder, 2012).
[7] C. Fracchiolla, N. D. Finkelstein, and K. A. Hinko, Characterizing Models of Informal Physics Programs, 2018 Physics Education Research Conference Proceedings , 1 (2018).
[8] E. A. Taysirand N. K. Taysir, Measuring Effectiveness in Nonprofit Organizations: An Integration Effort, Journal of Transnational Management **17**, 220 (2012).