Building with Biology
Participant Impact Evaluation Report

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- AJ Read Science Discovery Center (NY)
- Boonshoft Museum of Discovery (OH)
- BosLab (MA)
- Buffalo Museum of Science (NY)
- California Science Center (CA)
- Cape Fear Museum of History and Science (NC)
- Carnegie Museum of Montgomery County (IN)
- Challenger Learning Center of Alaska (AK)
- Children's Museum of Brownsville (TX)
- Children's Museum of Houston (TX)
- Children's Museum of Virginia (VA)
- Children's Museum in Oak Lawn (IL)
- Children's Discovery Museum (IL)
- College of William and Mary (VA)
- Creative Discovery Museum (TN)
- Discovery Place, Inc. (NC)
- Duke University (NC)
- Duluth Children's Museum (MN)
- Franklin Institute (PA)
- Gulf Coast Exploreum Science Center (AL)
- Imagine Children's Museum (WA)

- Joseph Moore Museum at Earlham College (IN)
- Kentucky Science Center (KY)
- Lander Children's Museum (WY)
- Las Cruces Museum of Nature and Science (NM)
- Lynn Meadows Discovery Center (MS)
- Madison Science Museum (WI)
- Maine Discovery Museum (ME)
- Maryland Science Center (MD)
- McWane Science Center (AL)
- Michigan Science Center (MI)
- Middle Tennessee State University (TN)
- Milton J Rubenstein Museum of Science and Technology (NY)
- Missouri University of Science and Technology (MO)
- Montana State University (MT)
- Morgridge Institute for Research (WI)
- Museum of Science, Boston (MA)
- National Ag Science Center (CA)
- North Carolina State University (NC)
- New York Hall of Science (NY)
- OH WOW! The Roger and Gloria Jones Children's Center for Science and Technology (OH)
- Ohio State University (OH)
- Oregon Museum of Science and Industry (OR)
- Open Bio Labs (VA)
- Orlando Science Center (FL)
- Pensacola MESS Hall (FL)
- Perot Museum of Nature and Science (TX)
- Pink Palace Museum (TN)
- Port Discovery Children's Museum (MD)
- Powerhouse Science Center (CA)
- Sci-Port: Louisiana's Science Center (LA)
- Science Center of Iowa (IA)
- Science Factory (OR)
- Science Museum of Minnesota (MN)
- ScienceWorks Hands-on Museum (OR)
- SELF International, Inc. (MN)
- Smithsonian Institution's National Museum of Natural History (Washington DC)
- Southern Connecticut State University (CT)
- SPI Spot (OH)
- SUNY Poly Children's Museum of Science (NY)
- Thanksgiving Point Institute (UT)
- Thinkery (TX)
- Tulsa Children's Museum (OK)
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Executive Summary

The Multi-Site Public Engagement with Science—Synthetic Biology (MSPES) initiative was an Innovations in Development project funded by the National Science Foundation (DRL-1421179) through the Advancing of Informal STEM Learning program (AISL). The Museum of Science, Boston (MOS) led the project, in collaboration with the American Association for the Advancement of Science (AAAS), BioBuilder, the Synthetic Biology Engineering Research Center (Synberc), Sciencenter, and the Science Museum of Minnesota (SMM). MSPES promoted public engagement with science (PES)—a model of mutual dialogue and learning between public and scientist audiences—through the creation and distribution of PES kits to nearly 200 informal science education sites around the country. Kits included two types of learning experiences: (1) forum programs during which scientists and teen or adult public participants engaged in 1-2 hour guided discussions, and (2) six hands-on activities with which scientists facilitated brief (typically 5-15 minute) interactions with visitors of all ages at a public event. Both activity types focused on socio-scientific issues in the field of synthetic biology.

This report shares the findings from an evaluation of the MSPES project, which focused on participants who engaged with the forum programs and public events which included hands-on activities. Data collection consisted of an evaluation capacity building effort, through which the core evaluation team trained data collectors to gather paper surveys at 34 forum sites and 43 event sites across the US. Surveys were then mailed to the core evaluation team, who compiled, entered, and analyzed the data. The evaluation questions that guided this study, and key findings for each, are:

- *What do participants learn from their PES experiences?*
  Both forum and event participants reported learning facts about and applications of synthetic biology, as well as learning about the field's relation to society and individuals. For instance, forum participants frequently learned about other participants' views, and the societal impacts of science. Event participants also learned about societal aspects of science, and often described learning about the overall significance of the scientific enterprise.
- *What do participants value about their participation in PES events?*
  Forum and event participants valued learning from their PES experiences. Additional values focused on the types of interactions the participants had: forum respondents valued hearing diverse opinions and discussing the topic, whereas event respondents valued the interactive and kid-friendly nature of the events, as well as the access to experts.
- *Does participation in a PES event increase participants' interest in public engagement or science topics?*
  Respondents to both the forum and event surveys reported increased interest in future behaviors related to PES and synthetic biology. This was especially true of event participants who engaged with multiple hands-on activities, and had multiple two-way conversations with facilitators.

Overall, this report shows that the Building with Biology kits promoted a range of positive outcomes for participants, providing valuable and enjoyable experiences that fostered authentic PES interactions. It also raises several opportunities for future work or study, which may deepen the field's understanding of the complex interactions between the multiple audiences involved in PES, and how to best foster desirable results.

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I. Introduction

1.1 Project overview

The Multi-Site Public Engagement with Science (MSPES) initiative was an Innovations in Development project funded by the National Science Foundation (DRL-1421179) through the Advancing Informal STEM Learning (AISL) program. The Museum of Science, Boston (MOS), the American Association for the Advancement of Science (AAAS), BioBuilder, the Synthetic Biology Engineering Research Center (Synberc), Sciencenter, and the Science Museum of Minnesota collaborated on the project. The project was led by the Nanoscale Informal Science Education Network (NISE Net), "*a national community of researchers and informal science educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology"* (NISE Network, 2011). MSPES focused on integrating and supporting public engagement with science (PES) practices in informal science education (ISE) institutions nationwide. PES is a different way of approaching information science education, in that it diverges from the traditional "public understanding of science" model, which involves one-way communication from experts to listeners in the lay public. The PES approach encourages a two-way interaction, through which experts and public audiences both contributed to the conversation and learned from each other. MSPES utilized NISE Net's experience with PES topics, and its network of over 350 museums in order to apply PES practices to improving public awareness of, understanding of, and interest in synthetic biology.

Synthetic biology (synbio) is a rapidly developing and expanding field that uses new techniques that combine biology and engineering to make new or modified living things, and materials. The field provides possible solutions to issues in energy, water quality, medicine, and materials science that raise societal, cultural, and ethical questions. Project leadership wished to pursue public engagement about synbio because of these wide-reaching scientific possibilities and their societal and ethical implications (SEI), and because professionals in the synbio field articulated a need for public input.

During the first year of funding, the project team collaborated with 12 science museums that partnered with local scientists to develop Building with Biology kits. Iterations of the kit activities were developed using Team-Based Inquiry (TBI), a formative evaluation approach for non-evaluation professionals to collect data and assess the effectiveness of educational experiences (Pattison, Cohn, & Kollmann, 2014). Across the 12 sites, developers used this cyclical process to ask prototyping questions, collect data, reflect, and improve the Building with Biology materials. Eight of the sites held pilot events in 2015, at which they facilitated the prototype activities with the public. Formative evaluation data collected from these sites informed the final selection and refinement of the kit activities. In 2016, the project team created 200 Building with Biology kits, and distributed them to educational institutions across the country. The distribution of kits is represented in Figure 1 below.

Figure 1: Distribution of Building with Biology kits 2016

1.2 Project Materials

The kits were equipped with two types of learning experiences:

- **Hands-on activities:** At public events, museum educators and scientists facilitated hands-on activities, which were short (about 5 minute) interactions that targeted family audiences. The six activities in the kit focused on synthetic biology content, and encouraged two-way conversations between public audiences and the people facilitating them. These activities were designed to spark conversation about not just the science behind synbio, but also scientist and visitors' opinions, values, and perceptions related to the science and its possible implications. Examples of intended discussions included the risks and benefits of genetically engineered food, potential effects of synbio on the environment, and the intersection of society and technology. Facilitators were museum educators, volunteers, and professionals, or researchers, graduate students, undergraduates, and DIY biologists with educational and professional experience with synthetic biology.
- **Forums:** This PES method is a longer, dialogue-based program that supports deliberation, problem solving, and consensus about a socio-scientific issue in small working groups. MSPES forums brought together members of the public, scientists, and other stakeholders for one to two hours to consider and respond to questions about SEI in synthetic biology. Each program began with an opening presentation about the topic, followed by guided, small group discussions. The MSPES project created two forum programs about current socio-scientific topics related to synbio:

- *Should We Edit the Genome? When, Why, and How Much?* This forum addressed the potential applications and socio-ethical dimensions of a new technology for genetic engineering, CRISPR. The participants explored the risks, opportunities and benefits that CRISPR technology had on different community members and stakeholders. Through discussion, they debated and developed a plan for integrating an application of this technology into society.
- *Should we Engineer the Mosquito?* This forum looked at the societal considerations of releasing genetically engineered mosquitoes into the environment as a method of controlling malaria transmission. The participants explored the various risks, opportunities, and benefits to different stakeholders, and developed a plan for implementing the genetically engineered mosquitoes in Mombasa, Kenya.

1.3 Project Audiences

The MSPES project aimed to increase the capacity for PES with two professional audiences:

- **ISE professionals:** ISE institutions are critical contributors to public STEM education, but their integration of PES has been limited (Kollmann, Bell, Iacovelli, & Beyer, 2012). Furthermore, practices and strategies for PES have differed among ISE institutions, with little collaboration. The MSPES project developed resources and tools that built a shared understanding of how to integrate PES into museum programming. This project also supported capacity building at ISE institutions that were not as familiar with PES, or that lacked the resources to integrate the practices and strategies autonomously. This dissemination of PES tools built a stronger community of ISE institutions that showed interest in increasing and improving the opportunities for meaningful interactions between local experts and their communities.
- **Synthetic biology scientists and engineers:** Historically, when developing new science and technology, researchers have sometimes been isolated from the complex social and ethical impacts of their work (Fischer 2000, Irwin, 2002). When scientists do participate in outreach, they tend to favor the more traditional "public understanding of science" approach rather than listening to or understanding public views (Besley & Nisbet, 2013). The MSPES project worked to influence scientists' understanding of public engagement by offering opportunities to interact directly with visitors, hear and understand public opinions, improve their ability to effectively communicate their science to the lay public, and be more active in their communities.

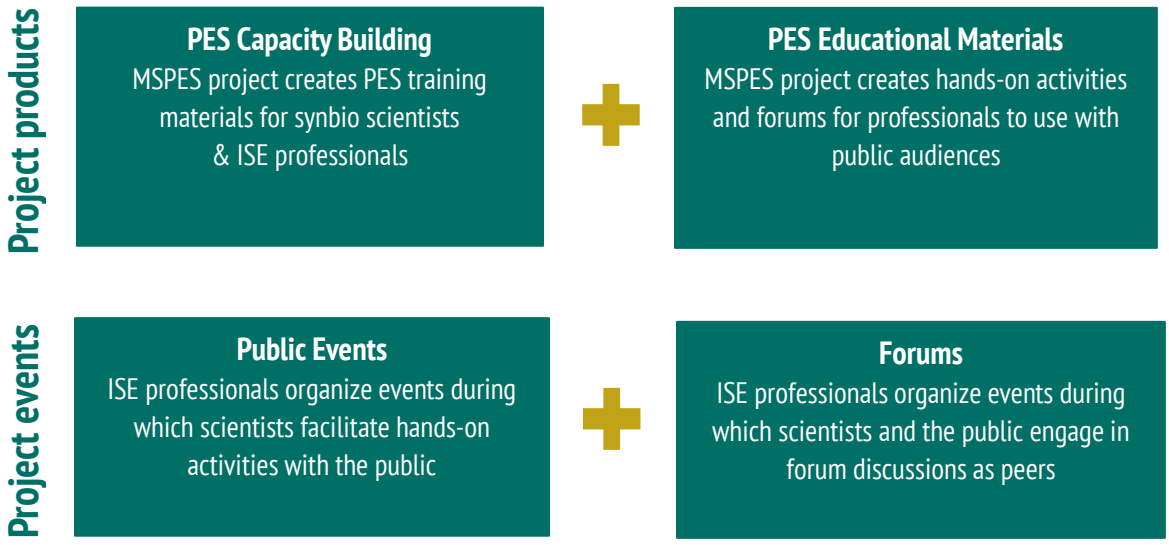
While professionals were the primary audience for the MSPES project, project leadership recognized that there were additional project impacts on the members of the public with whom the professionals interacted. Public audiences engaged in direct conversations with scientists about content, applications, considerations, and SEI of synthetic biology, as well as sharing their opinions and values about this topic. This report investigates this audience's knowledge, awareness, and understanding of synbio, their values related to synbio, and their engagement

in PES programs. For more information about the impacts on the professional audiences described above, see the MSPES summative evaluation report (Sanford & Quimby, 2017).

1.4 Evaluation overview

As described in the introduction, the primary goals of the MSEPS project were to build the capacity of scientists and ISE professionals in PES practices and to strengthen the socio-scientific understanding of synbio among members of the general public. This capacity building allowed those professionals and scientists to interact with members of the public at their local sites. This evaluation report shares the results of an internal evaluation led by a multi-institutional team of evaluators at the Museum of Science, Boston (MOS) and the Science Museum of Minnesota (SMM). This evaluation investigates the impacts on the public audiences who participated in Building with Biology public events and forums. In the case of the public events, data collection targeted public participants, but excluded the scientists and ISE professionals facilitating the activities. The impacts on scientists and ISE professionals were explored in the Rockman et al summative evaluation report (Sanford & Quimby, 2017). During the forums, scientists and members of the public participated in the program as peers; as such, both of these audiences were included in the analysis of forum impacts provided in this report. Figure 2 below illustrates capacity building for the professional audiences and how they interacted with the audiences for which data collection was targeted in this evaluation.

Figure 2: Building with Biology products and events



The evaluation questions that guided this impact evaluation include the following:

- **Knowledge, awareness, and understanding:** What do scientists and public audiences learn from their PES experiences? What do they learn from each other?
- **Benefits:** What do scientists and public audiences value about their participation in PES events?
- **Interest and engagement**: Does participation in a PES event increase scientist and public participants' interest in public engagement or science topics?

1.5 Additional Evaluation Reports

Several other evaluation projects investigated questions about this project that may be relevant to readers. A front-end evaluation study for this project assessed scientists' motivations to participate in PES. A write-up about this work is included in the Appendix. To learn more about the impacts on ISE professionals and scientists, see the summative evaluation report produced by Rockman et al (Sanford & Quimby, 2017). A third data collection effort focused on the public's views about synthetic biology. Results from this study were shared in an online workshop, the recording of which can be found at https://vimeo.com/221479572.

The national dissemination of the Building with Biology kits also provided an opportunity for assessment and development of professional practices in multi-site evaluation. Appendix A at the end of this report considers the methods and tools used to assess the PES activities, and investigates which methods and strategies were best suited for this project's multi-site, nationwide program evaluation efforts.

II. Methods

2.1 Data collection

When they applied for a kit, recipients of the Building with Biology kits could volunteer to participate in an evaluation capacity building effort during which they would receive training in evaluation, collect data about their public events, and receive customized reports about the data they collected. A total of 103 sites volunteered to do the evaluation. The evaluation team selected 60 sites, and 43 sites ultimately collected data about the impacts of their event with hands-on activities. Additionally, 33 sites received small monetary stipends to run a forum program. As a condition of receiving this funding, stipend recipients were required to collect data from forum participants. The Museum of Science, Boston also collected data about its forum programs even though it did not receive a stipend; this led to a total of 34 sites collecting data from participants at forums.

Data collectors at each site received a package of the materials needed to conduct the data collection, including instructions, paper surveys, signage, business cards with information about the evaluation, including how to contact the evaluation lead at MOS, and a pre-paid mailing address for returning completed surveys to the evaluation team. Prior to the events, data collectors were expected to participate in several training efforts to ensure systematic data collection and compliance with the Institutional Review Board (IRB) guidelines, including:

- Completing the *Protecting Human Research Participants* training from the National Institutes of Health (https://phrp.nihtraining.com/users/login.php)
- Reviewing the written instructions in the *Evaluation of Public Impacts Data Collection Guidelines* and/or *Forum Evaluation Data Collection Guidelines* (http://www.buildingwithbiology.org/sites/building-with biology/files/2016_Public_Evaluation_Guidelines.pdf and http://www.buildingwithbiology.org/sites/ Building-with-biology/files/2016_Forum_Evaluation_Guidelines.pdf)
- Participating in an online workshop, *Evaluating the Public's Experiences at Building with Biology Events* or *Evaluating Building with Biology Forums*, or watching the workshop recording and meeting virtually with an assigned mentor from the evaluation team (http://www.nisenet.org/catalog/online-workshop-evaluating-publics-experience-building-biology-events-recorded)
- Watching the *Building with Biology Evaluation and Data Collection* training video (https://vimeo.com/album/3828071/video/169711008)

All training materials are in the Appendix and available at http://www.buildingwithbiology.org/project-evaluation.

Although both the forum and public event surveys shared many common characteristics, the data collection processes differed, given the varied event formats:

- **Forum data collection process**: Paper surveys and writing instruments were placed on the tables where forum discussions took place. At the end of the program, the data collector or forum presenter read a script inviting all adult participants to complete the paper surveys before they left the event.
- **Public event data collection process:** When visitors arrived, they were offered a passport booklet that guided their PES experience by encouraging them to gather stamps for various actions (asking questions, sharing their opinions, etc.). The person distributing the passports would tell recipients (and any visitors who opted not to take the passport) that there would be a survey at the end. Each site had the option of using temporary tattoos included in their kit as thank-you items for people who completed surveys. When sites opted to do this, they were instructed to tell visitors about this when they received their passports. When groups were done with the event, one adult from each group was invited to fill out a survey. All group members were able to get a temporary tattoo as a "thank you," whether or not they completed a survey.

Surveys for both the forums and public events included open-ended questions, rating questions, and retrospective pre-post questions. The data was comprised of qualitative responses about what visitors learned and valued about their experiences, rating questions quantifying what they did and how much the event affected their interest, demographic data, and retrospective pre-post questions capturing how the event changed their level of knowledge around synthetic biology.

2.2 Sample Description

The overall sample represented 33 states; 26 states and Washington DC are represented in the public event sample, and forum data was collected in 24 states. These sites included:

- **Public events:** Sites that received Building with Biology kits were given the option to participate in the evaluation. In total, 103 sites volunteered to participate. Fifty sites were selected for the evaluation, 43 of which completed data collection. The sites were selected to capture visitor experiences from institutions representing a range of geographic regions, institution types (museums and universities), museum types, and institution size. Of the 43 total sites that completed the evaluation data collection, 38 were museums or science centers, 2 were colleges and universities, and 3 identified as another type of institution. The sample of museums included science/technology museums (30 of 38), children's museums (22 of 38), natural history/nature museums (8 of 38), and art/history museums (1 of 38). Four of these museums are considered to be

emerging or developing museums. The majority of the public event sites were small (17 of 43) or medium-sized (16 of 43).[1]

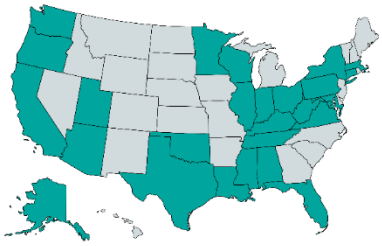
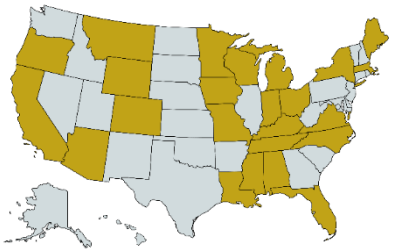
- **Forum events:** Project leadership selected sites to receive forum stipends based on their applications, with particular interest in selecting sites that represented diversity in geographic location, size, and type of institution. Thirty-three sites were selected to receive a stipend to host a forum. Of these 33, 30 participated in the evaluation. The Museum of Science, Boston, also participated in the evaluation, though they did not receive a stipend. Eighteen of the forum sites identified as museums or science centers, 7 as colleges or universities, and 9 as another type of institution. With regard to the museum types, 16 (of 18) were considered to be science/ technology centers, 8 (of 18) to be children's museums, 3 (of 18) to be natural history focused, and/or 1 (of 18) to be an art or history institution. Five of these 18 museums indicated on their applications that they were new or emerging. The majority of the forum sites (17 of 33) were considered small institutions, seven (of 33) sites were large institutions, and 5 (of 33) were medium-sized.[2]

Sites collected between 3 and 53 surveys, with an average of 16 surveys per site for the public events, and 23 surveys per site for the forums. The full distribution of demographics and response data for public events and forums are documented in Table 1, on the following page. There were some differences in the kinds of data collected from the forum and event participants. Age and gender questions differed between public and forum events. Public event surveys asked for this information about all group members, while forums only asked for this information from the individual respondent. Additionally, public event surveys did not ask group members to identify their STEM and synthetic biology backgrounds.

[1] Institution size was defined by annual budget. "Small" organizations were those with an annual budget under $1 million; "medium" was defined as an annual budget between $1 million and $6.5 million; and "large" organizations were those with budgets over $6.5 million.

[2] Institution size was defined by annual budget. "Small" organizations were those with an annual budget under $1 million; "medium" was defined as an annual budget between $1 million and $6.5 million; and "large" organizations were those with budgets over $6.5 million.

Table 1: Sample characteristics

	Public Events	Forums
Total evaluation sites	43	31
Total surveys	682	721
Average surveys per site	16	23
Maximum	32	53
Minimum	3	4
Geographic distribution of evaluation sites:		
Gender distributions:	**Public events (n= 1390 group members)**	**Forum events (n= 667 respondents)**
Female	75%	56%
Male	25%	44%
Other	<1%	<1%
Age distribution:	**Public events (n= 1436 group members)**	**Forum events (n= 659 respondents)**
0-3	5%	--
4-7	19%	--
8-12	19%	--
13-17	3%	--
18-24	5%	39%
25-34	14%	20%
35-44	19%	12%
45-64	13%	18%
65+	2%	11%
Occupation distribution:		**Forum events (n= 684 respondents)**
Scientist/ engineer	--	45%
Undergraduate in STEM	--	39%
Study or work in synthetic biology	--	19%
Attended a Building with Biology orientation	--	24%
Museum staff or volunteer	--	14%

2.3 Data analysis

This impact evaluation used both quantitative and qualitative analysis to assess the effectiveness of these events. Quantitative data analysis included a mix of descriptive and inferential statistics. Descriptive statistics included counts, percentages, medians, and averages. Where appropriate, inferential tests were used to assess differences within the sample (for example, differences between respondents who identify as synthetic biologists and those who do not). Many of these tests are non-parametric, given the relatively small subsample sizes and the fact that many of the data were not normally distributed. Chi Square ($\chi 2$) Tests were used to assess potential differences between two or more categories of frequency counts. When conducting 2x2 $\chi 2$ tests, evaluators provided the Fischer's Exact p-value due to low expected cell counts in some cases. Evaluators used Wilcoxon Signed Ranks Tests when trying to determine whether there were differences between two related samples of data that are ordinal (e.g., pre- and post- scores on a Likert scale of "Strongly Disagree" to "Strongly Agree"). Statistically significant differences—those for which the statistical test results in a p-value below .05—are marked with an asterisk (*). The details of these inferential statistics are included in footnotes throughout the text. For the sake of brevity, non-significant differences are not mentioned in the text.

Qualitative data analysis included both inductive coding and using existing code lists. Questions on the forum and event surveys asking respondents what they learned and valued about their experiences were coded using code lists that had been developed for a previous PES project. The codebooks were slightly adjusted to allow for synthetic biology content, but were designed to stay consistent to promote comparison between forum and event data, and to other projects. The codebooks (see Appendix) were tested during the pilot phase of the Building with Biology project, and then finalized for the full data collection effort. Evaluators first reviewed data with these criteria and then coded un-assigned comments using inductive coding. Inductive coding involves reviewing the data and identifying the most frequent themes (Patton, 2002).

The coding process involved multiple evaluators. Each question was blindly coded by two different coders. The coding was then compared to determine agreement or discrepancy in the coding. For the learning question, the inter-rater reliability was 89%. There was a 91% agreement among coders for the value question. When there was disagreement, a third evaluator would determine the final code.

2.4 Limitations

One limitation of this study was a lack of consistency across sites. The project allowed sites the flexibility to adapt the kits to suit their needs. Data collection did not track how many activities a respondent experienced or how long they engaged, but from similar past projects we know that participants had diverse experiences, lasting from five minutes to multiple hours. The training of volunteers who facilitated the hands-on activities varied as well, with 68% of

volunteers receiving an orientation ahead of the event. Thus, some facilitators were more prepared to interact with the public than others. Forums were generally more consistent in terms of length and kind of participant experience. However, some sites featured live presenters whereas others relied on videos. Additionally, the proportion of scientist participants varied, scientist training varied (65% attended an orientation), and there were two forum topics that sites could choose from. Both events and forums had variable attendance and audience composition (e.g., group type and age).

Additional inconsistencies may have arisen from the data collection process. The evaluation team undertook a substantial capacity building effort to train data collectors at each site via videos, written protocols, and ongoing mentorship. However, there was no way of ensuring fidelity to the prescribed data collection approach. Additionally, linking the event survey to the passport may have biased the sample if the passport appealed to some audiences more than others.

For the forums, the project purposefully invited scientists to be involved as equal participants with the public. We were interested in the differing outcomes for these two groups, but found that it was difficult to identify scientists because they were diverse and we could not always identify the invited ones. For the event, our scientists were invited and trained to be facilitators of the activities. The issues here were two-fold. Sometimes sites were not able to get scientists to be their facilitators so the mutual learning discussions we were hoping for did not always take place. Also, the public contains scientists, so it is important to understand that the line between publics and scientists is not clear.

Finally, there were potential limitations of the data collection instruments. It was not the intention of the project to create validated scales. Rather, surveys were based on questions that had been used in previous PES projects, and questions were pilot-tested at Building with Biology sites in 2015.

III. Forum Program Findings

This section shares data from the Building with Biology forum events that happened across the United States in summer 2016 (see section IV for findings about the hands-on activities). First, it shares data about the ways in which participants engaged with the forum programs. This information provides context for understanding the later findings. Then, the section addresses several evaluation questions:

- *What do scientists and publics learn from their PES experiences? What do they learn from each other?*
- *What do scientists and publics value about their participation in PES events?*
- *Does participation in a PES event increase scientist and public participants' interests in public engagement or science topics?*

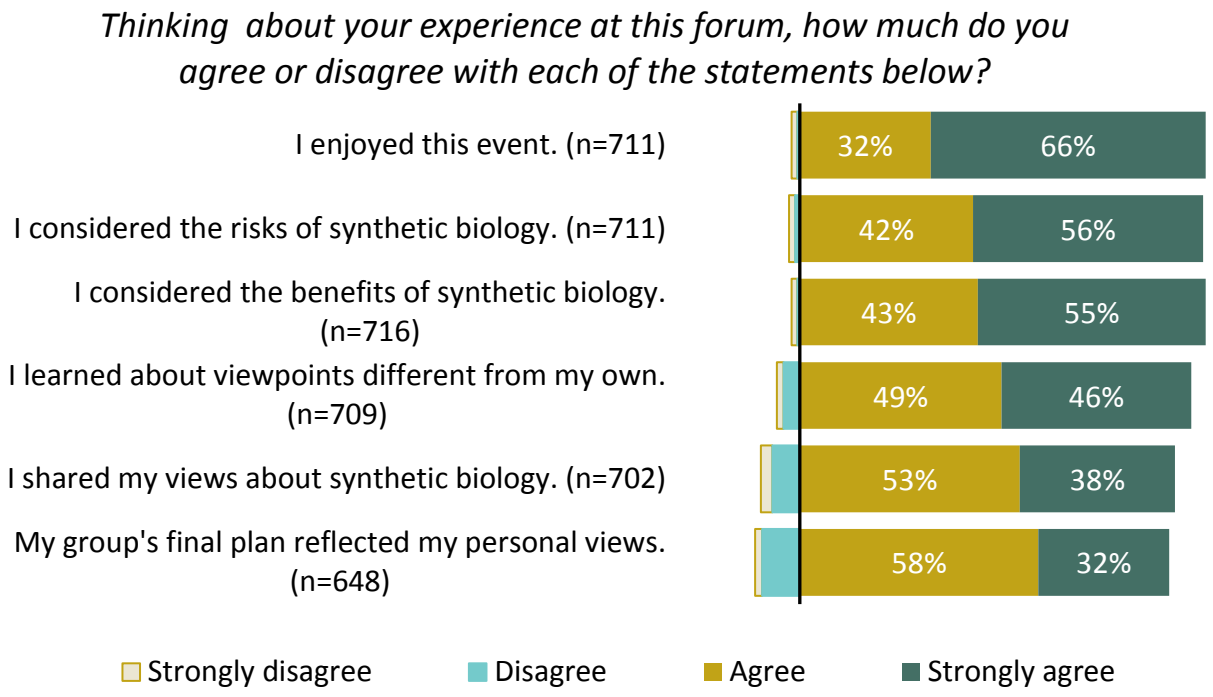
The data in this section come from paper surveys that were completed by adult participants at the end of the forum programs. Both scientists and members of the public filled out the surveys. In general, data from these two groups are combined, but in places where there were notable differences between the groups, the data are presented separately to allow for comparison. Most of the surveys (85%, n=613) are from sites that ran the *Should We Engineer the Mosquito?* forum, and the rest (15%, n=99) are from events that hosted the *Should We Edit the Genome? When, Why, and How Much?* forum.

There are four key findings about the forum programs, which are described on the following pages:

3.1 Participants reported that they enjoyed the Building with Biology forums, considered risks and benefits, and both learned from and contributed to the events.

To understand what forum participants did during their experiences, the survey asked how much respondents agreed or disagreed with a range of statements about different aspects of PES that they may have experienced during the forum. As shown in Figure 3, a majority of respondents agreed or strongly agreed with each of the statements, which included whether they enjoyed the experience (98% agreed or strongly agreed, n=711); considered risks (98%, n=711) and benefits (98%, n=716) of synthetic biology; learned about others' viewpoints (95%, n=709); shared their own views (91%, n=702); and had their views reflected in the final plan that each group created during the forum (90%, n=648).

Figure 3: Forum participants' experiences



These data demonstrate positive outcomes in all of these areas. It is notable that the responses about considering risks and benefits are similar; formative evaluation results indicated that people were more likely to report considering benefits than risks (MSPES Evaluation Team, 2016). The more balanced data may reflect the activity developers' efforts to modify the forums to better portray the science in an unbiased manner. Considering pros and cons of science is an important aspect of PES. Another factor of PES that requires balance is the give and take between learning and sharing. Both of these factors are strong in this data, again showing improvement from formative data where more people felt they had learned than contributed (MSPES Evaluation Team, 2016).

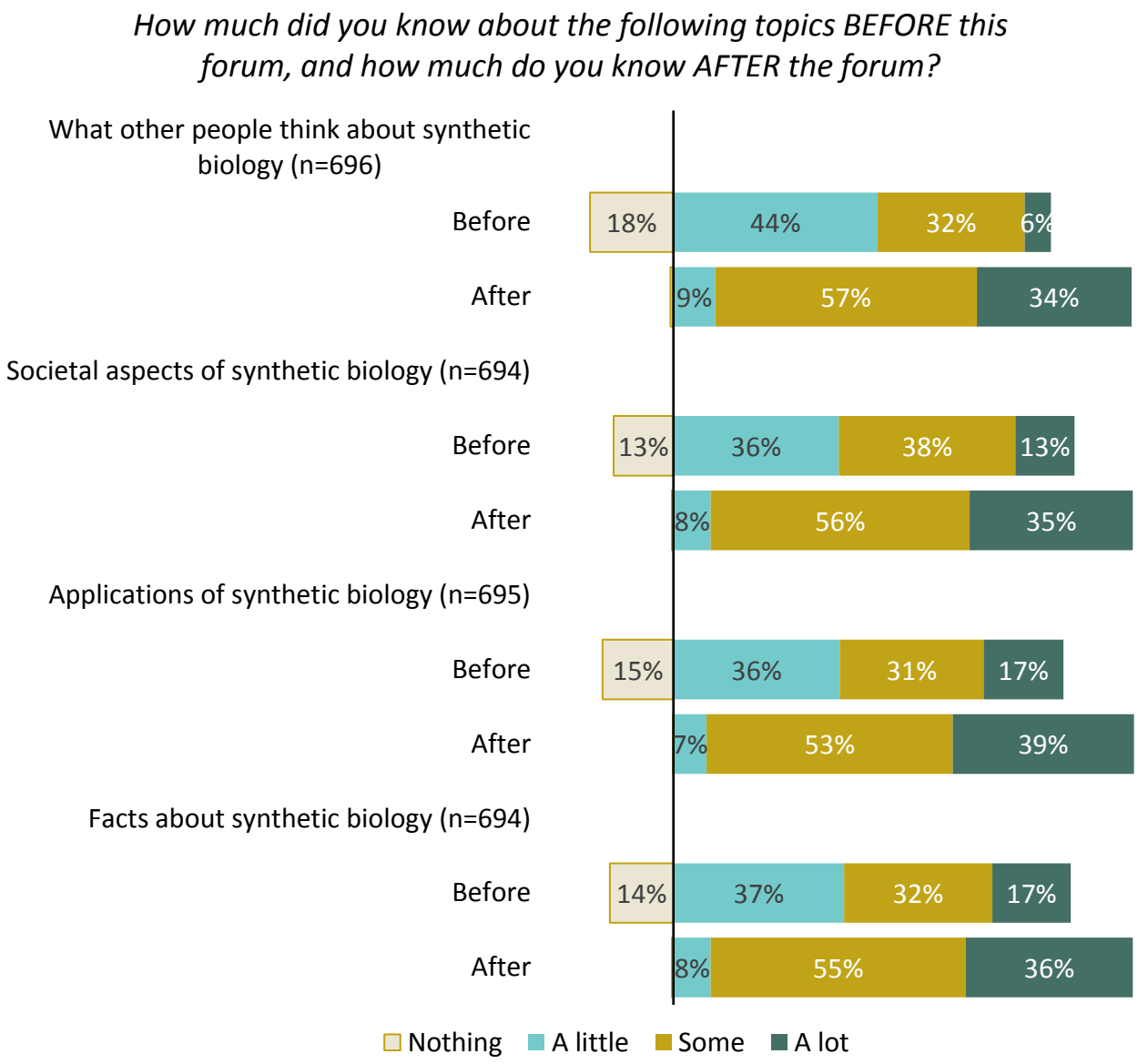
In general, synthetic biologists and non-synthetic biologists responded similarly to these questions. There were two statistically significant differences: synthetic biologists were more likely to agree they had shared their views (94.6%, n=130 for synthetic biologists vs. 89.7%, n=572 for the public)[3] and learned about the benefits of synthetic biology (98.5%, n=131 vs. 97.9%, n=585)[4] than respondents who did not identify as synthetic biologists. The fact that scientists participating in a forum about their own content area are more likely to share is unsurprising; they likely have high confidence and relevant knowledge for the conversation. The finding that synthetic biologists reported learning more about the benefits of synthetic biology is somewhat surprising; perhaps this was because many were early-career scientists, because they learned about the enthusiasm that public participants have for science, or because the interaction with public visitors helped the scientists see opportunities for applying the technology outside of the lab.

3.2 In addition to learning facts about synthetic biology, forum participants learned about the views of others, societal impacts, and applications.

To explore what participants learned from the forum experience, the survey asked both close- and open-ended questions. The close-ended question was a retrospective pre-post item, on which respondents indicated how much they knew before the program and after the program. More information about this retrospective question-type can be found in the methods section. Figure 4 shows the results of this question, which asks about people's learning about facts, applications, and societal aspects of synthetic biology, as well as what other people think about synthetic biology. In each of the four topics, there were statistically significant improvements, with respondents indicating that they knew more after the event than they had prior to it. The percentage of people who reported knowing "some" or "a lot" about what other people think about synthetic biology rose 53 percentage points, changing from 38% in the retrospective pre-questions to 91% in the post-responses (n=696). For knowledge about societal aspects of synthetic biology, the percent of people who reported knowing "some" or "a lot" rose 40 percentage points, from 51% to 91% (n=694). For knowledge about the applications of synthetic biology, this proportion increased 44 percentage points from 48% to 92% (n=695).,For knowledge about facts about synthetic biology, the percentage of people who reported knowing "some" or "a lot" rose 42 percentage points, from 49% to 91% (n=694).

[3] Mann-Whitney U Test (n=702, U=32437.50, p=.011)
[4] Mann-Whitney U Test (n=716, U=33340.50, p=.007)

Figure 4: Forum participants' knowledge before and after the forum[5]



As we might expect, synthetic biologists reported higher levels of knowledge about all four questions than non-synthetic biologists. This was true of "facts about synthetic biology", "applications of synthetic biology", "societal aspects of synthetic biology", and "what other

[5] *Facts about synthetic biology*: Wilcoxon Signed Ranks (n=694, Z=-18.21, p<.001)
Applications of synthetic biology: Wilcoxon Signed Ranks (n=695, Z=-18.66, p<.001)
Societal aspects of synthetic biology: Wilcoxon Signed Ranks (n=694, Z=-18.32, p<.001)
What other people think about synthetic biology: Wilcoxon Signed Ranks (n=696, Z=-19.76, p<.001)

people think about synthetic biology", both before and after the forum.[6] Table 2 shows that each question had a gap between the percentage of synthetic biologists and non-synthetic biologists who reported knowing "some" or "a lot." This gap ranged from a 26.5% to 56.2% difference between synthetic biologists and non-synthetic biologists in the pre-responses, and a 6.0% to 10.3% gap in the post-responses, depending on the topic. Thus, the gap in knowledge between synthetic biologists and other participants narrowed during the course of the forum, with the public "catching up" to the scientists. While we might have anticipated a ceiling effect in learning due to high initial knowledge levels for synthetic biologists, when looking at this group alone, synthetic biologists did show statistically significant increases in reported knowledge before and after the event for each of the four topics (facts about synthetic biology, applications of synthetic biology, societal aspects of synthetic biology, and what other people think about synthetic biology), with a 3.9% to 36.1% increase in synthetic biologists who reported knowing "some" or "a lot" about each topic between "before" and "after" responses.[7] These significant learning gains may have been partially due to the fact that many sites had high numbers of synthetic biology students as scientist participants, who may have been relatively new to the field.

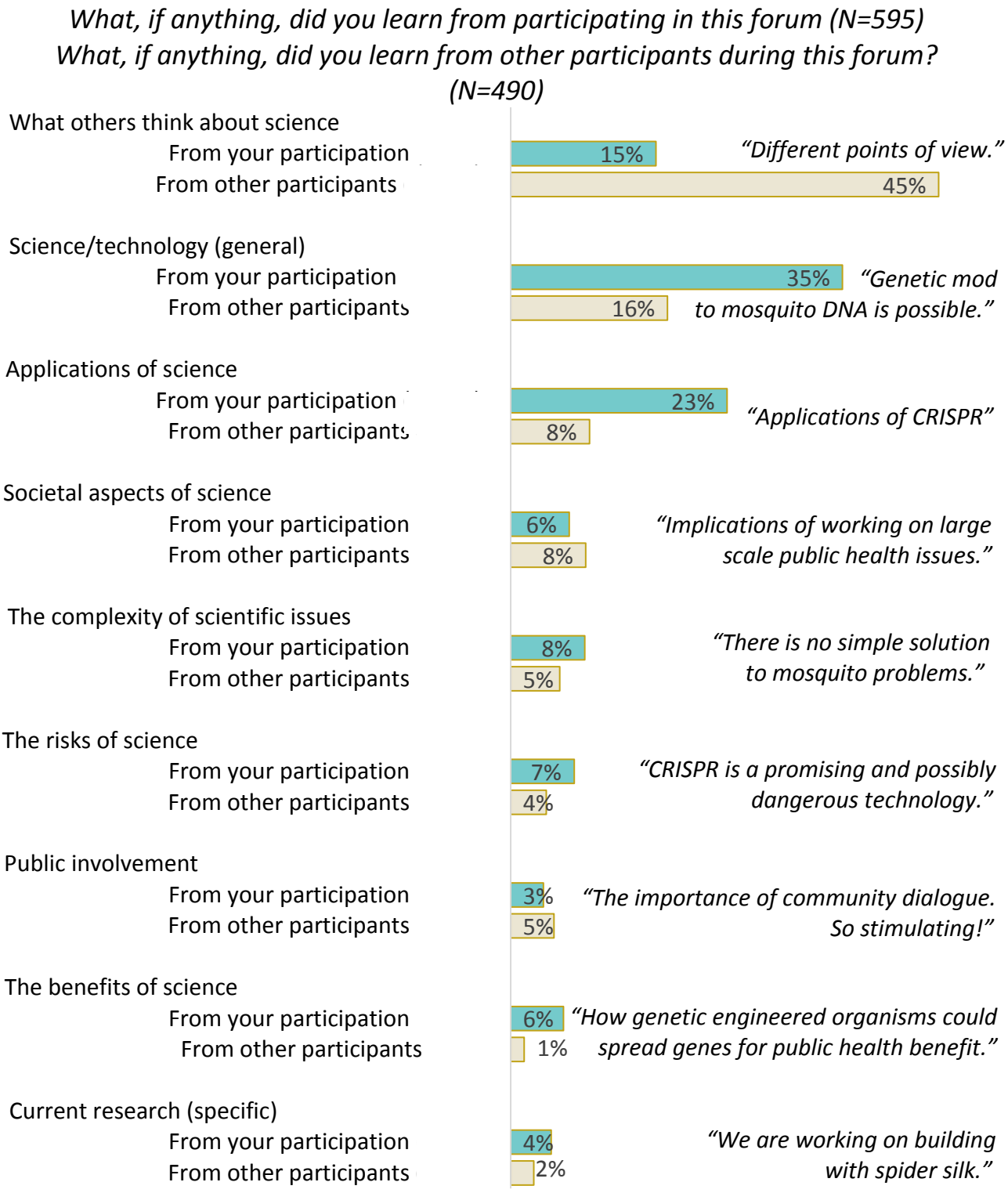
Table 2: Synthetic biologists' and general publics' reports of knowing "some" or "a lot" to survey question, "How much did you know about the following topics BEFORE this forum, and how much do you know AFTER the forum?"

	Synthetic biologists		*Non-synthetic biologists*	
	BEFORE	**AFTER**	**BEFORE**	**AFTER**
What other people think about synthetic biology	59.2% (n=130)	95.3% (n=130)	32.7% (n=566)	89.3% (n=566)
Societal aspects of synthetic biology	83.7% (n=129)	100.0% (n=129)	43.7% (n=565)	89.7% (n=565)
Applications of synthetic biology	89.8% (n=128)	100.0% (n=128)	39.0% (n=567)	91.0% (n=567)
Facts about synthetic biology	95.3% (n=126)	99.2% (n=126)	39.1% (n=568)	89.9% (n=568)

[6] *Before*: *Facts about synthetic biology*: Mann-Whitney U Test (n=695, U=10831.00, p<.001)
Before: Applications of synthetic biology: Mann-Whitney U Test (n=695, U=12650.50, p<.001)
Before: Societal aspects of synthetic biology: Mann-Whitney U Test (n=694, U=18076.50, p<.001)
Before: What other people think about synthetic biology: Mann-Whitney U Test (n=696, U=23907.00, p<.001)
After: Facts about synthetic biology: Mann-Whitney U Test (n=694, U=20560.00, p<.001)
After: Applications of synthetic biology: Mann-Whitney U Test (n=695, U=21194.00, p<.001)
After: Societal aspects of synthetic biology: Mann-Whitney U Test (n=694, U=24082.50, p<.001)
After: What other people think about synthetic biology: Mann-Whitney U Test (n=696, U=31092.50, p=.002)
[7] *Facts about synthetic biology*: Wilcoxon Signed Ranks (n=126, Z=-4.707, p < .001)
Applications of synthetic biology: Wilcoxon Signed Ranks (n=128, Z=-5.387, p < .001)
Societal aspects of synthetic biology: Wilcoxon Signed Ranks (n=129, Z=-6.548, p < .001)
What other people think about synthetic biology: Wilcoxon Signed Ranks (n=130, Z=-7.995, p < .001)

To supplement the quantitative data above, the survey also asked two open-response questions about learning. These questions allowed respondents to describe their learning in their own words. The first question focused on learning from the forum and the second asked about learning from other participants in the forum. Figure 5 shows the most common results of these two questions, with responses coded by theme. The table provides the frequency for each code within each question, and shares an example quotation for each code. A full table of codes and frequencies—including those with lower counts than shown below—is in Appendix F. The responses from these questions show an overall balance of learning outcomes one might anticipate from a PES activity. Many respondents learned about what other people think (n=308 of 1085 total learning comments). Others learned about scientific content, as summarized in the codes about science/technology (general) (n=285) and applications of science (n=174). Some respondents learned about the nature of science and its interactions with society, as demonstrated in the codes about societal aspects of science (n=74) and complexity of scientific issues (n=71). This suggests that the design of the forum program successfully supported multi-faceted learning for the broad range of participants and sites included in this sample. Given the differences in starting knowledge noted above, this is particularly notable. It may be that offering different types of information allows more people the chance to learn in a certain area, regardless of their starting knowledge.

Figure 5: Nine most frequent forum learning codes and example quotations



Several codes for these open-ended responses were more frequent for one question than the other, suggesting differences in what people were learning through the mutual interactions of the PES activity, versus other aspects of the forum programming (see Table 3). It is unsurprising that more people described learning what others think when responding to the question about learning from other participants (44.5%, n=490) than from overall participation (15.1%, n=595). However, these data show that respondents were also more likely to learn about ways for the public to be involved in science (4.5%, n=490) and policies about science (1.4%, n=490) when responding to the question about learning from other participants than when responding to the question about learning from the forum (3.4% and 0.5%, n=595). These factors—public involvement and policy—both have interpersonal or societal aspects, and these data may suggest that learning about such topics could be enhanced by PES programs that emphasize mutual conversation aspects, such as group interaction during forum programs. On the other hand, programs that want to foster more learning about science content may want to focus on other aspects of the forum format: there was proportionally higher learning about science/technology general (34.5%, n=595 vs. 16.3%, n=490) and current research (4.2%, n=595 vs. 2.4%, n=490) from the question about learning from the forum than from the question about learning from other participants. If there is more interest in raising knowledge about general scientific topics or current research, extending the introductory presentation and self-facilitating program materials could help meet this goal.

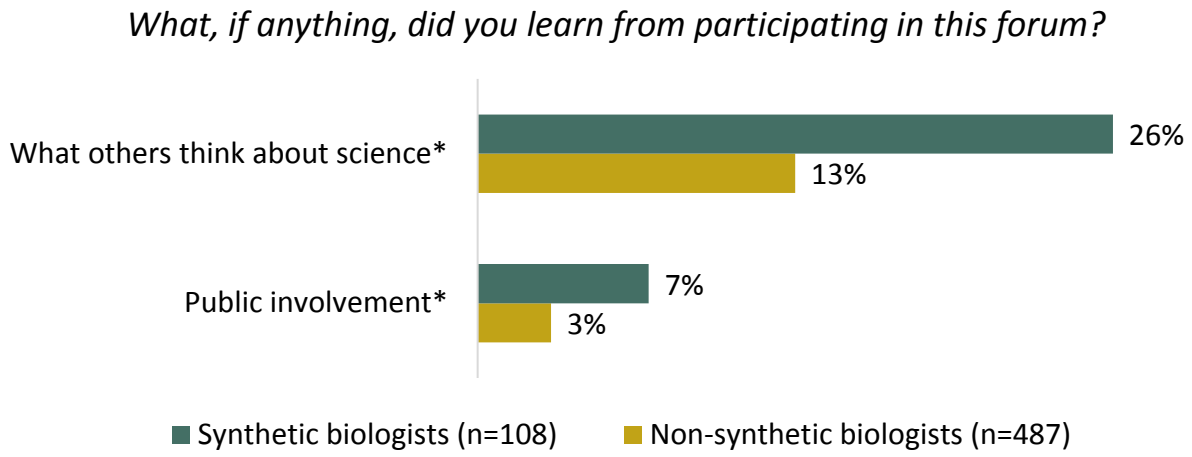
Table 3: Statistically significant differences in the frequency of response types for the two qualitative learning questions

	What, if anything, did you learn from participating in this forum? (N=595)	*What, if anything, did you learn from other participants during this forum? (N=490)*
Code	**Percentage**	**Percentage**
What others think about science*[8]	15.1%	44.5%
Science/technology (general)*[9]	34.5%	16.3%
Public involvement*[10]	3.4%	4.5%
Current research (specific)*[11]	4.2%	2.4%
Policies about science*[12]	0.5%	1.4%

[8] $\chi 2$ (1, n=721) = 13.162, Fischer's Exact 2-tailed p = .001
[9] $\chi 2$ (1, n=721) = 18.254, Fischer's Exact 2-tailed p < .001
[10] $\chi 2$ (1, n=721) = 9.928, Fischer's Exact 2-tailed p = .020
[11] $\chi 2$ (1, n=721) = 16.904, Fischer's Exact 2-tailed p = .007
[12] $\chi 2$ (1, n=721) = 32.816, Fischer's Exact 2-tailed p = .029

Synthetic biologists and non-synthetic biologists typically responded to these questions similarly. However, there were two statistically significant differences in the way these two audiences responded to the question about learning from participating. As shown in Figure 6 synthetic biologists were more likely than non-expert respondents to describe learning about what others think (25.9% compared to 12.7% for non-synthetic biologists) and public involvement (7.4% for synthetic biologists and 2.5% for non-synthetic biologists).[13, 14]

Figure 6: Statistically significant differences in the frequency of response types between synthetic biologists and non-synthetic biologists



Similarly to the quantitative data above, we would expect synthetic biologists to have high levels of knowledge about synthetic biology prior to the forum, but this is further evidence that the forum programs are well designed to offer a wide range of learning experiences for participants with many different backgrounds. When recruiting scientists, it may be valuable to tailor descriptions of the program to emphasize the potential for learning about these factors, like learning others' perspectives and ways the public can be involved in science, as these are outcomes that may be especially likely for scientists, as compared to other participants.

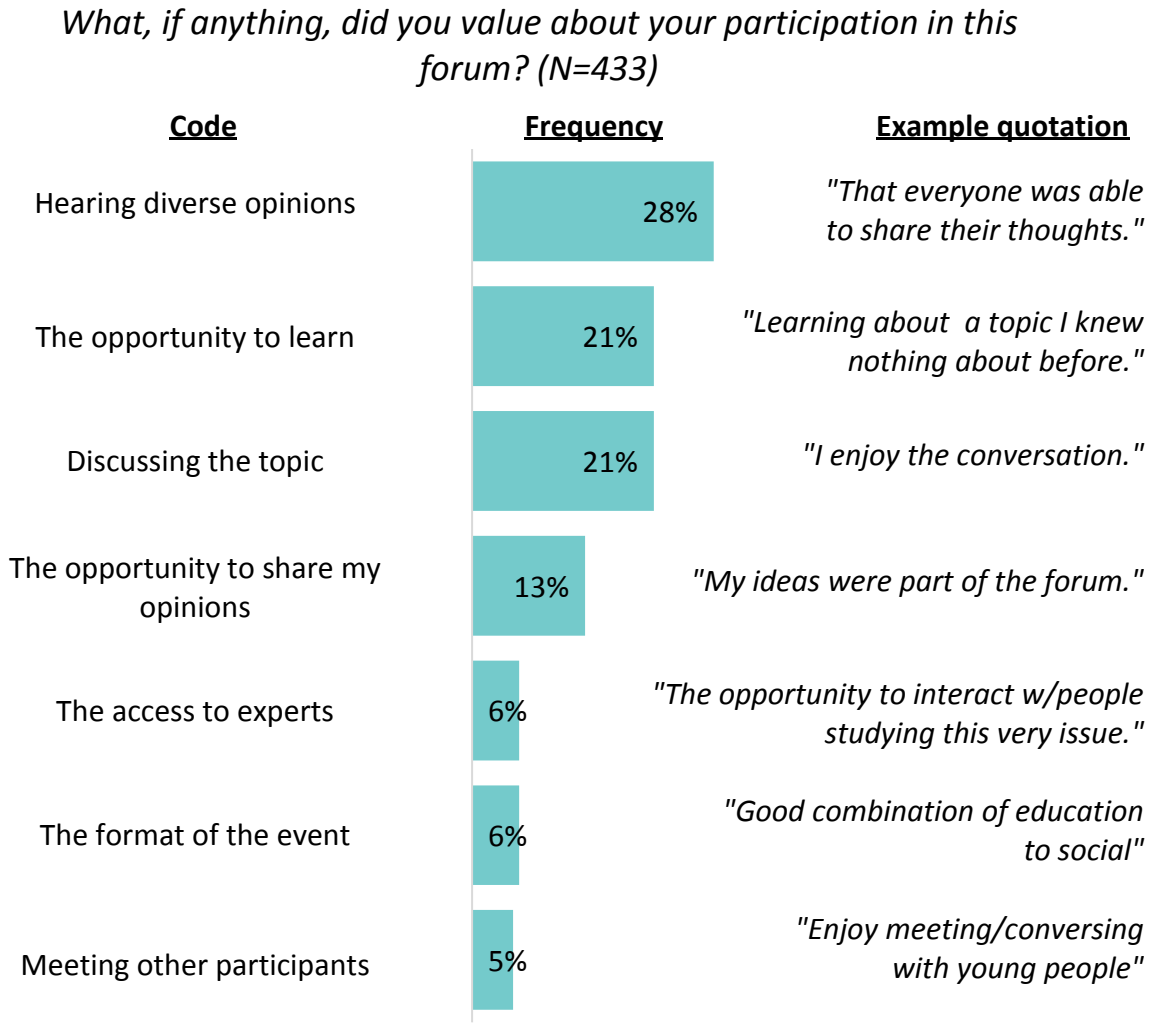
3.3 Forum participants valued hearing diverse opinions, learning, and engaging in discussion.

The survey asked an open-ended question about what respondents valued about their participation in the forum. Similarly to the qualitative data in the previous section, these responses were grouped based on their thematic content. As shown in Figure 7, of the 433 responses the most common themes were that people valued hearing diverse opinions (28.2%), the opportunity to learn (21.2%), discussing the topic (21.2%), and the opportunity to share their opinions (13.2%). These data show that people appreciate a range of things about the

[13] What others think: $\chi 2$ (1, n=595) = 11.988, Fischer's Exact 2-tailed p = .001
[14] Public involvement: $\chi 2$ (1, n=595) = 6.650, Fischer's Exact 2-tailed p = .017

programming, including discussion experiences that promote mutual learning about content, as well as other participants' views.

Figure 7: What forum participants valued



With several exceptions, synthetic biologists and non-synthetic biologists described what they valued in similar ways. One difference was that non-synthetic biologists were more likely to describe valuing the opportunity to learn (23.7% for non-synthetic biologists versus 11.5% for synthetic biologists).[15] In contrast, synthetic biologists were more likely to write that they valued discussing the topic (31.0% for synthetic biologists compared to 18.7% for non-synthetic

[15] $\chi 2$ (1, n=433) = 6.189, Fischer's Exact 2-tailed p = .012

biologists).[16] This demonstrates how experts and non-experts can have a mutually beneficial experience, but that the mutual benefit need not be both parties valuing the same thing. The differences may also have to do with what the different audiences consider "learning." The prior section showed that public audiences were more likely to describe learning content whereas scientists described learning about what others think—similar to what they describe valuing. Thus, both groups might value learning but scientists could be less likely to label their learning (which is less about gaining traditional content knowledge) as learning. PES organizers who recruit scientists might consider using the language of "mutual benefit" and emphasizing of the value of interacting with others, or being clear about the fact that "mutual learning" is inclusive of a broader range of learning than facts about science.

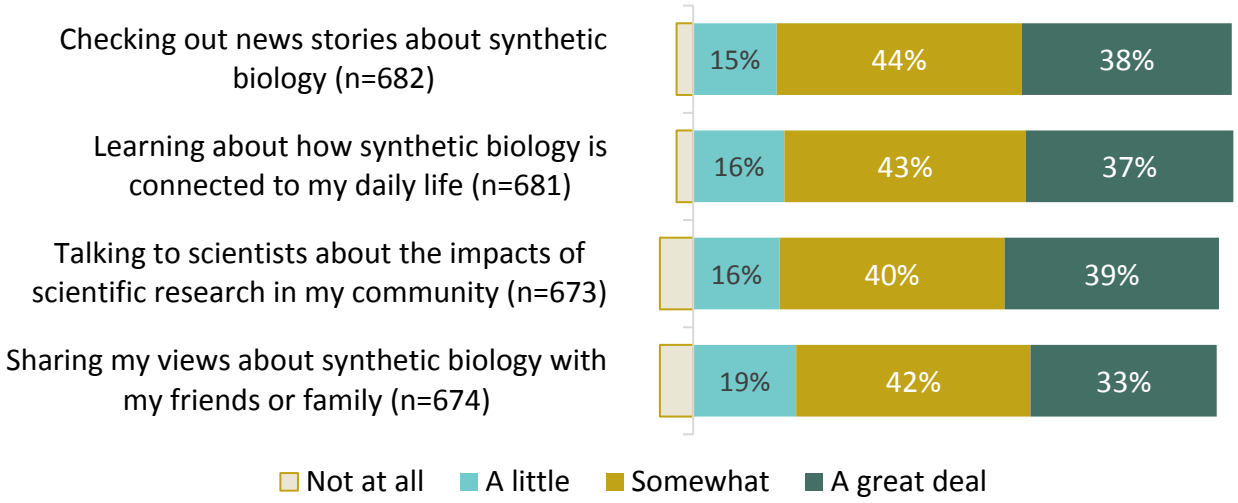
3.4 Forum participants reported increased interest in future behaviors related to synthetic biology, including talking to scientists, future learning, and sharing their views.

To explore the extent to which participants felt the event increased their interest in synthetic biology and related PES activities, the survey asked a multiple choice question about four different actions. Figure 8 shows these results, demonstrating that a majority of respondents felt their interest had increased either "somewhat" or "a great deal" for each of four activities: checking out news stories about synthetic biology (82%, n=672), learning how synthetic biology is connected to my daily life (81%, n=681), talking to scientists about the impacts of scientific research in my community (79%, n=673), and sharing my views about synthetic biology with my friends or family (76%, n=674). While follow-up data collection was not feasible for this project, these data are encouraging in suggesting that participation in a forum increases people's interest in continuing to participate in related activities in the future.

Figure 8: Forum participants' interest in future behavior

[16] $\chi 2$ (1, n=433) = 6.233, Fischer's Exact 2-tailed p = .018

How much did this event increase your interest in the following?



Similarly to the learning question, one might expect that synthetic biologists already had high levels of interest in these actions prior to the forum, and thus would show little change due to their participation. However, the data showed that, in general, the extent of increased interest was comparable for synthetic biologists and non-synthetic biologists. The one exception was increased interest in sharing views about synthetic biology with my friends or family; for this topic, synthetic biologists reported slightly larger gains in interest than respondents who did not identify as synthetic biologists (78.2% vs. 75.0% agree or strongly agree, n=128 vs. n=546).[17] This is another factor that could be emphasized when recruiting scientists: forum programming, and the process of talking about science with the public, may be a positive experience that gets scientists excited about doing more in the future by sharing with their friends and family, and giving them practice about how to do so in a fun and productive way.

[17] Mann-Whitney U Test (n=674, U=30918.00, p=.031)

IV. Public Event Findings

The following pages describe findings about the Building with Biology public events that used the hands-on activities. These events took place in sites across the country in summer 2016. Similar to the forum section, the structure of this section begins with descriptive data about what participants reported that they did during the events. Then, several findings address the evaluation questions below. Unlike the forums—during which scientists and members of the public participated as peers—for the public events, scientists facilitated the activities and members of the public interacted with those facilitators. This section focuses only on the public's experience. Data about the scientist facilitators' perspectives can be found in the summative evaluation report prepared by Rockman et al (Sanford & Quimby, 2017). The evaluation questions that guided this section are:

- *What do publics learn from their PES experiences?*
- *What do publics value about their participation in PES events?*
- *Does participation in a PES event increase public participants' interests in public engagement or science topics?*

To address these questions, the evaluation team trained data collectors at 43 sites to collect paper surveys from adult participants at the public events. The survey was connected to a passport activity, during which participants would track their PES actions as they visited the stations of hands-on activities. Upon completion of their experience with the event, one adult representative of each group was asked to fill out the survey.

The upcoming pages of this report detail four key findings about the public events:

4.1 Participants at Building with Biology's public events activities reported that they enjoyed the events, engaged deeply with hands-on activities and conversations, and had opportunities to learn, share, and consider risks and benefits of synthetic biology.

4.2 Event participants reported learning facts about and applications of synthetic biology, as well as learning about the significance of synthetic biology and societal aspects of science.

4.3 Event participants valued learning, the interactive and kid-friendly format, and access to experts.

4.4 Event participants reported increased interest in future behaviors related to synthetic biology.

4.1 Participants at Building with Biology's public events activities reported that they enjoyed the events, engaged deeply with hands-on activities and conversations, and had opportunities to learn, share, and consider risks and benefits of synthetic biology.

The public events were free-choice learning environments in which participants could engage with as much or as little as they liked. The passport activity that accompanied the data collection effort encouraged visitors to participate in the following activities:

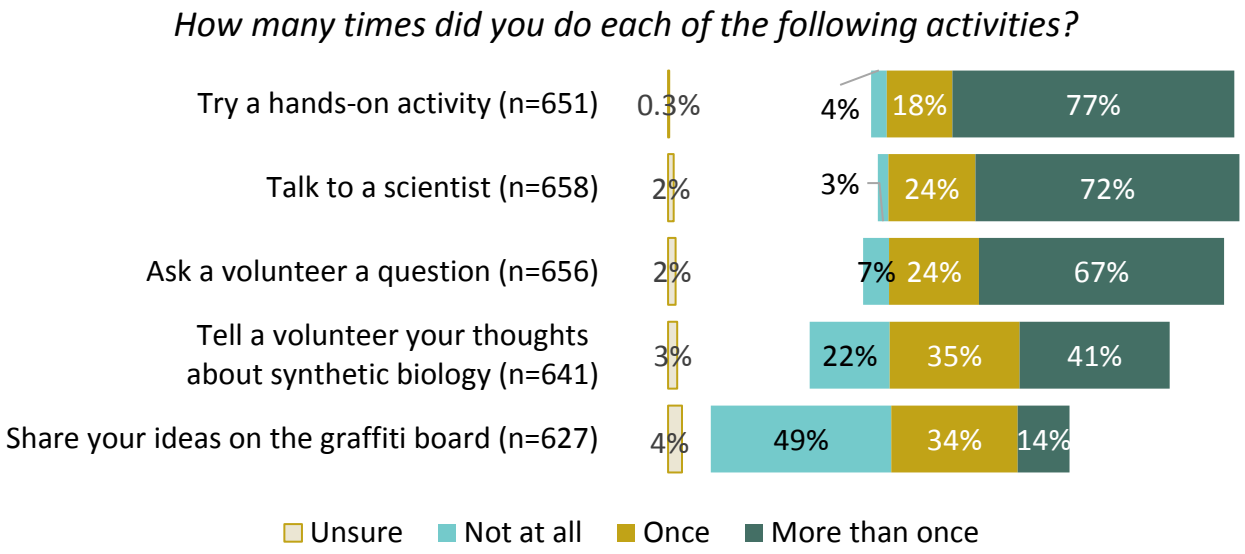
- Talking to a scientist about synthetic biology
- Sharing your ideas about synthetic biology on a graffiti wall
- Finding a volunteer and asking a question about synthetic biology
- Talking to a volunteer about what you like and don't like about synthetic biology

Whenever a visitor did one of these activities, she or he would receive a stamp in the passport book. The evaluation survey asked respondents to report how many times they had done these actions, as well as how many times they tried a hands-on activity. Figure 9 shows the results of this question.

Overall, the data show that respondents had deep levels of participation at Building with Biology events. However, there may be room to encourage more participation in activities that allow visitors to contribute to PES. More than 90% of respondents indicated that they had tried a hands-on activity (95%, n=651), talked to a scientist (96%, n=658), and asked a volunteer a question (91%, n=656). In fact, a majority of respondents reported that they had done each of these activities more than once (try a hands-on activity: 77%, n=651; talk to a scientist: 72%, n=658; and ask a volunteer a question: 67%, n=656). This is encouraging, suggesting that visitors had the opportunity for interactive learning as well as conversations with scientists. While it is possible that the survey reflects response bias, wherein those who were more involved were more likely to take the survey, these data nonetheless suggest a relatively high level of engagement with the Building with Biology event.

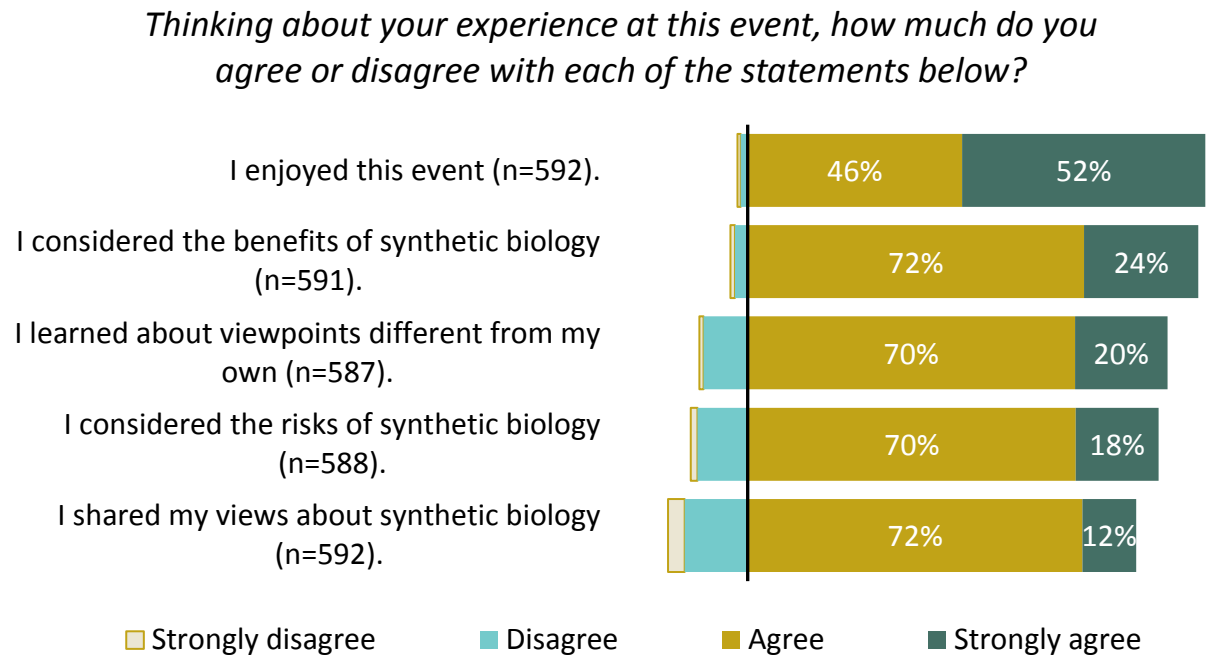
The two least frequent activities were sharing on the graffiti board (48%, n=627) and telling a volunteer your thoughts about synthetic biology (76%, n=641). Factors that might have contributed could be the placement of the graffiti board or the fact that it did not need to be facilitated and thus may have been standing alone without anyone encouraging participation, surrounded by staffed activities that were likely more enticing. The reduced likelihood to contribute extended beyond specific features of the graffiti board, though; nearly one quarter of respondents noted that they had not told a volunteer their thoughts about synthetic biology (22%, n=641).

Figure 9 Public participants' engagement with the event



A second survey question asked about the extent of visitors' enjoyment, learning, sharing, and consideration of synthetic biology's risks and benefits. The results are shown in Figure 10. More than 80% of all respondents agreed or strongly agreed with each of the items: 98% agreed or strongly agreed they enjoyed the event (n=592), 96% agreed or strongly agreed they considered the benefits of synthetic biology (n=591), 90% agreed or strongly agreed they learned about viewpoints different from their own (n=587), 88% agreed or strongly agreed they considered the risks of synthetic biology (n=588), and 84% agreed or strongly agreed they shared their views about synthetic biology (n=592).

Figure 10: Public participants' experiences



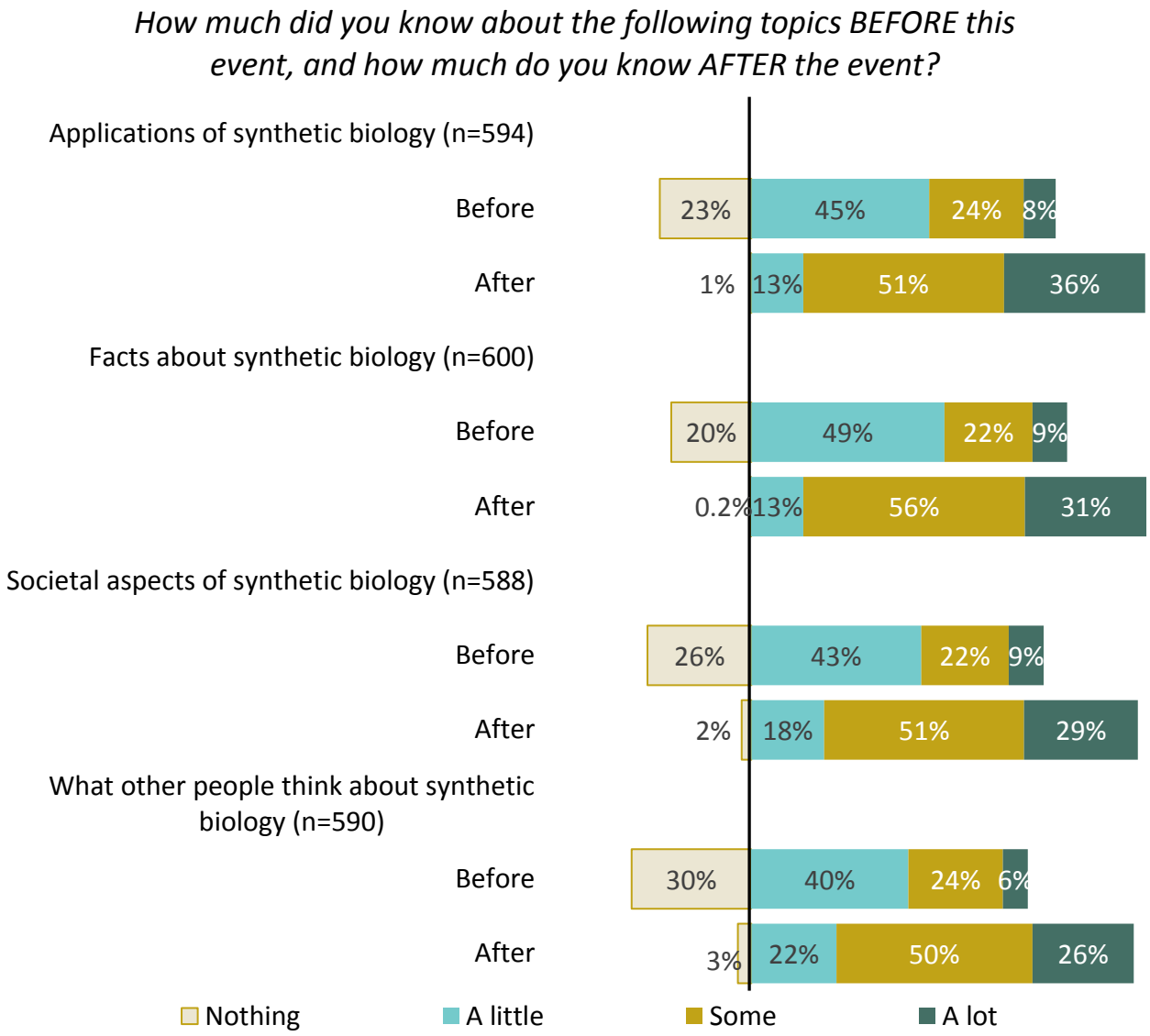
Both of the survey questions in this section show that sharing ideas or views was the action that respondents were least likely to report having done at the event (48% reported sharing their ideas on the graffiti board, n=627; 84% agreed or strongly agreed they had shared their views about synthetic biology, n=592). There may be room to provide additional opportunities to emphasize visitors' contributions to similar PES events in the future. For example, future events could provide additional training to encourage volunteers to ask visitors to share their own opinions. Opportunities for sharing could also be built more fully into the design of the hands-on activities, and event coordinators could consider ways to make sharing opportunities like graffiti boards more enticing. Sharing is particularly important because it is one half of the mutual-learning that distinguishes PES form more traditional public understanding models. While these data show some room for improvement in this area, it is promising that 96% of respondents (n=658) felt they talked to a scientist, which implies some level of contribution to a two-way dialogue. Thus, there is a strong foundation of conversation upon which to build future opportunities to share.

4.2 Event participants reported learning facts about and applications of synthetic biology, as well as learning about societal aspects of science.

Similar to the forum survey, the event survey asked about participants' learning in both qualitative and quantitative fashion. As shown in Figure 11, visitors reported how much they knew about four topics related to synthetic biology prior to the event, and then indicated how much they knew about those same topics after the event. The data from this retrospective pre-

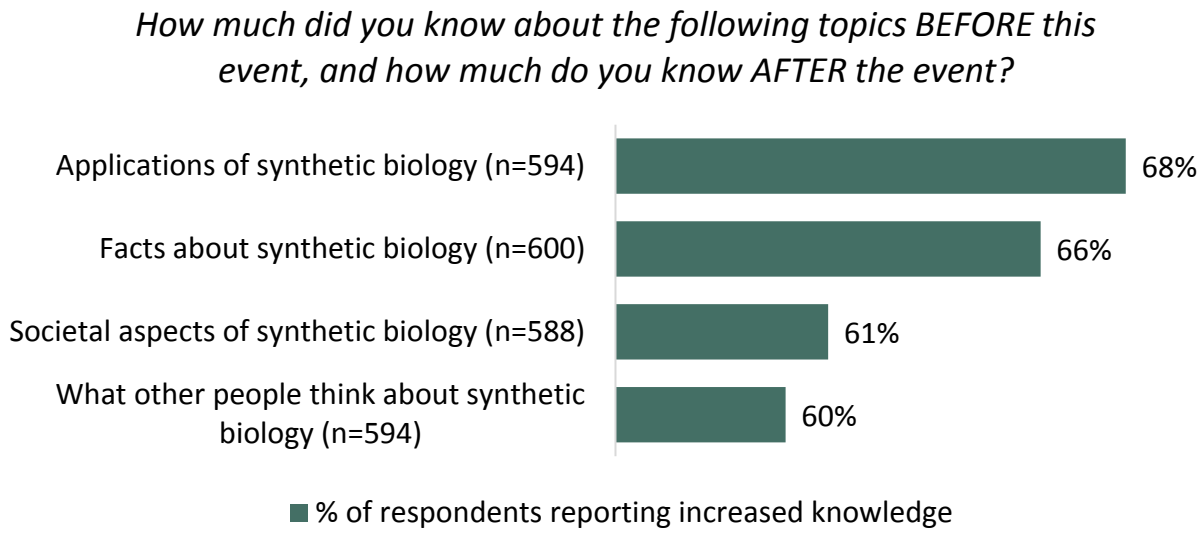
post question demonstrate statistically significant increases for each topic, with people reporting that they knew more about each topic after the event than before. As shown in Figures 11 and 12, change was greatest for applications of synthetic biology. Sixty-eight percent of respondents reported an increase, with the percentage of people reporting that they knew a lot about this topic rising from 8% before the event to 36% afterwards (n=594). This was followed closely by learning facts about synthetic biology, for which 66% reported an increase, with 9% reporting they knew a lot before the event and 31% reporting they knew a lot afterwards (n=600). In addition to learning about synthetic biology and its applications, public participants showed learning gains about aspects of the interplay between science and society. This included societal aspects of synthetic biology—for which61% reported an increase, changing from 9% to 29% of respondents who reported that they knew a lot (n=588)—and what other people think about synthetic biology, for which 60% reported an increase, growing from 6% to 26% of participants reporting that they knew a lot (n=590). This suggests that people were learning about synthetic biology but also experiencing aspects of an authentic PES experience beyond the kinds of topics and one-way transmission of learning that are characteristic of public understanding of science (McCallie et al., 2009).

Figure 11: Event participants' knowledge before and after the event[18]



[18] *Applications of synthetic biology*: Wilcoxon Signed Ranks (n=594, Z=-18.71, p<.001)
Facts about synthetic biology: Wilcoxon Signed Ranks (n=600, Z=-18.61, p<.001)
Societal aspects of synthetic biology: Wilcoxon Signed Ranks (n=588, Z=-18.78, p<.001)
What other people think about synthetic biology: Wilcoxon Signed Ranks (n=590, Z=-18.84, p<.001)

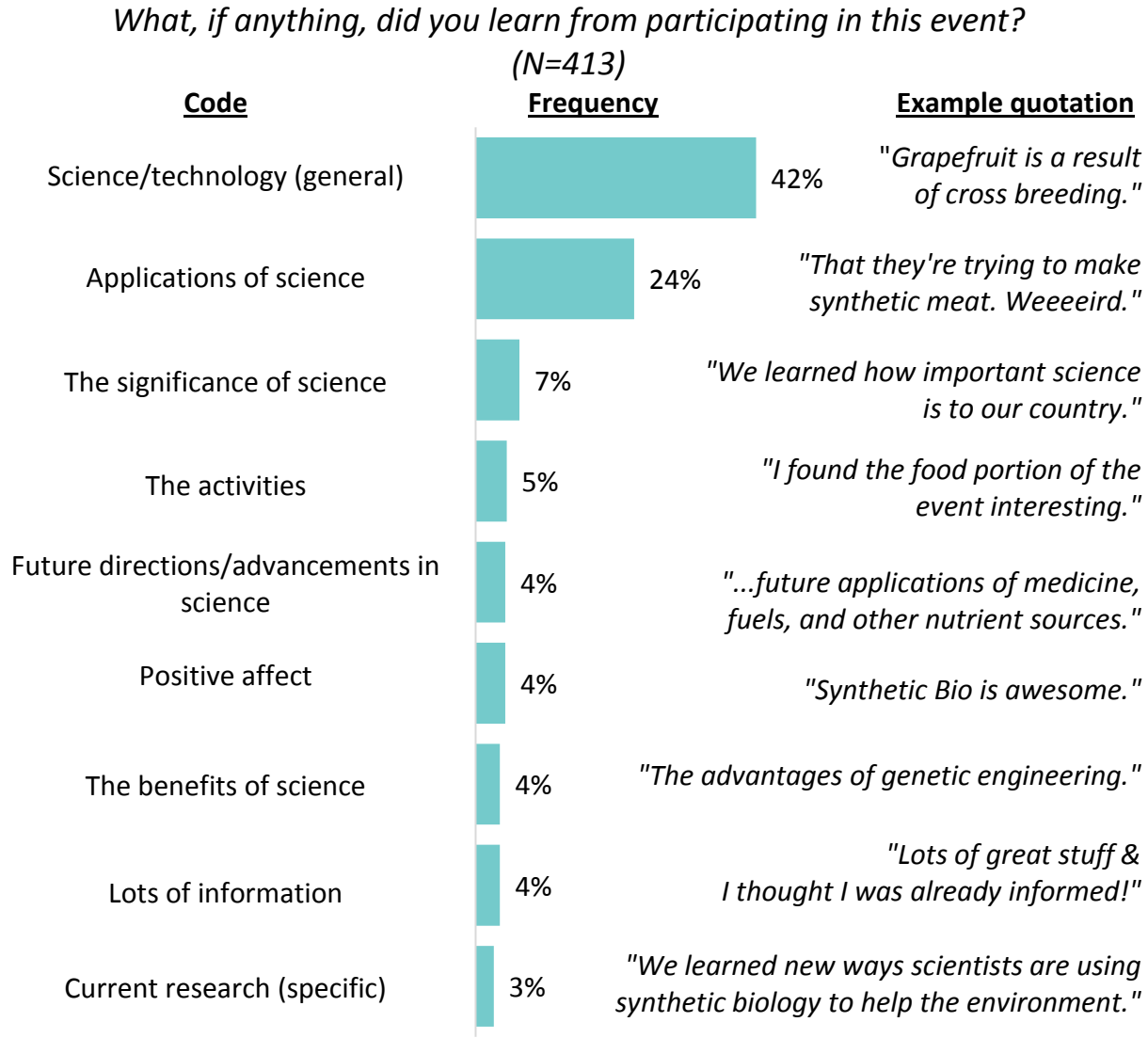
Figure 12: Percentage of event participants reporting increased knowledge



To complement the quantitative data about visitors' learning, the survey included an open-ended question about what visitors learned from the event.[19] Responses were then coded by thematic content, using the same coding scheme that was utilized for the forum data (see Appendix). The most common codes are shown in Figure 13, with example quotations for each. Similar to the quantitative data above, learning facts and applications were most common. This type of learning comprised nearly two thirds of the responses: of the 413 open-ended comments, general responses about science and technology learning were 42% of the responses, and learning about applications of science was present in 24% of the responses. Other content-related responses included learning about future directions or advancements in science (4%), or current research (3%). There was also evidence of learning about societal aspects of science, including learning about the significance of science (7%) and the benefits of science (4%). Other common learning included understanding the specific activities (5%), general positive comments (4%), or learning "a lot" (4%). Frequencies for all codes are provided in Appendix F.

[19] Whereas the forum survey included two open-ended learning questions, the event survey included only one. The question about learning from other participants was only included on the forum survey.

Figure 13: Event participants' learning



Both the quantitative and qualitative data in this section show that participants in the Building with Biology events reported learning from their experiences, and that the topics that they learned about were most often science content and applications, followed by the societal aspects of science. The efforts to have participants learn about synthetic biology seem to have been especially effective at the Building with Biology events using hands-on activities. Further exploration of the affordances of forums and hands-on activities supports this, showing that forums may be best suited to support learning about others' views while hands-on activities may be especially effective at encouraging learning about facts and applications (Todd, Kollmann, Haupt, & Pfeifle, 2017). However, while there were relatively lower levels of learning

about others' views among hands-on activity participants, the quantitative data showed that there were still statistically significant learning increases in what participants reported knowing about what other people think about synthetic biology (60% reporting an increase, n=590) and societal aspects of synthetic biology (61% reporting an increase, n=588). Thus, each PES type has affordances but both can be effective at supporting multiple kinds of learning.

4.3 Event participants valued learning, the interactive and kid-friendly format, and access to experts.

Data from the section about participation in the hands-on activities (see page 34) showed that people enjoyed the events (98% agreed or strongly agreed, n=592). In addition to that enjoyment, the event survey asked respondents to describe in their own words what they found valuable about their participation in the event. The results are shown in Figure 14. Of the 301 open-ended responses, more than one fourth of the responses described valuing the opportunity to learn (29%). The next most common codes, with 18% of responses each, were valuing the interactive or fun experience; the great experience for kids; and access to experts.

Figure 14: Aspects of the event that participants found valuable

What, if anything, did you value about your participation in this event? (n=301)

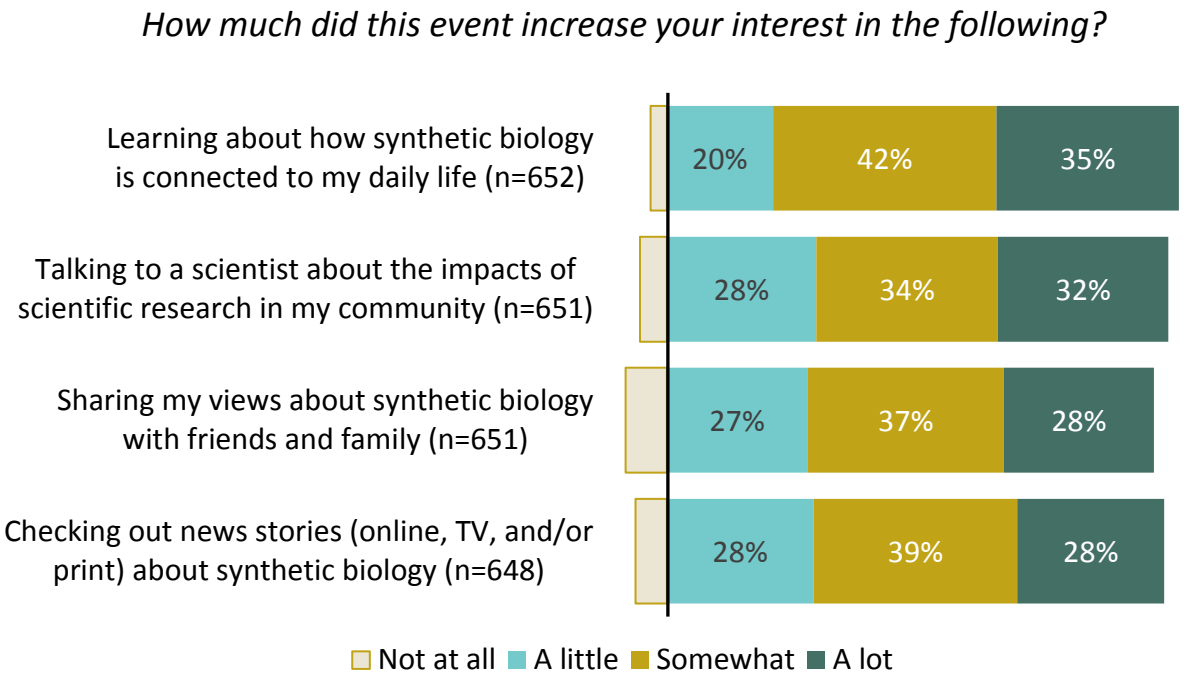
Code	Frequency	Example Quoatation
The opportunity to learn	29%	*"I learned about how syn bio would affect my daily life."*
The interactive/fun experience	18%	*"I loved the hands-on activities that helped illustrate the concepts of DNA and viruses."*
The great experience for kids	18%	*"It was very engaging for kids."*
The access to experts	18%	*"Talking to [an] actual scientist."*
The format of the event	8%	*"The fact that you were able to teach lessons creatively in an appealing and kinetic manner."*
The topic of synthetic biology	7%	*"How many ways it's being used - not just farm and meds."*
Other	4%	*"I like to see other people excited about synthetic biology."*
Discussing the topic	4%	*"A great way to open discussion with kids."*
Nothing	4%	*"N/A."*

These data about respondents' values align with data about learning, and show patterns across the forum surveys and hands-on activity surveys. The prior section noted that hands-on activity respondents frequently reported learning content (facts and applications of science), and the values data here show that aspects of the event associated with that content learning—including overall learning (29%, n=301) and access to experts (18%, n=301)—were among the most valuable aspects of the overall experience. In contrast, forum respondents who were more likely to learn about others' views were more likely to value aspects of the event that promote learning about others' views, such as hearing diverse opinions (28%, n=433 for forums vs. 2%, n=301 for hands-on activities) and discussing the topic (19%, n=433 for forums vs. 4%, n=301 for hands-on activities). The alignment of learning and values is encouraging in that participants are most valuing what they are most learning. Differences between hands-on activities and forums suggests that the two event types have distinct affordances, which can be leveraged based on event planners' goals. For example, 18% of the responses about what hands-on activity participants valued were about the kid-friendly nature of the event (n=301). Forums are generally unsuitable for young children, so if event planners wish to host families, hands-on activities are a good choice that these groups can find valuable.

4.4 Event participants reported increased interest in future behaviors related to synthetic biology.

Evaluators were interested in knowing how participation in the hands-on activities might influence future behavior. One survey question asked about four different actions related to PES and synthetic biology, having people report how much the event increased their interest in those actions. As shown in Figure 15, more than 65% of respondents indicated that they were "somewhat" or "a lot" more interested in each action: 77% reported their interest in learning about how synthetic biology is connected to daily life increased "somewhat" or "a lot" (n=652); this proportion was 66% for increased interest in talking to a scientist about the impacts of scientific research in my community (n=651); it was 65% for sharing my views about synthetic biology with friends and family (n=651); and the percentage was 77% for checking out news stories about synthetic biology (n=648).

Figure 15: Event participants' interest in future behavior



Discussion and Conclusion

While the prior sections describe forum and event data separately, the following pages reflect on the findings as a whole, describing the overall impacts that the Building with Biology project had on participants. These reflections are organized by the themes of the evaluation questions about what people learned, what they valued about their experience, and how participation affected their interest in synthetic biology-related activities.

Overall findings include:

1. Learning: Forum and event participants learned facts about, applications of, and societal implications of synthetic biology.
2. Values: The Building with Biology events—including both forum programs and hands-on activities—successfully fostered authentic PES engagement that participants found valuable and enjoyable.
3. Interest: Building with Biology participants in both the forums and events reported increased interest in future behaviors related to synthetic biology.

1. Forum and event participants learned facts about, applications of, and societal implications of synthetic biology.

All types of participants in Building with Biology events—including forum attendees, those who interacted with hands-on activities, scientists, and non-scientist members of the public—reported increased levels of learning. One notable finding is that the learning was not restricted to content knowledge such as basic facts about synthetic biology. Although learning about facts and applications was prevalent,[20] participants also reported learning about what other people think, societal aspects of synthetic biology, the complexity of scientific issues, and the significance of science in today's world. This is consistent with data from other evaluations of forums (Flagg & Knight-Williams, 2008; Kollmann & Goss, 2011, Kollmann, Reich, & Lindgren-Streicher, 2009). It is encouraging that Building with Biology participants gained this type of learning in the forums and hands-on activities; as shown in Table 4, these factors are closer to PES than public understanding of science on the spectrum of content foci between these two types of learning.

[20] In responding to an open-ended question about what, if anything, you learned from participating in this [forum/event], 35% of forum respondents and 42% of event respondents described learning facts about science or technology and 23% of forum participants and 24% of event participants described learning about the applications of science (n=595 for forum responses and n=413 for event responses.)

TABLE 4. Three dimensions of public understanding and public engagement with science (Adapted from McCallie et al. 2009).

	Content focus of the project	Audience involvement in the project	Expert involvement in the project
Public Understanding of Science	Understanding of the natural and human-made world	Learning from watching, listening, and viewing lectures, media, exhibits, etc.	Experts serve as advisors and provide input to the project
↕	The nature of the scientific/ engineering process or enterprise	Asking questions of experts and interactive inquiry learning	Experts actively present their expertise to the public
↕	Societal and environmental impacts and implications of STEM	Consultation and sharing views and knowledge among participants and experts	Experts work to become skilled and informed communicators
↕	Personal, community, and societal values related to STEM applications	Deliberation with other participants and group problem solving	Experts welcome and value participant inputs and direction
Public Engagement with Science	Institutional priority or public policy change related to STEM	Participants produce recommendations or reports	Experts act on participant input and direction

The forum surveys were collected from all forum participants, capturing perspectives from both public audiences and scientists. Both audiences reported positive learning. Scientists had higher initial levels of knowledge about synthetic biology than did public respondents (see pages 22-23 for details). However, the scientists still showed statistically significant learning gains in the quantitative data, and in an open-ended question about what they learned from participating, scientists were more likely than public respondents to describe learning what others think about synthetic biology (25.9% vs. 12.7%, n=595) and how the public can be involved in science (7.4% vs. 2.5%, n=595).

2. *The Building with Biology events—including both forum programs and hands-on activities—successfully fostered authentic PES engagement that participants found valuable and enjoyable.*

The data show that people valued their Building with Biology experiences, whether they interacted with hands-on activities or forum programs. In terms of overall enjoyment, 98% of respondents to both the event (n=592) and forum survey (n=711) agreed or strongly agreed that they enjoyed the event. This is highly encouraging, especially since the type of interactive PES experiences this project provided can be different from what visitors expect when coming to an informal science education institution. It is also positive that both types of learning experiences, despite the differences in their format, were enjoyable. This could suggest that

marketing attracted appropriate audiences for each program and that the materials were designed in such a way that they were suitable for those who participated.

In addition to enjoyment, survey respondents indicated that they valued many aspects of their experiences. In an open-ended question about what they valued about the event, both forum and event survey respondents often described valuing the learning that they had gained through their experiences (21% of forum respondents, n=433; 29% of event respondents, n=301). Forum respondents also reported valuing core components of discussion-based programming, including hearing other participants' diverse opinions (28%, n=433), discussing the topic (21%, n=433), and sharing their own opinions (13%, n=433). Those who had interacted with hands-on activities tended to value the interactive and fun nature of the events (18%, n=301), the kid-friendly activities (18%, n=301), and access to experts (18%, n=301). Differences between scientists and public audiences were that scientists more often reported that valued the opportunity to discuss the topic (31.0% vs. 18.7%, n=433), public participants were more likely to value learning (23.7% vs. 11.5%, n=433). Many of the aspects that respondents valued align well with the definition of Public Engagement with Science, which encourages learning, sharing, discussing, and interaction between publics and scientists. This suggests that Building with Biology was successful in promoting the types of engagement it intended to provide around mutual engagement and learning between publics and scientists, and that many people recognized and valued these interactions.

3. Building with Biology participants in both the forums and events reported increased interest in future behaviors related to synthetic biology.

This project assessed participants' reported interest in future behaviors related to PES and synthetic biology. Both forum and event survey respondents indicated that their participation increased their interest in the four future actions included on the survey: (1) learning about how synthetic biology is connected to daily life,[21] (2) talking to a scientist about the impacts of scientific research in my community,[22] (3) sharing my views about synthetic biology with friends and family,[23] and (4) checking out news stories about synthetic biology.[24] For each of these items, more than 65% of event and forum participants reported that their interest had

[21] 81% of forum respondents (n=681) and 77% of event participants (n=652) indicated that their interest increased "somewhat" or "a great deal."
[22] 79% of forum respondents (n=673) and 66% of event participants (n=651) indicated that their interest increased "somewhat" or "a great deal."
[23] 76% of forum respondents (n=674) and 65% of event participants (n=651) indicated that their interest increased "somewhat" or "a great deal."
[24] 82% of forum respondents (n=672) and 77% of event participants (n=648) indicated that their interest increased "somewhat" or "a great deal."

increased "somewhat" or "a great deal." Compared to public participants, scientists at the forums more often reported increased interest in sharing their views about synthetic biology with friends and family.[25]

Opportunities for future work

The results of this evaluation are overall very positive. When looking forward towards areas of future study, there are a few possibilities for follow-up projects and studies:

- ***Continuing to promote PES content and participant involvement***: Table 4, above, describes three aspects of interaction on a spectrum from public understanding of science to public engagement with science: content focus, audience involvement, and expert involvement. The Building with Biology project made deliberate choices to move away from the side of the spectrum that is characteristic of public understanding of science, which resulted in many outcomes that are reflective of authentic PES experiences. There are also areas where future projects could continue to move farther on the spectrum towards PES. For instance, a future project might include content that more heavily focuses on public policy change related to STEM; hands-on activities might be able to provide opportunities for participants to provide recommendations; and next initiatives might design PES activities with scientists to ensure that participants' input can be directly applied by the scientists. While these are areas for potential next steps, some of these aspects might be difficult to achieve on a scale as large as the current project, as policy conversations and scientist co-creation may work best at a local level.
- ***Ways to contribute***: Both forum and event survey respondents more strongly agreed that they learned from the event than that they shared their own views.[26] The differences are not large, and the majority of respondents do agree or strongly agree that they shared their views (91%, n=702 for forums and 84%, n=592 for public events), but this trend is something to watch for in future projects. It is also notable that, in comparing scientists and public participants' responses to the question about sharing on the forum survey, the scientists were statistically significantly more likely to feel that they had shared during the experience (94.6%, n=130 for scientists vs. 89.7%, n=572 for publics). Having similar levels of sharing between publics and scientists may be a difficult balance to achieve, since scientists often come to these events with more topical knowledge. PES organizers have previously noted difficulties in preventing scientists

[25] 78.2% of scientists reported an increase (n=128) and 75.0% of public participants reported an increase (n=546).
[26] Among forum respondents, 46% strongly agreed that they learned about viewpoints different from their own (n=709) compared to 38% who strongly agreed they shared their views about synthetic biology (n=702). For public event participants, 20% strongly agreed they learned about viewpoints different from their own (n=587) compared to 12% who strongly agreed they shared their views about synthetic biology (n=592).

from dominating conversations. Facilitation techniques and scientist training may help with this challenge.

- ***Measuring different learning types***: Future researchers and evaluators of PES who are interested in assessing learning could benefit from the comparison between this study's two open-ended learning questions on the forum survey. The survey asked both, "What, if anything, did you learn from participating in this forum?" and, "What, if anything, did you learn from other participants during this forum?" There were differences between the responses to these two questions: responses to the first question included more comments about factual learning, and responses to the latter tended to be more suggestive of learning about others' thoughts and opinions. It may be that people naturally think of learning facts when they are asked about learning broadly, and are unsure as to whether learning about other PES outcomes applies to the question. Crafting questions that accurately gather the desired types of responses will be important for future PES evaluation.

Overall reflections

The Building with Biology project brought PES activities to nearly 200 informal science education sites around the country, making it one of the largest initiatives of its kind to date. Several groups investigated this project through data collection efforts, including the current study produced by internal evaluators, a summative evaluation by Rockman et al, and a research study by Drs. Gretchen Gano and Mahmud Farooque. To understand the full outcomes of the project for all of the involved audiences requires one to consider all three of these studies.

This report affirms that PES is promising in the outcomes that it can produce, and also complex in the interactions between scientists and publics that it entails. There are many opportunities to continue learning from this type of programming, and to continue generating benefits for multiple audiences, bridging fields, and promoting learning that values all people as stakeholders in the scientific enterprise that is inextricably connected to our society.

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Appendix A: Event survey

Data Collector Initials: _____ Survey Number: _____ Site Name: _____ Time: _____

Building with Biology Survey

Are you 18 or older? If so, please tell us about your experience!
Participation is voluntary. All responses are anonymous.

1. How many times did you do each of the following activities? (Please check)

	Not at all	Once	More than once	Unsure
Talk to a scientist	☐	☐	☐	☐
Ask a volunteer a question	☐	☐	☐	☐
Share your ideas on the graffiti board	☐	☐	☐	☐
Tell a volunteer your thoughts about synthetic biology	☐	☐	☐	☐
Try a hands-on activity (drawing, playing a game, etc.)	☐	☐	☐	☐

2. What, if anything, did you learn from participating in this event?

3. How much did you know about the following topics BEFORE the Building with Biology event, and how much do you know AFTER the event? (Check one 'BEFORE' and one 'AFTER' for each topic)

	BEFORE the event, I knew…				AFTER the event, I know…			
	Nothing	A little	Some	A lot	Nothing	A little	Some	A lot
Facts about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Applications of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Societal aspects of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
What other people think about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐

4. How much did this event increase your interest in the following? (Please check)

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology	☐	☐	☐	☐
Learning about how synthetic biology is connected to my daily life	☐	☐	☐	☐
Talking to a scientist about the impacts of scientific research in my community	☐	☐	☐	☐
Sharing my views about synthetic biology with friends and family	☐	☐	☐	☐

5. Thinking about your experience at this event, how much do you agree or disagree with each of the statements below? (Please check)

	Strongly disagree	Disagree	Agree	Strongly agree
I shared my views about synthetic biology.	☐	☐	☐	☐
I considered the benefits of synthetic biology.	☐	☐	☐	☐
I considered the risks of synthetic biology.	☐	☐	☐	☐
I learned about viewpoints different from my own.	☐	☐	☐	☐
I enjoyed this event.	☐	☐	☐	☐

6. What, if anything, did you value about your participation in this event?

7. What is your age and gender? If applicable, what are the ages and genders of your group members? (Fill in the table below)

	Example	YOU (person filling out this survey)	Additional group members (if applicable)			
			1	2	3	4
Gender (write in)	Female					
Age (write in)	52					

Even if you're new to the ideas in synthetic biology, your opinions can shape the development of its tools and applications. The next questions are from scientists who want to know what you think!

8. What applications of synthetic biology would you like scientists and engineers to work on? (Please check all that apply)

☐ Agriculture ☐ Fuel ☐ Software

☐ Electronics ☐ Medicine ☐ Other: _____

☐ Food ☐ Personal Care ☐ None of the above

9. How might synthetic biology change our lives?

10. What question would you most like to ask a scientist about synthetic biology?

Appendix B: Evaluation of Public Impacts Data Collection Guidelines

Evaluation of Public Impacts Data Collection Guidelines

Introduction

The purpose of this evaluation is to understand what public visitors over the age of 18 learn from the Building with Biology hands-on activities and what they find valuable about their participation. We have selected 50 sites to participate in this evaluation. The Building with Biology Evaluation Team will provide these sites with a box of evaluation materials, evaluation support, and training for one data collector from each site. This person will be responsible for collecting paper surveys from adult visitors at the end of a passport activity and sending the public evaluation data to the Evaluation Team electronically and by mail. The Evaluation Team will then analyze the data and send you an individual report about what your visitors learned and valued. At the end of the evaluation period, the Evaluation Team will also offer a webinar to share findings from all evaluation cohort participants.

NOTE: This document was prepared for sites that have been selected as participants in the Building with Biology public event evaluation. Nearly twice as many sites expressed interest in this evaluation as we were able to accommodate. If you are interested in evaluation but were not selected to be a part of the evaluation cohort, you are still welcome to use the protocols, attend the professional development opportunities, and use the surveys that the Evaluation Team has created. These resources are available at www.buildingwithbiology.org/project-evaluation.

Unfortunately, the Evaluation Team will not be able to send physical materials or analyze data for sites that were not selected to be part of the evaluation cohort. **Please do not mail us your data if you have not been selected as an evaluation site.**

This document outlines the details of the evaluation process, including:

- The data collector's responsibilities
- The support you will receive from the Evaluation Team
- Details about the evaluation materials
- Information about the data collection process
- How to prepare for your event

At the end of this document you will find a *Building with Biology Public Evaluation Overview* section that includes a checklist of action items for the evaluation and recruitment scripts.

The evaluation data collector

For the purposes of this evaluation, you will need to select *one person* who is responsible for five tasks. This person will need to devote the full duration of the event to evaluation tasks, so she or he should NOT be responsible for coordinating the full event or managing volunteers.

NOTE: If you are using your hands-on activities with the public on multiple days, the data collector only needs to collect data on one day (although you're welcome to do more).

The data collector is responsible for:

- ***Completing human subjects training***: The evaluation data collector needs to provide the Building with Biology Evaluation Team with a current copy of a completion certificate for a human subjects training course administered by either the National Institutes of Health (NIH) or the Collaborative Institutional Training Initiative (CITI). If the designated person has already completed this training, she or he can send an existing copy of the completion certificate. If the person does not have a current certificate of completion, she or he must take the free, 2-hour online course from the NIH, accessible at https://phrp.nihtraining.com/users/login.php. Completion certificates must be sent to Sarah Pfeifle at spfeifle@mos.org at least one week prior to your forum.
- ***Attending the Building with Biology public evaluation webinar***: The Building with Biology Evaluation Team will host an online webinar about this evaluation. While we hope the data collector will attend this webinar live, we understand that scheduling can be a challenge. If the data collector is unable to attend, we ask that she or he watch the recording of the webinar and speak with his or her Evaluation Team contact. The webinar will be Tuesday, June 14 at 1:00-2:00 ET. To learn more and register for the

webinar, visit: http://www.surveygizmo.com/s3/2736656/Evaluating-the-Public-s-Experience-at-Building-with-Biology-Events

- ***Watching the Building with Biology evaluation video***: The Building with Biology Evaluation Team is producing a short video that summarizes data collection practices. In addition to attending the webinar, the data collector should watch this brief video. A link to the video will be emailed to you, and it will be available on www.buildingwithbiology.org/project-evaluation.
- ***Collecting data at the event***: This document provides additional detail about data collection, which will consist of a passport activity and collecting paper surveys from visitors at the end of their Building with Biology experience. The person collecting data should be able to devote complete attention to the evaluation for the duration of the event. If your site is hosting multiple events, you only need to collect data on one day.
- ***Mailing the collected data to the Evaluation Team***: After the event, the data collector will need to send all data to the Building with Biology Evaluation Team so the Team can analyze and report on the data. First, the data collector should scan or take a picture of: (1) paper surveys and (2) responses on your graffiti board. Digital files should be sent to Sarah Pfeifle at spfeifle@mos.org. Then, the data collector should place the surveys and worksheets in the addressed, pre-paid mailing envelope included in your evaluation materials and ship the envelope to the Museum of Science at the following address:

  Sarah Pfeifle
  Research & Evaluation Department
  Museum of Science, Boston
  1 Science Park
  Boston, MA 02114

If it is not feasible for all of these items to be completed by the same person, please speak with your Evaluation Team contact. It may be possible to share roles in a different way. The Evaluation Team will need a human subjects training certificate for all people collecting data.

Support from the Building with Biology Evaluation Team

Each site will have a designated contact from the Building with Biology Evaluation Team who will provide assistance throughout this evaluation. At this point, you should have received an email identifying your Evaluation Team contact. Please feel free to reach out to this person with any questions you have about the evaluation. Evaluation contacts include:

Elizabeth Kollmann	Sarah Pfeifle	Katie Todd	Gretchen Haupt
ekollmann@mos.org	spfeifle@mos.org	ktodd@mos.org	ghaupt@smm.org
617-589-0467	617-589-0202	617-589-4235	651-312-1757

You may also contact Elizabeth Kollmann, the Evaluation Team leader, should you have any issues or concerns with the evaluation study.

Materials

This evaluation depends on your use of specific supplies. Some of these supplies are included in your main Building with Biology kit. Others are in a separate box of evaluation materials. We also ask that you gather some pens and pencils at your site that visitors can use to fill out their surveys. The full list of materials you will need for the evaluation is printed below.

From your Building with Biology kit:

- 100 Event Passports (You can print additional copies at: http://bit.ly/BwBPassport)
- Marker stamps – 1 for each station
- "I'm a scientist" stickers
- Temporary tattoos
- Graffiti board
- Graffiti board sign stand (NOTE: you will replace the sign from your kit with a new one we provide in the evaluation box)

From your evaluation box:

- 20 *Building with Biology Surveys* (You may print more at: http://bit.ly/BwBsurvey)
- *Evaluation Surveys Envelope* for completed surveys
- Passport Station sign and sign stand
- Graffiti board sign (place this in the stand from your kit, replacing the sign from your kit)
- 25 *Evaluation Information* cards
- Pre-paid mailing envelope addressed to the Museum of Science

For you to gather at your site:

- Pens or pencils for survey completion
- Clipboards (optional)

NOTE: Your evaluation kit includes a sign to go with your graffiti board. This sign has consent language on it to let your visitors know that you will be collecting their responses. You will need to use this sign rather than the sign included in your Building with Biology kit, which does not have consent language printed on it.

NOTE: We provide 20 surveys in your evaluation box, and we hope you will be able to get 20 visitors to complete them. You are welcome to print more surveys from http://bit.ly/BwBsurvey if you would like. This would provide your site with more data for your individualized report, which will help you better understand your visitors' experiences. However, collecting more than 20 surveys is optional.

About the passports

This evaluation depends on your use of a passport activity that is included in your Building with Biology kit. The passport activity provides structure for the evaluation: once visitors complete the activity, they return to the Passport Station where they got their passports to fill out a paper survey (if they are adults) and receive a small giveaway (the temporary tattoos).

The Building with Biology passports are designed to encourage visitors to engage with the hands-on activities and talk with your volunteers. Visitors are encouraged to collect as many stamps as they can by asking activity facilitators to stamp their passports each time the visitors complete one of four actions:

1. **Talk to a scientist** about synthetic biology
2. **Share your ideas** about synthetic biology on the graffiti board *(Note: please use the graffiti board in your kit and make sure you have a volunteer at that station!)*
3. Find a volunteer and **ask a question** about synthetic biology
4. Talk to a volunteer about what you **like and don't like** about synthetic biology

NOTE: The passport does not include language prompting visitors to return at the end of their experience, so it is crucial that the person introducing and distributing the passports tells the visitors to come back when they are finished in order to fill out the survey (for adults only) and receive a temporary tattoo. The *Passport Introduction Script*, below, is for this purpose.

Your Building with Biology kit includes 100 passports. If you would like additional passports, they can be printed from the following link: http://bit.ly/BwBPassport

The passports in your kit are un-folded. To create a nice booklet, the sheets need to be folded top to bottom and then left to right so the stamp pages are inside. You can either do this ahead of your event or ask your visitors to do it themselves when they pick up their passports.

Preparing for your event

To make your evaluation run smoothly, it is important to prepare your volunteers for the passport activity and set up your materials before visitors arrive. The following sections guide these preparations.

Volunteer orientation

At your volunteer orientation, you will need to tell volunteers about the passports and prepare them to stamp visitors' passports. We recommend having sample passports and markers on hand to show the volunteers during the orientation. A PowerPoint presentation slide about the passports is included in the orientation PowerPoint provided in your kit.

Each volunteer will need to be prepared to stamp visitors' passports if:

- Visitors **ask a question** about synthetic biology
- Visitors tell the volunteer what they **like and don't like** about synthetic biology

Let volunteers who are scientists know that they will be asked to wear "I'm a scientist" stickers at the event. These volunteers should be ready to stamp passports if:

- Visitors **talk to the scientist** volunteer about synthetic biology

Make sure the graffiti board will be facilitated during the event, as this activity is included in the passport. The volunteer(s) at the graffiti board will need to stamp passports if:

- Visitors **share their ideas** about synthetic biology on the graffiti board

If you have staff members or other people facilitating activities who will not be attending your Building with Biology orientation, make sure to train them about how to stamp passports.

Setup at the event

Prepare for your data collection by setting up your space with all the materials you will need. Before your visitors arrive, make sure every activity station has a stamp marker, and make sure every volunteer or staff facilitator knows to stamp visitors' passports. Give "I'm a scientist" stickers to scientists who are facilitating activities and ask them to wear the stickers visibly. While we do not require you to use all of the activities in the Building with Biology kit, make sure to use the graffiti board, and ensure that the activity will be facilitated by a volunteer who is trained to stamp passports for visitors who complete the activity. **The graffiti board is connected to the passport, and collecting visitors' responses from the graffiti board is part of this evaluation.**

When setting up the graffiti board, make sure you have both the poster and the sign stand. **You will need to replace the graffiti board sign that came with your Building with Biology kit. Please use the sign that was included in your evaluation box, instead of the one from your kit.**

The version of the sign in your evaluation box includes consent language to tell your visitors that their responses will be collected.

To set up the Passport Station, find a location where you can offer passports to visitors as they enter the Building with Biology space and where they can return to fill out a survey and get their takeaway. Display the Passport Station sign visibly using the sign stand in your evaluation box. Make sure the Passport Station has your passports at it. We recommend folding the passports ahead of time so they are ready for use. Alternatively, your visitors can fold the passports as part of their activity. Ensure that your Passport Station has *Building with Biology Surveys*, pens or pencils, the *Evaluation Surveys Envelope* that you will use to store completed surveys, *Evaluation Information* cards that you can give to visitors who have questions about the evaluation, and the temporary tattoos from your kit that you can use as take-away prizes for visitors. If you have clipboards, you can have visitors use them to fill out their surveys.

The Passport Station

You will need to set up a Passport Station at your event where you will distribute passports and collect surveys. The ideal location for the Passport Station would be near both the entrance and exit of the Building with Biology area. We recognize that not all sites are set up such that this is possible, but we hope you will do your best to find a location where visitors will receive their passports at the beginning of their experience and have a flowing path by which they return to complete a survey. Please feel free to discuss your setup with your Evaluation Team contact.

Data collection using the passport activity

Distributing passports

As people arrive at the event, use the *Passport Introduction Script* (see below) to introduce visitors to the activity. This Script encourages visitors to return to the Passport Station when they are done in order to complete a survey (if the visitor is an adult) and receive a temporary tattoo. Note that all adult visitors should be invited to fill out a survey at the end of their experience, whether or not they use a passport. Visitors of all ages can receive passports, and multiple people in one group can receive passports. If you are able to have multiple people at your Passport Station, the person distributing passports does not need to be the data collector who has completed human subjects training. **Note: Please record the time you start and stop distributing passports, and the total number of passports you distribute.** Your Building with Biology report will ask you to provide this information.

Collecting data at the Passport Station

When visitors return to the Passport Station at the end of their Building with Biology experience, the evaluation data collector should use the *Survey Informed Consent Script* (see below) to invite all adult visitors to complete the survey. When visitors consent to complete the survey, hand them a survey and a pen or pencil. If you have them, you can have your survey on a clipboard. Give the visitor space to complete the survey. When the visitor is finished, the data collector should thank the participant, check and collect the survey, and offer temporary tattoos to all group members. Visitors can take their passports home. After collecting the survey, the data collector should fill in the survey header with his or her initials, the site name, the survey number (i.e., if you collect 20 surveys, number the surveys 1 to 20), and the time. Completed surveys should be placed in the *Evaluation Surveys Envelope* in your evaluation box, and the Envelope should be kept out of visitors' reach.

NOTE: It is important to invite all adult visitors to complete a survey, whether or not they do the passport activity. This will make your data more representative of your full audience.

Passport Introduction Script

Welcome to Building with Biology! This event is one of nearly 200 events across the country where you can try some activities and talk with scientists about the emerging field of synthetic biology. We have a passport activity that helps to guide your experience. You can use your passport to collect stamps for doing the different activities and talking to the scientists and volunteers. Would you like a passport today?

[**If yes**]: Great, thanks! Here you go. [*Distribute passport*] When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

[**If no**]: No problem. I hope you enjoy the activities! When you're done, if you come back to this station, we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

Survey Informed Consent Script

Thanks for participating in the event today! Here's the survey I was telling you about earlier. Will you spend a few minutes to give us feedback about the event so we can improve our future programs?

[**If yes**] Thank you!

[**If no**] Have a great day!

After the event

Once the event is over, the data collector should scan or take clear photographs of both sides of the surveys and the graffiti board responses that he or she collected. Send these digital files to Sarah Pfeifle at spfeifle@mos.org. Then, place all these materials in the addressed, pre-paid mailing envelope included in your evaluation materials and mail the envelope to:

Sarah Pfeifle
Research & Evaluation Department
Museum of Science, Boston
1 Science Park
Boston, MA 02114

The Evaluation Team will then enter your data, analyze it, and provide you with an individualized report sometime this fall or winter.

Building with Biology Public Evaluation Overview

Before the date of the event:

- ☐ Identify one data collector for the evaluation.
- ☐ Send the data collector's human subjects training completion certificate to spfeifle@mos.org at least **one week before your event**.
- ☐ Have the data collector attend the evaluation webinar on **Tuesday, June 14 from 1:00-2:00 ET**, or watch the recorded webinar and call/email your Evaluation Team contact.
- ☐ Have the data collector read this document thoroughly.
- ☐ Fold your passports (or decide that you will have your visitors fold them).

At your volunteer orientation:

- ☐ Tell volunteers about stamping passports at the event.
- ☐ Identify and train at least one person to facilitate the graffiti board.

Setup for your event:

- ☐ Set up each activity station with a stamp marker.
- ☐ Make sure all volunteers know about stamping passports.
- ☐ Give "I'm a scientist" stickers to scientist volunteers and ask them to wear the stickers.
- ☐ Set up the graffiti board and the graffiti board sign from your evaluation kit (NOT the sign from your Building with Biology kit).
- ☐ Set up the Passport Station near the entrance of the event with:
  - ☐ Passports
  - ☐ The Passport Station sign in its stand
  - ☐ *Building with Biology Surveys*
  - ☐ Pens or pencils for survey completion
  - ☐ The *Evaluation Surveys Envelope* for storing completed surveys
  - ☐ Temporary tattoos
  - ☐ *Evaluation Information* cards

During your event:

- ☐ Use Passport Invitation Script (see back of this page) when passing out passports.
- ☐ Record what time you start and stop distributing passports.
- ☐ Record how many passports you distribute.
- ☐ Use Survey Informed Consent Script (see back) to invite adult visitors to complete surveys.
- ☐ Collect paper surveys from adult visitors.
- ☐ Check for completion and fill in the survey headers when you receive surveys.
- ☐ Place completed surveys in the *Evaluation Surveys Envelope*, out of the reach of visitors.

☐ Offer temporary tattoos to visitors, whether or not they complete a survey.

*After the event – **within one week of your event**:*

☐ Scan or take pictures of surveys and graffiti board responses and send to spfeifle@mos.org.

☐ Mail data to the Evaluation Team using the envelope in your evaluation box.

Recruitment Scripts

First interaction with visitors: When visitors approach the Passport Station, use the Passport Introduction Script to welcome visitors to the event, offer them a passport, and ask adults to come back to complete a survey when they're done.

Passport Introduction Script: Welcome to Building with Biology! This event is one of nearly 200 events across the country where you can try some activities and talk with scientists about the emerging field of synthetic biology. We have a passport activity that helps to guide your experience. You can use your passport to collect stamps for doing the different activities and talking to the scientists and volunteers. Would you like a passport today?

[**If yes**]: Great, thanks! Here you go. [Distribute passport] When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

[**If no**]: No problem. I hope you enjoy the activities! When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

Second interaction with visitors: When visitors return to the Passport Station at the end of their experience, invite all adult visitors (whether or not they used a passport) to complete the survey using the Survey Informed Consent Script. Offer temporary tattoos to all group members who would like them. The receipt of tattoos is NOT dependent on filling out a survey. After collecting a survey, fill in the header and store the survey in the *Evaluation Surveys Envelope*.

Survey Informed Consent Script: Thanks for participating in the event today! Here's the survey I was telling you about earlier. Will you spend a few minutes to give us feedback about the event so we can improve our future programs?

[**If yes**] Thank you!

[If no] Have a great day!

Consent signs: Please be sure to display the Passport Station sign at your table where you are collecting surveys, and the graffiti board sign at your graffiti board station. These signs include human subject protection and consent language that is required by this project's Institutional Review Board.


Building with Biology
Passport Station
1. Get your Passport HERE
The passport will guide your event experience.
2. COME BACK when you're done
We'll give you a prize and ask you to fill out a short feedback survey.
• Only adults 18 and older can complete the survey.
• The survey is anonymous and voluntary.
• You can skip questions or quit at any time.
• We appreciate your feedback, and we will use it to improve future programming.


How might synthetic biology change our lives?
Write your ideas on sticky notes and share them on the graffiti board!
• We appreciate your responses.
• Participation is anonymous and voluntary.
• Responses may be used for research and evaluation purposes, and may be shared with scientists and other interested parties.
Building with Biology

Appendix C: Forum Survey

Data Collector Initials: _____ Survey Number: _____ Site Name: _____ Time: _____

Forum Survey

Are you 18 or older? If so, please tell us about your experience!
Participation is voluntary. All responses are anonymous.

1. Thinking about your experience at this forum, how much do you agree or disagree with each of the statements below? (Please check)

	Strongly disagree	Disagree	Agree	Strongly agree
I shared my views about synthetic biology.	☐	☐	☐	☐
I considered the benefits of synthetic biology.	☐	☐	☐	☐
I considered the risks of synthetic biology.	☐	☐	☐	☐
My group's final plan reflected my personal views.	☐	☐	☐	☐
I learned about viewpoints different from my own.	☐	☐	☐	☐
I enjoyed this event.	☐	☐	☐	☐

2. What, if anything, did you learn from participating in this forum?

3. Did both scientists and non-scientists participate in your group discussion? (Please check)

☐ Yes ☐ No ☐ I'm not sure

4. What, if anything, did you learn from other participants during this forum?

5. How much did you know about the following topics BEFORE this forum, and how much do you know AFTER the forum? (Check one 'BEFORE' and one 'AFTER' for each topic)

	BEFORE the forum, I knew…				AFTER the forum, I know…			
	Nothing	A little	Some	A lot	Nothing	A little	Some	A lot
Facts about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Applications of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Societal aspects of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
What other people think about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐

6. How much did this event increase your interest in the following? (Please check)

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology	☐	☐	☐	☐
Learning about how synthetic biology is connected to my daily life	☐	☐	☐	☐
Talking to a scientist about the impacts of scientific research in my community	☐	☐	☐	☐
Sharing my views about synthetic biology with friends and family	☐	☐	☐	☐

7. What, if anything, did you value about your participation in this forum?

8. Do the following statements apply to you? (Please check all that apply)

	Yes	No
I am a scientist or engineer.	☐	☐
I am an undergraduate or graduate student in a STEM (science, technology, engineering, or mathematics) field.	☐	☐
I study or work in the field of synthetic biology.	☐	☐
I attended a Building with Biology orientation.	☐	☐
I am a museum staff member or ongoing museum volunteer.	☐	☐

9. How did you hear about this event?

10. What is your age? _____ What is your gender? _____

Even if you're new to the ideas in synthetic biology, your opinions can shape the development of its tools and applications. The next questions are from scientists who want to know what you think!

11. What applications of synthetic biology would you like scientists and engineers to work on? (Please check all that apply)

☐ Agriculture ☐ Fuel ☐ Software

☐ Electronics ☐ Medicine ☐ Other: _____

☐ Food ☐ Personal Care ☐ None of the above

12. How might synthetic biology change our lives?

13. What question would you most like to ask a scientist about synthetic biology?

Appendix D: Protocol for forum data collection

Forum Evaluation
Data Collection Guidelines

Introduction

The purpose of this evaluation is to understand what forum discussion participants—including public visitors and scientist volunteers--learn from the Building with Biology forums and find valuable about their experiences. Recipients of forum stipends are required to collect data as described in this document. The Building with Biology Evaluation Team will provide all forum recipients with an envelope of evaluation materials, evaluation support, and training for one data collector from your site. This person will collect paper surveys from forum participants and serve as the primary contact for the Evaluation Team. Your data collector will send the forum data to the Evaluation Team electronically and by mail. The Evaluation Team will then analyze the data and send you an individual report about what your visitors learned and valued. The Evaluation Team will also offer a webinar to share findings from all forum stipend recipients.

NOTE: This document was prepared for sites that have received a Building with Biology forum stipend. If you are interested in forum evaluation but have not received a stipend, you are still welcome to use the protocols, attend the professional development opportunities, and use the surveys that the Evaluation Team has created. These resources are available at www.buildingwithbiology.org/project-evaluation.

Unfortunately, the Evaluation Team will not be able to send physical materials or analyze data for sites that did not receive a stipend. **Please do not mail us your data if you have not received a stipend.**

This document outlines the details of the evaluation process, including:

- Responsibilities of the evaluation data collector
- Support you will receive from the Evaluation Team

- Materials you will use for the evaluation
- Information about the data collection process
- How to prepare for your event

At the end of this document, you will find a *Forum Evaluation Overview* section that includes a checklist of action items for the evaluation and recruitment scripts.

The evaluation data collector

For the purposes of this evaluation, you will need to select *one person* who is responsible for five evaluation tasks. Ideally, this should be someone other than the person leading the forum program. Please talk to your evaluation contact if you are interested in having the forum host and the forum data collector be the same person. The data collector will be responsible for:

- ***Completing human subjects training***: The evaluation data collector needs to provide the Building with Biology Evaluation Team with a current copy of a completion certificate for a human subjects training course administered by either the National Institutes of Health (NIH) or the Collaborative Institutional Training Initiative (CITI). If the designated person has already completed this training, she or he can send an existing copy of the completion certificate. If the person does not have a current certificate of completion, she or he must take the free, 2-hour online course from the NIH, accessible at https://phrp.nihtraining.com/users/login.php. Completion certificates must be sent to Sarah Pfeifle at spfeifle@mos.org at least one week prior to your forum.
- ***Attending the Building with Biology forum evaluation webinar***: The Building with Biology Evaluation Team will host an online webinar about this evaluation. While we hope the data collector will attend this webinar live, we understand that scheduling can be a challenge. If the data collector is unable to attend, we ask that she or he watch the recording of the webinar and speak with his or her Evaluation Team contact. The webinar will be Thursday, June 23, 2:00-3:00 ET. To learn more and register for the webinar, visit: http://www.surveygizmo.com/s3/2736592/Evaluating-Building-with-Biology-Forums
- ***Watching the Building with Biology evaluation video***: The Building with Biology Evaluation Team is producing a short video that summarizes data collection practices. In addition to attending the webinar, the data collector should watch this brief video. A link to the video will be emailed to you, and it will be available for reference on www.buildingwithbiology.org/project-evaluation.

- ***Collecting data at the forum***: The data collector will be responsible for collecting the surveys, provided as a part of the forum evaluation materials, from individuals who participate in the forum. This document provides additional detail about data collection.
- ***Mailing the collected data to the Evaluation Team***: After the event, the data collector will need to send all data to the Building with Biology Evaluation Team so the Team can analyze and report on the data. First, the data collector should scan or take a picture of: (1) completed *Forum Surveys* and (2) participants' discussion recommendation worksheets. Digital files should be sent to Sarah Pfeifle at spfeifle@mos.org. Then, the data collector should place the completed surveys and discussion worksheets in the addressed, pre-paid mailing envelope included in the evaluation materials and ship the envelope to the Museum of Science at the following address:

  Sarah Pfeifle
  Research & Evaluation Department
  Museum of Science, Boston
  1 Science Park
  Boston, MA 02114

If it is not feasible for all of these items to be completed by the same person, please speak with your Evaluation Team contact. It may be possible to share roles in a different way. The Evaluation Team will need a human subjects training certificate for all people collecting data.

Support from the Building with Biology Evaluation Team

Each site will have a designated contact from the Building with Biology Evaluation Team who will provide assistance throughout this evaluation. At this point, you should have received an email identifying your Evaluation Team contact. Please feel free to reach out to this person with any questions you have about the evaluation. Evaluation contacts include:

Gretchen Haupt	Elizabeth Kollmann	Sarah Pfeifle	Katie Todd
ghaupt@smm.org	ekollmann@mos.org	spfeifle@mos.org	ktodd@mos.org
651-312-1757	617-589-0467	617-589-0202	617-589-4235

You may also contact Elizabeth Kollmann, the Evaluation Team leader, should you have any issues or concerns with the evaluation study.

Materials

This evaluation depends on your use of specific supplies. Most of these supplies are included in the envelope of evaluation materials you will receive. We also ask that you gather some pens

and pencils at your site that visitors can use to fill out their surveys. The full list of materials you will need for the evaluation is printed below.

From your evaluation envelope:

- 40 *Forum Surveys* (If you are expecting more than 40 participants, you can print additional surveys at http://bit.ly/BwBforumsurvey)
- *Evaluation Surveys Envelope* for completed surveys
- 25 *Evaluation Information* cards
- Pre-paid mailing envelope addressed to the Museum of Science

For you to gather at your site:

- Pens or pencils for survey completion

From the Building with Biology kit or website:

- Discussion worksheets (each Building with Biology forum includes these worksheets, which participants use to write out their group recommendations)

Setup

Prepare for your data collection by placing paper surveys and pens or pencils on each table. If possible, there should be at least one survey and one pen or pencil for each chair at the table. Your evaluation envelope includes 40 paper copies of the *Forum Survey*. If you need more, you are welcome to print additional copies. The surveys are available at http://bit.ly/BwBforumsurvey.

In addition to the setup of the participants' tables, make sure you have the *Evaluation Information* cards and the *Evaluation Surveys Envelope* with you. If anyone has questions about the evaluation, please give them an *Evaluation Information* card. These cards include the contact information for the leader of the Evaluation Team, Elizabeth Kollmann, so participants can direct any questions to her. You will use the *Evaluation Surveys Envelope* to store the completed surveys.

Introducing the survey

If possible, the person facilitating the forum should let participants know that they will be asked to complete a survey at the end of their experience. A good time to do this is when the facilitator tells the participants what materials are on their table. People have many materials to manage during the forum, so it is useful to tell them that they can put the *Forum Survey* aside until the end of the event. Alerting people about the survey will also help prime them to

think of feedback during the program and introduces the survey as part of the experience rather than an extra add-on at the end. The *Should We Engineer the Mosquito* and *Editing the Genome: Now We Can. Should We?* guides include a script that includes a bulleted list beginning with "On your tables, you'll see…" You can add the following bullet point at the end of that list:

> "You will also see ***Forum Surveys*** on your tables. We value your feedback about this program and will invite you to complete this survey at the end of the program."

Inviting participants to complete the survey

At the end of the forum, you will want to ask adult participants to fill out the *Forum Surveys* at their tables. In closing the program, the evaluation data collector or facilitator of the forum can use the following language, which includes human subject protection language required by this project's Institutional Review Board:

> "We are trying to get feedback about this forum, and we would like to know what you think about it. On your table, you will see some *Forum Surveys*. If you are age 18 or older, we invite you to complete the survey. It should only take about 5 minutes to complete. Your answers will be anonymous, you can quit at any time, and you can choose not to answer a question if you want. It shouldn't make you uncomfortable at all, and it would help us design activities that will be better for you and everyone else in the future. We'll be collecting completed surveys as you leave."

Collecting data

As people leave the event, the evaluation data collector should station him or herself by the exit with the *Evaluation Information* cards and the *Evaluation Surveys Envelope*. She or he will collect the surveys and thank the participants by saying, "Thank you so much! Your feedback will help us improve our future programs." If anyone has questions about the evaluation, they can get an *Evaluation Information* card. Completed surveys should be placed in the *Evaluation Surveys Envelope*.

Once participants have left, the data collector should go around the tables to collect the groups' worksheets with their final recommendations written on them (these worksheets are part of the forum activity and are included in the forum materials). These should be placed in the *Evaluation Surveys Envelope* with the surveys. The tables may also have additional completed surveys that participants did not hand to the evaluation data collector. All of these materials should be placed in the *Evaluation Surveys Envelope*.

After the forum

Once the forum is over, the data collector should fill in the survey headers with her or his initials, the survey number (i.e., if you collect 22 surveys, number the surveys 1 to 22), and the name of the site where the forum took place. Then, scan or take clear photographs of both sides of the surveys and the completed worksheets that were collected. Send these digital files to Sarah Pfeifle at spfeifle@mos.org. Finally, place all these materials in the addressed, pre-paid mailing envelope that was provided in your kit and mail the envelope back to the Evaluation Team at the Museum of Science, using the address below:

Sarah Pfeifle
Research & Evaluation Department
Museum of Science, Boston
1 Science Park
Boston, MA 02114

The Team will then enter your data, analyze it, and provide you with an individualized report sometime this fall or winter.

Building with Biology Forum Evaluation Overview

Before the date of the event:

- ☐ Identify one data collector for the evaluation.
- ☐ Send the data collector's human subjects training completion certificate (NIH or CITI) to spfeifle@mos.org at least **one week before your forum**.
- ☐ Have the data collector attend the live evaluation webinar on **Thursday, June 23 from 2:00-3:00 ET**, or watch the recorded webinar and call/email your Evaluation Team contact.
- ☐ Make sure that the data collector watches the evaluation video.
- ☐ Have the data collector read the *Forum Evaluation Data Collection Guidelines* thoroughly.
- ☐ Meet with the forum facilitator to make sure he or she will introduce the survey at the beginning of the program and ask participants to fill it out at the end of the program.

Setup for your event:

- ☐ Set up each table with:
  - ☐ *Forum Surveys* (enough for each person at the table)
  - ☐ Pens or pencils
- ☐ Make sure you have the following materials with you:
  - ☐ *Evaluation Information* cards
  - ☐ The *Evaluation Surveys Envelope* from your evaluation envelope

During your event:

- ☐ Have the facilitator introduce the *Forum Surveys* at the beginning of the program (see reverse of this page for suggested language).
- ☐ At the end of the program, have the facilitator use the *Recruitment Script* (see reverse of this page) to ask adult participants to complete the survey.
- ☐ The data collector should position him or herself by the exit to:
  - Collect paper surveys from adult participants as they leave the forum
  - Thank participants for their feedback
  - Offer *Evaluation Information* cards to anyone who has questions about the evaluation
- ☐ Place completed surveys in the *Evaluation Surveys Envelope*, out of the reach of visitors.
- ☐ Gather completed recommendation worksheets and surveys that were left on tables. Place them in the *Evaluation Surveys Envelope*.

*After the event – **within one week of your event**:*

- ☐ Fill in the survey headers with the data collector's initials, survey number, and site name.
- ☐ Scan or take pictures of surveys and worksheets and send to spfeifle@mos.org.

Mail surveys and recommendation worksheets to the Evaluation Team using the addressed, pre-paid envelope in your evaluation envelope.

Recruitment Scripts

First introduction to the surveys: When the forum facilitator introduces the materials participants will be using during the forum, she or he should tell participants about the *Forum Surveys*. Here is a script which includes human subject protection language required by this project's Institutional Review Board:

> "You will also see ***Forum Surveys*** on your tables. We value your feedback about this program and will invite you to complete this survey at the end of the program."

Asking adult participants to complete the survey: At the end of the forum, you will want to ask adult participants to fill out the *Forum Surveys* at their tables. In closing the program, the evaluation data collector or facilitator of the forum should use the following language:

> "We are trying to get feedback about this forum, and we would like to know what you think about it. On your table, you will see some *Forum Surveys*. If you are age 18 or older, we invite you to complete the survey. It should only take about 5 minutes to complete. Your answers will be anonymous, you can quit at any time, and you can choose not to answer a question if you want. It shouldn't make you uncomfortable at all, and it would help us design activities that will be better for you and everyone else in the future. We'll be collecting completed surveys as you leave."

Appendix E: Codebooks for qualitative analysis

Building with Biology Codebook on Learning

What, if anything, did you learn from participating in this event?

CODE: I learned about…	***EXAMPLE QUOTES***	***NOTES***
FACTS & KNOWLEDGE		
1. The **significance** of synthetic biology	*"**[Synthetic] Biology affects our lives every day. For good or bad**"* *"**[SynBio] is just a small piece to a massive puzzle for all of us to work towards solving problems**."*	These are comments about why synthetic biology matters or how it is connected to the broader world.
2. The **science/technology** of synthetic biology (facts)	*"**I learned what a pathway is…**"*	These are any statements about learning pieces of information related to synthetic biology, including the general definition of what the field is, that do NOT fall under the categories below (applications/policies/current research).
3. **Applications** of synthetic biology	*"**I learned algae could be used as fuel…**"* *"**…that the gut microbe of mosquitos can be used to combat disease**."*	Note that these are more specific than the general 'science/technology' code. Any statement that is about an application or use of synthetic biology should be coded here, instead.
4. **Policies** about synthetic biology	*"**Patent law and commercial production of bioengineered solutions are complex.**"*	Note that these are more specific than the general 'science/technology' code. Any statement that is about a policy or regulation related to synthetic biology should be coded here, instead.

5. **Current research** about synthetic biology (specific)	*"**I learned the most recent trending of the biology field today…**"*	To be coded here, the comment should specifically say something about learning information about synthetic biology that is current, recent, cutting edge, or something along those lines.
6. **Places** where synthetic biology research happens	*"How **community biolabs** are currently established."* *"I learned a lot about how lab issues are dealt with in **places like MIT**."*	These are comments that mention the actual locations where synthetic biology happens, whether it's a community lab, someone's house, or a traditional laboratory.
7. **Funding** of synthetic biology	*"**How complicated the funding of research can be** and the pressures to publish"*	This is a specific mention of the economics of synthetic biology work.
8. **Future** directions of synthetic biology	*"**How this research could be used in the future.**"*	This code includes specific mentions of future work.

SOCIETY & ATTITUDES		
9. The **risks** of synthetic biology	*"**We need to think about the ramifications of synthetic bio**"*	This code specifically mentions the fact that synthetic biology or its applications have risks or potential negative consequences.
10. The **benefits** of synthetic biology	*"**How beneficial synthetic biology is on all walks of life**"*	This code specifically mentions the fact that synthetic biology or its applications can be positive or beneficial.
11. **Societal aspects** of synthetic biology	*"**Our choices as humans/scientists can affect more than we may initially realize.**"*	Comments for this code discuss the ways synthetic biology interplay with society or play into complex societal systems.
12. What **others** think about synthetic biology	*"**I got to think about different viewpoints.**"* *"**There are so many different perspectives that***	These are comments about diverse opinions, or learning other people's views about synthetic biology.

	***are just as important to consider.*"**	
13. **The complexity** of the issues surrounding synthetic biology	*"**It is not as simple to create synthetic biology as new articles imply.**"*	This code captures comments that describe the fact that synthetic biology is complicated and/or consists of many different components. It may be related to the science/technology or its implications .
14. **Public involvement** in synthetic biology	*"**We need to have a broader public understanding of science in general as well as synthetic biology and genetic engineering, specifically.**"*	This code could contain comments about how individuals can become more involved or the general importance of public involvement.
15. What I need to **consider** about synthetic biology (self-reflection/self-awareness)	*"**I got to understand my own views better.**"*	This code is for self-reflection, or comments where the respondent said they learned more about themselves.

GENERAL		
16. **Advancements** in science and technology (general)	*"**Real progress is being made**"*	These are vague comments that do not relate specifically to synthetic biology or a related topic. If a comment fits above, it should be coded there, and this should just be for more general statements.
17. The **researchers/scientists** who participated	*"[Volunteers'] **devotion and passion for experimentation.**"*	This is a code for comments about the volunteers who facilitated activities or the scientists who participated in the forums.
18. The **activities**	*"**Hands on learning-helpful to the kids.**"* *"**Fun projects.**"*	These are statements about the hands-on activities or the format of the forum, but specifically related to the educational materials/programming.

19. **Other**		Code here when the comment does not fit under any of the codes above.
20. **Lots of information**	*"**I learned a lot**."*	These are for comments where people say they learned a lot but they don't specify what they learned.
21. **Very little**	*"**Not much**."*	These are for comments where people say they did not learn very much.
22. **Nothing**	*"**Nothing.**"* *"**N/A**"*	This code captures instances when people say they did not learn anything.
23. **No answer**		Code in this category when the question was left blank.

Building with Biology Codebook on Value

What, if anything, did you value about your participation in this event?

CODE: I valued…	EXAMPLE QUOTES	NOTES
KNOWLEDGE/ACCESS		
1. The **topic** of synthetic biology	*"I learned about **home-based synthetic biology**"* *"Introduction about t**he whole synthetic biology field**"*	This is broadly defined, so comments about genetic engineering or other related topics would be coded here as well as specific mentions of synthetic biology. These example quotes could be double coded with opportunity to learn, as well.
2. The opportunity to **learn**	*"**Ability to learn something new…**"* *"**Better informed** about the variety of genetic modification approaches available"*	This is any mention of learning, and may often be combined with other codes. For example, the second quote could be double coded with the topic of synbio.
3. The access to **experts**	*"I liked being able to talk to **the scientists** about things in the news…"* *"**cutting edge scientists were on hand**"*	If someone mentions the volunteers broadly, it would only be coded here if there were a specific mention of knowledge/expertise in the field. The first quotation could also be coded with the discussion code.
4. Thinking about **societal/ethical** issues	*"Opportunities to talk with a diverse group of the public about **synthetic biology and its implications**"* *"We did discuss **problems of safety and lab culture in a DIY space**"*	This could be considerations about how synthetic biology impacts/is impacted by society or considerations around the ethics/morality of synthetic biology. The first part of the first quote could be coded under the discussion code and the diverse views code.
(ACTIVE) DIALOGUE		
5. **Discussing** the topic	*"**Opportunities to talk** with a diverse group of the public about synthetic biology and its implications"*	This mentions conversation, dialogue, or discussion that implies two-way interaction (two or more people taking turns talking, not just

	*"**It was exciting to have a conversation about these issues.**"*	one person talking and one listening).
6. Hearing **diverse opinions**	*"Getting to learn about **other people's attitudes towards syn bio and biotechnology in general**"* *"**Interesting to get different perspectives and concerns**"*	This is a mention of hearing multiple views, which could come from the public or activity facilitators.
7. **Meeting** other participants	*"**Meeting people** with different ideas/backgrounds"*	The second part of this quote could be coded as diverse opinions.
8. The opportunity to **share** my opinions	*"I valued that **I was able to contribute** to the conversations."*	This specifically mentions that the respondent contributed to the conversation or activity.

GENERAL		
9. The **format** of the event	*"**I liked the combination of activities and presentations**."*	These are general comments about the format of the event.
10. Everything	*"**Everything**."*	This is most likely a comment that says 'everything' or 'all of it' or something vague along those lines.
11. The **interactive/fun** experience	*"**It was very interactive**"* *"**Enjoyed the interactive displays**"*	This specifically mentions that the experience was interactive, hands-on, enjoyable, fun, or a similar descriptor.
12. Great experience for **kids**	*"**Value to get the kids involved**"* *"**Kid friendly**"*	This needs to specifically mention that it was suitable for children, kids, or teens.
13. Nothing	*"**Nothing**"* *"**N/A**"*	The person specifically said they did not find anything valuable.

14. Other		Any comment that does not fit in one of the above codes. Feel free to use this code liberally during data entry.
15. **No answer**		Go ahead and code this for anyone who leaves the question blank.

Appendix F: Additional data

Forum Post-surveys: Qualitative Data

This appendix includes full qualitative coding of forum post-survey questions about what participants learned and valued from their experiences:

TABLE 1. What, if anything, did you learn from participating in this forum? (N=595).

Code	Number of respondents	Percentage	Example quote
Science/technology (general)*[27]	205	34.5%	"I learned a lot of specific science information."
Applications of science	134	22.5%	"Options for controlling malaria, including gene drive and other methods."
What others think about science*[28]	90	15.1%	"People have extremely varying opinions on what to do and that's awesome."
The complexity of scientific issues	46	7.7%	"There's a lot to take into consideration when trying to make a decision on someone's life."
The risks of science	39	6.6%	"[I] learned more about the technology and risks."
Societal aspects of science	36	6.1%	"Ethical issues that may arise, religious perspective."
The benefits of science	33	5.5%	"GE mosquitoes are helpful."
Current research (specific)*[29]	25	4.2%	"There are many new experiments looking to end the scare of viruses affecting our world today."
Public involvement*[30]	20	3.4%	"The importance of community dialogue."

[27] $\chi 2$ (1, n=721) = 18.254, Fischer's Exact 2-tailed $p < .001$
[28] $\chi 2$ (1, n=721) = 13.162, Fischer's Exact 2-tailed $p = .001$
[29] $\chi 2$ (1, n=721) = 16.904, Fischer's Exact 2-tailed $p = .007$
[30] $\chi 2$ (1, n=721) = 9.928, Fischer's Exact 2-tailed $p = .020$

What I need to consider (self-reflection)	15	2.5%	"I learned about my own viewpoints on emerging technologies by fleshing them out."
Lots of information	15	2.5%	"Too many to list."
The activities	12	2.0%	"Someone is producing great discussion/ workgroup materials."
Future directions/advancements in science	12	2.0%	"I learned more about the options out there for what the possibilities are."
Other	10	1.7%	"I learned that there are more nerd in this town than I thought."
The significance of science	10	1.7%	"The importance of synthetic biology."
Community education	5	0.8%	"I learned how important it is to explain clearly what CRISPR is."
The researchers/scientists who participated	4	0.7%	"The scientist's passion and knowledge behind what she does."
Did not answer question	4	0.7%	"Yes!!"
Policies about science*[31]	3	0.5%	"A person in my group brought perspective on the legal aspects of this topic."
Nothing	2	0.3%	"I already knew something about this."
Positive affect	2	0.3%	"Science can be really interesting and fun"
Places where research happens	1	0.2%	"Current research on UW-Madison campus."
Funding of science	0	0.0%	--

[31] $\chi 2$ (1, n=721) = 32.816, Fischer's Exact 2-tailed p = .029

TABLE 2. What, if anything, did you learn from other participants during this forum? (N=490).

Code	Number of respondents	Percentage	Example Quote
What others think about science*[32]	218	44.5%	"All the different viewpoints to take into account."
Science/technology (general)*[33]	80	16.3%	"I learned more about the science of our topic."
Applications of science	40	8.2%	"Detailed information about the engineering "solution" for the problems."
Societal aspects of science	38	7.8%	"I thought more about the economic and societal considerations."
The complexity of scientific issues	25	5.1%	"How complex the issues are."
Public involvement*[34]	22	4.5%	"Also, the need for more public engagement."
Other	20	4.1%	"History of Louisiana."
The risks of science	18	3.7%	"That antibiotics are dangerous in some respects."
Nothing	14	2.9%	"I did not learn anything."
What I need to consider (self-reflection)	13	2.7%	"My table-mates brought up interesting questions that helped me view the topic in different ways."
Current research (specific)*[35]	12	2.4%	"About Zika, clinical trials."
The benefits of science	7	1.4%	"With close and cautionary observations, synthetic biology's application in daily life could be safe and beneficial!"
Lots of information	7	1.4%	"Too many things to innumerate."

[32] $\chi 2$ (1, n=721) = 13.162, Fischer's Exact 2-tailed p = .001
[33] $\chi 2$ (1, n=721) = 18.254, Fischer's Exact 2-tailed p < .001
[34] $\chi 2$ (1, n=721) = 9.928, Fischer's Exact 2-tailed p = .020
[35] $\chi 2$ (1, n=721) = 16.904, Fischer's Exact 2-tailed p = .007

Policies about science*[36]	7	1.4%	"…that government involvement in the use of this technology is necessary."
The researchers/scientists who participated	7	1.4%	"We have lots of active scientists in town."
Did not answer question	6	1.2%	"We all wanted more data about what studies have been done, but had great fun adding in what knowledge we did have."
Community education	5	1.0%	"That education is important on all levels, and that ethics education would be very beneficial."
The activities	4	0.8%	"I learned that the presentations were clear for non-scientific persons."
Future directions/advancements in science	1	0.2%	"We are a weak, illogical species, but we all have the potential to achieve greatness."
Positive affect	1	0.2%	"May science prevail!"
Funding of science	1	0.2%	"We really focused on… the questions of who funds this."
Places where research happens	0	0.0%	--
The significance of science	0	0.0%	--

[36] $\chi 2$ (1, n=721) = 32.816, Fischer's Exact 2-tailed p = .029

TABLE 3. What, if anything, did you value about your participation in this forum? (N=433).

Code	Count	Percentage	Example Quote
Hearing diverse opinions	122	28.2%	"I liked hearing the variety of opinions."
The opportunity to learn	92	21.2%	"The opportunity to learn and discuss in a laid back, respectful environment."
Discussing the topic	92	21.2%	"The group discussion."
The opportunity to share my opinions	57	13.2%	"My opinions were considered."
The access to experts	24	5.5%	"It was great to hear and learn from an expert in the field that worked with West Nile virus for over 15 years."
The format of the event	24	5.5%	"Great format, good mix of people."
Meeting other participants	21	4.8%	"Met some interesting people in different views."
The topic of synthetic biology	11	2.5%	"Exciting info."
Other	9	2.1%	"To be honest, food."
Self-reflection	8	1.8%	"I feel more aware and I can be more aware of these issues in the future."
Everything	8	1.8%	"Everything."
The interactive/fun experience	8	1.8%	"Fun way to do 'smart' things."
Nothing	7	1.6%	"Nothing."
Did not answer question	5	1.2%	"I'd rather have there be a longer lecture."
The societal/ ethic aspects	0	0%	--
The great experience for kids	0	0%	--

Public Event Post-surveys: Qualitative Data

This appendix includes full qualitative coding of event post-survey questions about what public visitors learned and valued from their experiences:

TABLE 4. What, if anything, did you learn from participating in this event? (N=413).

Code	Count	Percentage	Example Quote
Science/technology (general)	172	41.6%	"Details about DNA, basis of synthetic biology."
Applications of science	97	23.5%	"There are many practical applications of synthetic biology."
The significance of science	27	6.5%	"The importance of synthetic biology."
The activities	19	4.6%	"My children loved making DNA."
Future directions/advancements in science	18	4.4%	"What science is doing for the future."
Positive affect	18	4.4%	"Synthetic biology is awesome and super cool!"
The benefits of science	15	3.6%	"Benefits to environment."
Lots of information	15	3.6%	"A lot of new facts."
Current research (specific)	11	2.7%	"Had no idea about research involving synthetic foods and biology. Wow!"
What I need to consider (self-reflection)	10	2.4%	"I learned to rethink food choices from another person's perspective."
The risks of science	8	1.9%	"That synthetic biology is a growing field, it's also very controversial, the consequences…"
Did not answer question	8	1.9%	"Do not eat soylent green."
Societal aspects of science	7	1.7%	"What different cultures may value most."
The complexity of scientific issues	7	1.7%	"There are many different ways to look at each problem to find the right solution."

The researchers/scientists who participated	7	1.7%	"We met a researcher [who] worked on a medication my child had taken for years."
Nothing	6	1.5%	"I didn't learn anything because I'm a biology instructor."
What others think about science	5	1.2%	"How different people/ groups react to [synthetic biology]."
Community education	4	1.0%	"I would love to have some of these activities in our classrooms."
Places where research happens	3	0.7%	"I learned about the Biolab and what they are trying to accomplish."
Funding of science	2	0.5%	"Money allocation"
Very little	2	0.5%	"I learned a little from all of them."
Public involvement	1	0.2%	"That kids need more science education."
Other	16	0.2%	"We have good schools here for scientists."
Policies about science	0	0%	--

TABLE 5. What, if anything, did you value about your participation in this event? (N=301).

Code	Count	Percentage	Example Quotation
The opportunity to learn	87	28.9%	"Great learning for my daughter."
The interactive/fun experience	54	17.9%	"Hands-on learning"
The great experience for kids	54	17.9%	"Kids enjoyed it"
The access to experts	53	17.6%	"Well informed scientists and helpers to teach us about synthetic biology."
The format of the event	24	8.0%	"The fact that you were able to teach lessons creatively in an appealing and kinematic manner."
The topic of synthetic biology	22	7.3%	"Understanding more of the advances in synthetic biology."
Other	13	4.3%	"Time with my daughter."
Discussing the topic	12	4.0%	"How it engages dialogue [with] family"
Nothing	12	4.0%	"N/A"
Thinking about societal/ethical issues	10	3.3%	"I talked about moral concerns about synthetic biology, which I [had] never thought about."
Did not answer question	9	3.0%	"Yes."
Everything	8	2.7%	"I valued all of it, it got me even more interested in science now."
Hearing diverse opinions	7	2.3%	"It gives us the option to understand different beliefs about synthetic biology."
The opportunity to share my opinions	6	2.0%	"I felt like my opinion mattered."
Meeting other participants	4	1.3%	"I met new people also interested in synthetic biology."

Appendix G: Front-end evaluation study: Scientists' motivations for and benefits of participating in public engagement with science

Introduction

The Multi-Site Public Engagement with Science (MSPES) project aimed to build capacity among informal science education (ISE) institutions to develop and implement public engagement with science (PES) programming. Specifically, the project collaborated with scientists in the field of synthetic biology, and utilized a network structure created by the National Informal STEM Education Network (NISE Net) to disseminate PES products. Products consisted of hands-on, table-top activities that scientist volunteers facilitated with the public and in-depth forum discussions or conversation activities during which scientists and members of the public conversed.

Prior research has identified relevant background about scientists' motivations for and impacts of participating in PES activities. These studies have found that factors predicting scientists' participation include a feeling of obligation to share research with the public, attitudes about PES, perceived behavioral control, and descriptive norms (Besley, 2014; Goss & Kollmann, 2011; Poliakoff & Webb, 2007; Storksdieck, Foutz, & Ong, 2008). Studies of the impacts of PES have found that scientists benefit from establishing new outreach opportunities and learning about informal science education, inquiry pedagogy, and science communication (Kollmann, 2011; Sickler, Foutz, Ong, Storksdieck, & Kisiel, 2011). However, these studies leave several questions about their applicability to the MSPES project. For instance, the Besley piece looks exclusively at online engagement, the Poliakoff and Webb article focuses on European scientists, and the others take only a cursory look at the motivations for participation.

Therefore, MSPES evaluators conducted a front-end evaluation with the goal of establishing a baseline understanding of scientists' motivations for, and benefits of, participating in museum-led PES activities. Ultimately, this evaluation could inform thinking about how to attract scientists to engage in PES activities as well as inform discussions about appropriate impacts for scientist participants. Evaluators collected online surveys and conducted exploratory interviews with scientists who have participated in: (1) forums through the Museum of Science, Boston (MOS), NISE Net, or Portal to the Public, as well as (2) scientists who have engaged in public events such as NanoDays, the Renewable Energy Fair, and the Seattle Science Festival. The team collected data from scientists in each of these two groups for a total of 11 surveys and interviews.

Evaluation questions included:

- *Motivations*:
    1. Why do scientists decide to participate in PES activities?
    2. What were their expectations for the events or activities?

- *Benefits*:
    3. What did scientists value about their participation in PES events?

4. How did they feel their participation personally benefits them?

Methods

Overview

This front-end study employed a mixed-methods approach to collect both qualitative and quantitative data from participants. Data collection consisted of an online survey and a follow-up exploratory interview. These methods were selected for the study because evaluators were interested in knowing categorical information about the respondents' history with PES, while they also wanted to be able to probe for in-depth information about the respondents' individual experiences. The two-part data collection facilitated efficient use of time, as the survey generated the necessary background information about the respondents' history with PES in a fast, user-friendly format for the respondents. Then, the interviewer was able to use that quantitative data to develop individualized interview questions that were appropriate for the respondent given her or his past participation. Instruments are provided at the end of this appendix.

Data collection

Evaluators recruited study participants by contacting volunteer coordinators and event organizers of PES events that involved either hands-on activities or forum programs. These coordinators and organizers provided the evaluators with a list of participants that included an even split between scientists who had experience with forums and hands-on activities. Evaluators then contacted these participants via email and invited them to take part in the study. Sixteen scientists were invited to participate (8 with hands-on experience and 8 with forum experience), and eleven completed the study (5 with hands-on experience and 6 with forum experience). This study was designed to be exploratory and primarily qualitative. The evaluators sought a group of experienced PES participants who could provide in-depth feedback about their experiences. Due to the heavily qualitative nature of the study, a relatively small sample size was sufficient.

Data collection began with an online survey. Many of the items from the online survey were developed from prior research in this area, especially the work of John Besley (Besley, 2014; Goss & Kollmann, 2011; Kollmann, 2011; Poliakoff & Webb, 2007; Sickler, Foutz, Ong, Storksdieck, & Kisiel, 2011; and Storksdieck, Foutz, & Ong, 2008). These studies informed the themes of this study, and some of the individual question items were adapted from these researchers' instruments. The topics of the close-ended questions on the survey included:

- The types of outreach activities the respondents had previously participated in
- The respondents' goals when participating in outreach, and
- Factors the respondents considered when deciding whether or not to participate in outreach.
- Factors about one specific PES the respondent had participated in.

Following respondents' completion of the online survey, an evaluator conducted a phone interview with each participant. The evaluator took notes during each conversation and, if the participant consented, these interviews were recorded for analysis. The interview consisted of 16 open-ended questions, as well as a series of probing questions when additional information was desired. Many of the questions were based on responses from the online survey. For example, many of the questions asked the respondent to specifically discuss the

event that they had described on the online survey. Other questions asked about PES experiences more broadly. Some questions reminded interviewees of how they had responded to a certain question on the survey. Then, the interviewer asked the interviewee to explain why she or he had felt that way. The types of questions included:

- What the respondent's prior PES experiences had consisted of
- Motivations for participating in PES
- Expectations for a PES experience
- What the respondent had learned during PES
- What the respondent valued about participating in PES
- The respondent's goals for PES events

Data analysis

Quantitative survey data was analyzed using descriptive statistics. Qualitative interview data was coded using inductive coding analysis, a process by which evaluators group data based on emergent thematic content (Patton, 2002). Where applicable, results were compared based on whether respondents were discussing hands-on activities or forum discussions. The small sample size of this front-end study means comparisons are descriptive; no statistically significant differences were computed. However, these findings may inform future work in this area.

Findings and Discussion: Motivations

This findings section shares data about scientists' reasons for participating in PES events, and their expectations for these events. These findings address the following evaluation questions related to scientist motivations:

Why do scientists decide to participate in PES activities?

What were their expectations for the events or activities?

Five findings emerged from the data about volunteers' reasons for participating in PES. These findings are explained in detail on the following pages, and include:

I. Respondents often described a desire to interact with the public as a motivation for participating. When prompted, they also found two-way interaction to be an important goal for PES.

II. Front-end subjects found the topic of an event to be highly important, and preferred to do outreach about their own areas of research.

III. Front-end respondents' decisions to participate depended on whether the type of activity offered at an outreach event matched the facilitator's goals for reaching the public.

IV. A host venue's reputation and ability to reach the scientist's intended audience impacted the attractiveness of an event for front-end subjects.

V. When deciding to participate in outreach, front-end subjects emphasized the importance of logistical factors, including timing, over social factors.

VI. A majority of respondents' expectations for the events related to their ability to engage in two-way interactions or learn from the public. Most felt that the PES events in which they had participated had met their expectations.

I. Respondents often described a desire to interact with the public as a motivation for participating. When prompted, they also found two-way interaction to be an important goal for PES.

During the front-end follow-up interview, respondents were asked to describe a museum-organized outreach event that they had participated in. Five of the eleven respondents described events with hands-on activities, while six spoke about forum programs. The interviewer then asked, "What were your motivations for participating in this event?" Evaluators did not observe any trends in motivations based on the type of event that the interviewees had experienced.

Interviewees most frequently described their motivations as extrinsic factors—things that are focused on benefit to others (serving the public, pleasing an employer) rather than intrinsic factors that benefit one's self (personal enjoyment, advancing one's own career). For example, six of the eleven respondents noted that they were motivated to participate in a museum-led outreach event because they wanted to **educate public participants** in the event. Some of these responses mentioned wanting to help the public learn about specific content areas, such as, "[I wanted to be involved in] conveying the urgency of climate change," (Subject 5) or, "[I wanted to participate in] communicating the complexities of seafood and the science of aquaculture" (Subject 2). Other responses in this category were more general. One scientist described, "[I was motivated to] share what I know with the public at large. It's important that people are aware of the information" (Subject 9).

Another six interviewees indicated that they were motivated by the chance **to give the public accessible exposure to science.** Again, these responses ranged from more general communication goals, to very specific ones. One general statement was, "[I wanted to] demystify the science" (Subject 1). A more specific comment included, "[I wished to be involved in] exciting women in science, providing role models. I want to break down stereotypes" (Subject 5). Addressing misperceptions of science as overly complicated was important to one interviewee, who shared, "There are challenges with the public with the perception of science being too complicated. They opt out, don't think about it. This is a good way to engage people who are interested to help them understand they can engage themselves" (Subject 2).

Five additional interviewees indicated a third extrinsic motivation: **participating because it is part of their job**. Some of these scientists indicated a sense of duty to participate, sharing things like, "As a chemist and a chemistry professor, I feel an obligation to share what I know with the public at large" (Subject 9). Others explained that their job included a philosophy that supported outreach, even though participation was not a required aspect of their role. One noted, "We're a nonprofit organization dedicated to green chemistry. Our mission is to spread the word" (Subject 1) and another added, "It's core to the mission of my job and the institution I work for" (Subject 2).

A final extrinsic motivation, with three responses, was that the scientists wished to **reach more people**. One described, "The goal is to engage with as many people as possible" (Subject 3) and another added, "[I was motivated to] talk to more people!" (Subject 1). These most common themes in the data show that the scientists

included in this sample primarily described their motivations based on external factors such as a duty, commitment, or desire to serve others.

In addition to the extrinsic factors described above, several respondents were motivated by the opportunity to develop a stronger relationship with the museum partner. Three respondents mentioned a desire for **involvement with the museum**. For example, two discussed enthusiasm for involvement with museums, stating, "I love museums! Since I was a kid I loved museums and it's really cool to be there on the floor, being a part of it all" (Subject 4) and, "[I was motivated by] the process of being part of the [museum's] work, and this exciting discussion program" (Subject 8). Another shared an ongoing collaboration, describing, "I have a long working history with [museum]" (Subject 10).

Two additional respondents mentioned that they were involved in **helping the museum develop the program**. One shared, "Originally I agreed to attend because I helped the organizers set up their approach for one of the topics" (Subject 6) while the other indicated, "I funded a portion of it" (Subject 7). Another two-sided motivation, which two respondents mentioned, was the opportunity to **discuss the topic**. For instance, subject 7 described, "I was interested in engaging the public in two-way dialogue."

Two participants shared an intrinsic motivation (a reason that benefits one's self). These were both about wanting to **learn communication techniques**. One articulated, "We could benefit from learning how to communicate our story differently" (Subject 7). The second interviewee said, "I wanted to learn how to translate research findings that can be overseen by the public" (Subject 8). Finally, one last interviewee's response did not fit in any of the above categories. This person shared, "Really, I participated because I was invited!" (Subject 11). Overall, the responses to this question portray a range of motivations, with a trend towards being motivated because of impacts on the public.

In these open-ended responses, few scientists were specifically mentioning two-way interactions, or the ways the public could contribute to their learning. However, the survey data suggest that, while these goals may not be front of mind for scientists, they do perceive them as important. The survey asked scientists to rank the importance of nine potential goals for PES activities on a 4-point scale from not at all important to very important. The goals were framed such that they investigated different aspects of the mutually-beneficial nature of PES; the questions look at the benefit to the scientist, benefit to the public, and two-way interactions. These goals included:

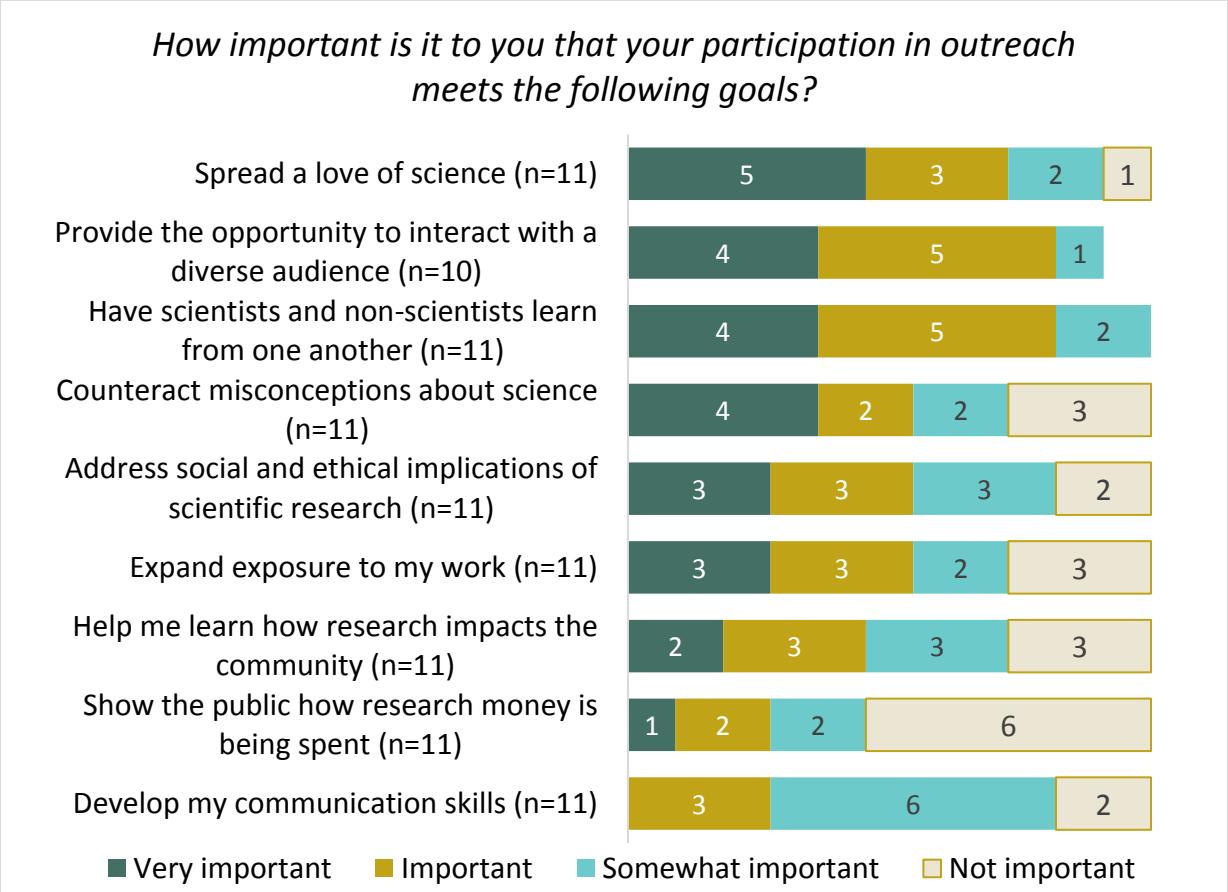
- Spreading a love of science
- Interacting with a diverse audience
- Mutual learning between scientists and publics
- Counteracting misconceptions about science
- Addressing societal and ethical implications of science
- Expanding exposure to the scientist's own work
- Learning how research impacts the community
- Developing communication skills

- Showing the public how research funds are spent.

Two goals were ranked as very important, important, or somewhat important by all respondents: providing the opportunity to interact with a diverse audience, and having scientists and non-scientists learn from one another. Both of these reflect the mutual learning aspects of PES. Ten of the eleven respondents responded that spreading a love of science was very important, important, or somewhat important. This complements the data from the prior section, that scientists are often motivated by what they can do for the public. Factors of benefit to the scientist—such as expanding exposure to their own work and developing their communication skills—were generally rated as less important. The full results from this question are shown in Table 1.

Table 1: Front-end survey respondents' goals

How important is it to you that your participation in outreach meets the following goals?



To learn more about these close-ended survey responses, the interview asked scientists to expand upon their answers by explaining why they felt these goals were important. Evaluators asked different respondents about

different goals to get responses about a wide range. Thus, the following quotations are not representative of the full sample. One respondent described why **spreading a love of science** was important, saying, "I study climate change. You can't protect it if you don't love it" (Subject 5). One person was asked about providing the opportunity to **interact with a diverse audience**. This scientist explained, "It could be a doctor or a plumber. It's nice because you reach a different group than we do through our networking and social media. We don't have that outreach capacity, so it's valuable to partner" (Subject 1). Four respondents described the goal of having **scientists and non-scientists learn from one another**. One posited, "Scientists can stay in their world and not necessarily understand the impacts and what people are interested in…for non-scientists, it's useful to hear what their taxes are funding" (Subject 7). Another shared, "Every community member, every business owner has a stake and an opinion, with different reasoning behind it. Everyone needs to come to the table" (Subject 3). The other two respondents noted, "That's what makes dialogue meaningful. It's counterproductive otherwise" (Subject 11) and, "We need to hear their interests. It's not just what the public should know" (Subject 2). In terms of the importance of **counteracting misconceptions**, one respondent shared, "It's a positive factor if people are able to look at issues like climate change not as a plus or minus opinion piece but as factual science that they have some grasp of" (Subject 9). The scientist who described the goal of addressing social and ethical implications said, "The events I'm involved in are at the intersection of policy and science" (Subject 10). Subject 6 explained the value of **expanding exposure** to her work, noting, "Working in a small nonprofit, we have large geographic reach relative to staff size." Describing the importance of **learning how research impacts the community**, Subject 8 shared, "Research is important if it's translated into practical life. I really value this idea of translation to applications." One respondent described why **showing the public how public research funds are spent**, saying, "It's a difficult environment for science funding…there's a real need, not just for students, but for the country, for science to not be halted. It's not just the amount of funding, but the year-to year aspect. We need the public's support" (Subject 9). Finally, when discussing the importance of **improving communication skills**, Subject 11 stated, "It's important for scientist to develop effective communication. It's very different from how scientists communicate with one another. We don't do a good job talking to the rest of society about value and limitations."

After respondents explained the reasoning behind their survey responses about goals of public engagement with science, the interviewer asked respondents what other goals the respondents felt were important for outreach activities to achieve. Similar to the other open-ended questions, most responses focused on the scientists' ability to provide a valuable experience for the public. Several reiterated the goal of **sharing knowledge**, saying things like, "[I want to] spread the content of Green Chemistry" (Subject 4). Three others described the goal of **sharing opportunities for the public to take action**. For instance, one explained the need to focus on, "How to engage people in action. It's good to educate, there's value in that, but pushing to the next step and walking away feeling like there's something they can do. An active step. It promotes citizen science, whether or not people recognize it or call it that. At a lot of these events, we need to focus on what people will do, not just learn" (Subject 2). Two interviewees discussed a goal of **making science available to the public**. For example, one explained, "Building a sense of community and knocking down barriers. With energy efficiency, people see it as big and daunting, but when you realize there are small steps, it's positive" (Subject 3). One respondent emphasized the goal of **nurturing children's curiosity**. This person said, "[My goal is to] nurture the innate

curiosity that kids of all ages have. Browse around my website; you'll see the variety of programs that do just that. Meaningful activities, science, art, religion, economy" (Subject 11). Three respondents to this question focused on benefits to themselves, namely the goal of **improving communication skills**. These interviewees mentioned things like, "Thoughtful people identify gaps in our ability to understand and explain why we're doing what we're doing. We can try out different explanations and language" (Subject 10).

These data about why scientists participate in outreach activities and their goals for doing so may be valuable when considering recruitment options for future events. For example, knowing that many people are interested in reaching the public may be relevant when inviting scientists to participate: organizers might wish to describe the event as a service opportunity or emphasize the scale of the audience they are likely to reach. Knowing that people are not initially mentioning the two-way interactions that are representative of authentic Public Engagement with Science (PES), it may be especially important to inform volunteers of the expectations for PES from the outset. Some scientists may be more familiar with the traditional model of Public Understanding of Science (PUS) outreach, which emphasizes one-way transmission of information from experts to the public. However, it is encouraging that, when prompted with these mutual-learning goals on the survey, scientists are reporting that they are important. Another factor to consider is whether different scientist audiences may tend towards different motivations. For example, Building with Biology attracted volunteers who are at different stages in their professional careers (undergraduates through PIs, etc.). Scientists of different ages and experience levels may have different motivations for participating in PES. Organizers should be willing to listen to scientists to hear what they would like to get from the experience, and assess whether those goals align with the organizer's goals for the event.

II. Front-end subjects found the topic of an event to be highly important, and preferred to do outreach about their own areas of research.

The front-end survey asked participants to rate the importance of several logistical components of an outreach event. As shown in Table 2, most respondents indicated that the topic of the event was "very important" (6 of 10) or "important" (3 of 10).

Table 2: Front-end survey respondents' importance of the event topic

When deciding to participate in an outreach activity, how important is the topic of the event? (n=10)

	Count
Very important	6
Important	3
Somewhat important	1
Not important	0

During the interview, evaluators asked an open-ended follow-up question: "What about an event topic makes you more likely to participate?" The most common response to this question was that scientists wanted to do outreach **about their area of research**. Seven of the eleven respondents indicated that this was the case. For example, one mentioned that it was a matter of personal ability to discuss a topic, saying, "[The topic] has to do with what I have to offer, whether it's my field or what I've learned on my own" (Subject 9). Several felt the connection to their area of research was important due to relevance. For instance, one described, "[The topic is interesting if] it's relevant to me and my area of work, my interests. Just relevancy" (Subject 8). One specifically mentioned that the relevance was necessary to justify the time. One said, "[The topic needs to be] relevant to the work we're doing. I have to prove to my boss that it's worth going. It's got to fit our agenda" (Subject 3).

Other than connections to one's own field of research, two respondents said topics were more appealing if the scientist could **learn about the public's views of a particular topic**. One shared, "We want to see the community's response to a certain topic" (Subject 6). Two additional respondents said topics could be interesting if the **venue frames the conversation in an interesting way**. For instance, an interviewee described, "[A topic is compelling based on] the overall goal of the event and the openness with which the topic is being dealt with" (Subject 7). There were two other comments that did not represent any trends in the data: one person preferred a topic about which (s)he had previously prepared materials. This person said, "[Some topics] take longer to prepare. The forum series was easier to prepare for because we already do a lot on that topic. Other topics just need to be developed from scratch. It's more work" (Subject 10). The last respondent preferred a topic for which the public has an open mind. The respondent described, "[I prefer] topics focused on solutions and understanding rather than debate. I've debated with climate change deniers. It feels like a waste of air. I want people open to changing their minds." These responses support the Building with Biology project's efforts to recruit volunteers who already had experience with synthetic biology. In addition to valuing sharing one's own area of expertise that many scientists are likely passionate about, scientists who already have relevant content expertise may be able to focus more on the interaction, without the stress of learning new material and having concerns about accuracy while speaking with the public.

III. Front-end respondents' decisions to participate depended on whether the type of activity offered at an outreach event matched the facilitator's goals for reaching the public.

When asked to rate the importance of the type of activities at an outreach event, front-end subjects were relatively split about whether it was "very important" (3 of 11), "important" (4 of 11), or "somewhat important" (4 of 11). These data are visualized in Table 3.

Table 3: Front-end survey respondents' importance of the type of activities offered at an event

When deciding to participate in an outreach activity, how important is the type of activities at the event? (n=11)

	Count
Very important	3
Important	4
Somewhat important	4
Not important	0

The front-end survey presented scientists with a list of different formats for outreach (hands-on activities, discussion-type forums, and lectures), and asked respondents to select which ones they had personally experienced. Then, the interviewer verbally reminded the respondents of their response to that survey question and asked if they valued participating in one type of activity more than the other(s), and if so, why. The results show that most scientists in this study (7 of 11) did not value one type of outreach more than another, but rather they valued different outreach types depending on which outreach strategy will most effectively allow them to engage with their target audience. For example, one scientist explained, "There's value in a lot of them. Different mediums work for different learning styles. Different people gravitate more towards some than others" (Subject 1). Another respondent indicated, "They're all meaningful and have different purposes. Each needs to be done with specific strategies based on the audience" (Subject 11). Respondents also noted that there was diversity within one type of activity. One described, "Even within one category the level of engagement can be varied" (Subject 6).

In describing their reasons for valuing different types of activities, respondents shared a number of benefits and drawbacks. A summary of these benefits and drawbacks is presented below in Table 4. While respondents identified more benefits and fewer drawbacks for certain activities, the number of pros and cons should be interpreted with caution. As discussed, respondents did not say that one type was overall more valuable than another; instead they emphasized the diversity within activity types in engaging different audiences and addressing different goals. Overall, these data support the idea that there is no single type of activity that best meets facilitators' goals, and that having a suite of options, similar to the Building with Biology kits, is valuable.

Table 4: Front-end respondents' perceived benefits and drawbacks about different activity types

Do you value participating in one type of activity more than the other(s)? Why? (N=11).

	Benefits	Drawbacks
Hands-on Activities	Opportunity for dialogue (2) Engaging more parts of the brain Making science feel do-able Involving people in the scientific process Concrete Powerful Meaningful participation	Has to peak visitor interest Training sessions for communicators are important Not everyone is good at facilitating

	Student enjoyment of leading activities	
Discussions	Valuable for both scientists and public (2) Opportunity for the public to share Public can talk to experts Makes scientists seem relatable Scientists can receive applicable feedback	Not always very much feedback from visitors
Lectures	Valuable for education Opportunity for public to ask questions Enjoyable	Minimal audience feedback Less satisfying One-way transmission Less investment Not a new experience

IV. A host venue's reputation and ability to reach the scientist's intended audience impacted the attractiveness of an event for front-end subjects.

The front-end survey asked respondents to rate the importance of the organizer in deciding whether or not to participate in an outreach event. As shown in Table 5, 4 of 11 respondents indicated that the organizer was "important" or "very important", with another 6 of 11 indicating that it was "somewhat important."

Table 5: Front-end survey respondents' importance of the event organizer

When deciding to participate in an outreach activity, how important is the organizer of the event? (n=11)

	Count
Very important	1
Important	3
Somewhat important	6
Not important	1

This study was particularly interested in investigating the role of museums in organizing PES events, so the interview included a question that probed for open-ended responses about event venues. The question asked, "Are there any characteristics of organizers or venues that make one more attractive than another?" The top responses (with 5 of 11 responses each) were that scientists valued a venue if it had a positive reputation and the ability to attract a diverse audience. In terms of the **venue's positive reputation**, several people described the need for trust. One described, "There needs to be a level of trust in the organizer" (Subject 9), while another

said, "A local organizer or venue that people trust is useful" (Subject 7). Others described an interest in venues that are respected in the community, saying things like, "[I'm attracted to] the prestige of the [museum]. It's fun to tell others you're going there. It adds extra motivation" (Subject 4).

Other frequent codes had to do with the venue's ability to attract an audience. Another 5 of 11 respondents described an interest in a **venue that attracts a diverse audience**. For example, one shared, "An organization that reaches underserved populations is important. I don't want to just talk to the entitled" (Subject 5). Two people described an interest in reaching people they don't normally interact with. One expressed an interest to address the question of, "How many of the people coming are people I haven't gotten to yet?" (Subject 2), while the other added, "I like to look for things that aren't the usual suspects. Many people at the museum don't think about environmental stuff. I want people who don't think about topics regularly. I want access to people I don't engage with normally" (Subject 3). In addition to wanting a diverse audience, the next most common code was wanting a **venue that attracts a large audience**. One said, "Knowing the audience reach is important. There need to be enough people at the event" (Subject 5). Another added the importance of spreading the topic by saying, "[I judge a venue by] how well the organizer can amplify the message" (Subject 2).

Several other respondents (4 of 11) described a desire to **fit with the venue's style**. One articulated, "The style of outreach varies from place to place" (Subject 1) and another further described, "Personally, I prefer the museum because I'm there as a thinker. I'm not in that role in other events" (Subject 10). Similar to style is a venue's **organizational capacity**. Two respondents described this feature, with one saying, "Working with someone I know is good with logistics is important" (Subject 5), and the other adding, "[I look for features like] organizers. All should be very effective" (Subject 9). The **physical location** was mentioned by three respondents. One said, "Transportation matters" (Subject 3) a second shared, "Events held at publically accessible spaces with good mass transit and parking plays a role [in my decision to participate]" (Subject 6), and the third voiced, "[I look for] not just a lecture hall, but facilities that are interesting to the eye" (Subject 7). Finally, one respondent noted that there was no particular difference based on the venue, noting, "Whenever someone asks, we go," (Subject 4).

V. When deciding to participate in outreach, front-end subjects emphasized the importance of logistical factors, including timing, over social factors.

Following the questions described in the previous sections, the front-end interview asked respondents what other factors needed to be present for them to participate in an outreach activity, allowing scientists to frame their reasons for participation in their own words. Responses from this question showed that practical constraints were of primary importance for this sample. Six of the eleven respondents suggested that they needed to have the **time** available. These interviewees said things like, "A lot of it is timing" (Subject 5), or "Scheduling [needs to work]—it's a trade off. Events during the regular work schedule are better. Weekend events are hard because we don't have flexibility" (Subject 6).

Five interviewees said the **logistics**—including transportation, setup, and other assistance—needed to be manageable if they were going to participate. For example, one described difficulties of getting student volunteers to the event, saying, "[We need to address] challenges of getting college students to different locations. It puts a barrier. We need the students to get there!" (Subject 1). Another added, "[I consider] how much stuff we can bring and how we get it there" (Subject 3). A third respondent emphasized the need to understand the logistics, saying, "[We need to be able to] make logistics work. Having a clear idea of how many people, how much help, and crowd control for kids" (Subject 5).

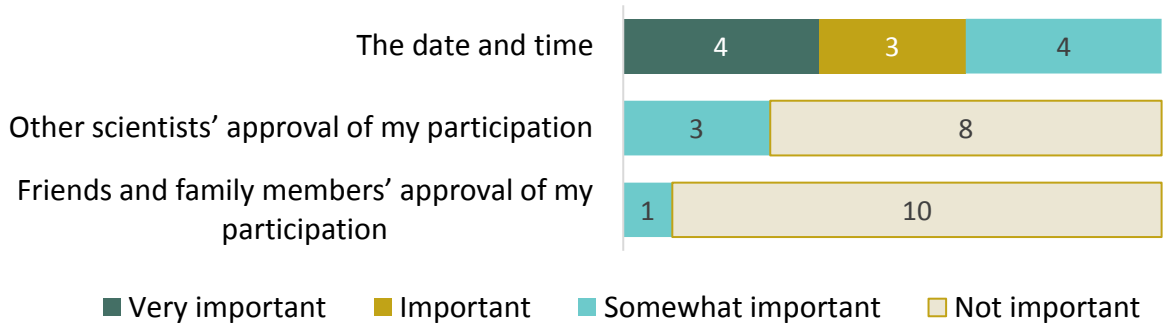
When considering other factors that are important in deciding to participate in outreach, four additional interviewees described wanting the event to **reach a large audience**. One of the respondents said, "[I consider] the size of the audience: if we're feeling like we're reaching more people or people we haven't already reached, we'd be more likely to participate" (Subject 6). A similar perspective was, "Ideally if I'm attending or sharing, I prefer to have a larger audience. 100 as a minimum" (Subject 7). Finally, two respondents stated that, in order to participate, they need to be **interested in the event**. One described, "I talk to [the organizer] about what's going on and see if it overlaps with our interest and if we'll really enjoy it" (Subject 10) and the other added, "[We'll participate] if we're excited and want to do it as individuals" (Subject 1).

Reflecting on these responses, some seem like obvious factors that would be true of any event. While this is likely true, they demonstrate respondents' willingness to say no if these considerations are not addressed. Especially in communities where access to scientists can be difficult, organizers may do well to communicate with the potential volunteers when planning the event, to make sure basic organizational decisions like the timing or logistical setup of the event do not preclude valuable volunteer participation.

Further supporting this trend is data from the front-end survey, which included a question about the importance of the date and time as well as social factors for deciding to participate in outreach. Results of this question are in Table 6, showing that all respondents felt the date and time were "very important" (4 of 11), "important" (3 of 11), or "somewhat important" (4 of 11). By contrast, only 3 of 11 respondents felt other scientists' approval of their participation was "somewhat important" (none felt it was "very important" or "important"), and only 1 of 11 reported that friends and family members' approval of their participation was "somewhat important" (again, none felt this factor was "important" or "very important").

Table 6: Front-end survey respondents' importance of the event date and time

When deciding to participate in an outreach activity, how important are the following factors? (n=11)



VI. A majority of respondents' expectations for the events related to their ability to engage in two-way interactions or learn from the public. Most felt the PES events in which they had participated had met their expectations.

During the interview, the evaluator asked scientists what they expected to get out of their interaction with the public. The two most frequent themes within their responses were that the **scientists expected to learn from the public** (5 of 11 respondents). For example, one scientist whose research focuses on child development described the expectation of learning from the public by saying, "I don't have kids myself, but there were many parents there, and I hoped to hear their points of view" (Subject 8). Another shared, "I wanted to understand people's values and judgments based on the materials" (Subject 7). Three subjects described expecting the **two-way learning** that is characteristic of public engagement with science. For instance, subject 5 said, "I was hoping for 2-way interaction," and subject two noted, "I was hoping for an interesting conversation." The final three respondents indicated that they expected to **educate or change the public's perceptions**. Subject 1 described, "I was hoping that the public would get a better understanding, building awareness…walking away feeling positive about science." Subject 3 noted, "I have lots of expectations. Sometimes it's just education about a topic. For example, sustainable transportation. We try to show people it's easy to get around town without driving." While the sample size was small, there may be a trend with the participants who had participated in forums being more likely to expect learning from the public (4 of 5) while those who had done hands-on activities may have been more likely to expect the public to learn from them (3 of 3).

After asking what scientists expected to get out of their experience, the interviewer asked whether the respondents' prior PES experiences had met their expectations. Nine of the eleven respondents indicated that the events met their expectations, with the remaining two noting that their expectations had been partially met. The interviewer then probed the interviewees to explain why the events met or partially met their expectations. Responses did not align neatly with the responses from the previous question about what scientists expected, except that three of the eleven respondents noted that they **learned from the event**—the top theme from the prior question. For example, one described, "[The public's input] factored into real decision making. It's interesting data about people's sense of threats—when people are willing to do something" (Subject 7). Subject 8 noted, "They helped me think in a new way that I hadn't considered before." The other scientists shared a wide range of thoughts about why the event met expectations. Three respondents each said that their expectations had been met because of the **size of the audience** ("There are thousands of people there" (Subject 3)) the **level of audience engagement** ("People who were there were extremely active and engaged" (Subject 8)), **general positive comments** ("The discussion was more than I'd hoped for" (Subject 7)), or the fact that the respondents **knew what to expect** ("I'm used to it. I know what to expect" (Subject 2)). The two respondents who felt their participation had only partially met expectations described, "Usually [it met expectations]. People tend to leave happy" (Subject 4), and, "The sheer numbers did [meet expectations, but] I wanted more feedback about how well we were doing" (Subject 5).

Findings and Discussion: Benefits

This findings section shares data about the benefits scientists feel they obtain through participating in PES. Specifically, these findings address the following evaluation questions:

What do scientists value about their participation in PES events?

How do scientists feel their participation in PES benefits them personally?

Four findings emerged from the data about the benefits scientists got from PES. These findings are explained in detail on the following pages, and include:

I. Scientists valued the opportunity to give back to society through the PES format.

II. Respondents' participation in PES helped them learn about the public, how science impacts society, and how to engage the public.

III. Respondents found networking with peers, seeing the public's interest in science, and their own enjoyment to be unexpected benefits of public engagement with science.

IV. Scientists felt museums could add networking, try innovative formats, and enhance recruitment to make outreach more valuable for scientists.

I. Scientists valued the opportunity to contribute to society and exchange knowledge through the PES format.

During the interview, the evaluator asked scientists what they valued most about participating in outreach. The two most common themes (representing nine of the eleven responses, combined) both involved the scientists' ability to contribute to society through the event: five of the eleven respondents noted that they valued giving back to the community, and four said they valued sharing knowledge. For example, one scientist who valued **giving back to the community** described, "It's a chance to feel like I'm making an actual difference. Lectures and papers with scientists don't have the same real-world impacts" (Subject 5). Another noted, "I'm service-motivated. I want to give back, and I want my students to give back. It's great to feel like part of a community. It gives you a sense of belonging" (Subject 4). Four scientists indicated that they valued **sharing knowledge** with the public. One described the process as being satisfying, saying, "It provides the opportunity to share great work we do with people who don't have time or understanding about what we do. It's satisfying to share" (Subject 7). Another had more of a traditional view of education, noting, "I value the ability to educate people. Also to make people aware of issues that otherwise they would not have the opportunity to think about" (Subject 8).

In addition to the data about scientists giving knowledge or other service to public, three of the eleven respondents indicated that they considered **their own learning** to be the most valuable part of outreach. These scientists described learning what others think, gaining feedback from the public, and gaining skills in science communication. Two shared a desire to learn the public's perspectives, noting, "I value the purpose of doing it. The responses I get from the audiences I visit" (Subject 11). Another said, "We don't know everything. I don't know what my neighbors think" (Subject 3). For one respondent, scientists' learning was about the method of communication, and was intertwined with public learning. This interviewee shared, "[I valued] the opportunity to learn how to share science with the public" (Subject 9). More information about scientists' learning as a benefit of PES participation is included in the next section.

II. Respondents' participation in PES helped them learn about the public, how science impacts society, and how to engage the public.

Both the survey and interview collected data about scientists' learning from participating in PES activities. On the survey, scientists considered a museum-led PES event in which they had participated, and rated their level of agreement with the statement "Public participants and scientists learned from each other at this event." As shown in Table 7, almost all respondents either "strongly agreed" (4 of 11) or "agreed" (6 of 11) with this statement.

Table 7: Front-end survey respondents' sense of mutual learning

How much do you agree or disagree with the following statement: Public participants and scientists learned from each other at this event. (n=11)

	Count
Strongly agree	4
Agree	6
Neither agree nor disagree	1
Disagree	0
Strongly disagree	0

Following up on these responses, the interviewer asked scientists what, if anything, they had learned from the public at the museum-led outreach event they had selected in the survey. In the interview, all eleven respondents indicated that they had learned from the public during these events. Many of these comments were about learning directly about the public and the way they interact with science. The most common response was that scientists learned **how science impacts the community** (4 of 11 responses). For instance, one described learning, "How people prioritize aspects of their home, environment, and community. How these environmental challenges impact people locally" (Subject 6). Another shared, "Every time we learn something different. I found out that immigrant mothers don't use [product] because they didn't know it was for them, that it was public. We found out that property managers were really encouraging climate change work because it would help them save money" (Subject 3). Three respondents said that they learned about **the public's interest in the events.** Subject 9 noted, "The number one thing [I learned] was how eager people are for these experiences. Parents are very eager for their children. Kids—I guess with kids I'm a little less surprised—but kids are hungry for hands-on experiences. It's very interesting to see the enthusiasm." Another respondent shared, "I learned how open people can be if it's fun and hands-on" (Subject 4). Scientists also learned about the **diversity of the public** (2 of 11). Subject 2 said, "It was a very diverse community of people. It can be eye opening to experience the differences from ethnic communities." Another respondent echoed this feeling, sharing, "It's fantastic to see a diverse audience both in age, race, and gender. It's interesting to see tables of people who wouldn't naturally gravitate together having useful conversations" (Subject 7).

Some of the responses were about learning more about the methods of PES engagement. Three of the eleven interviewees reported that they learned **how to engage with the public**. One described, "[I learned that] there's lots of preparation in how to make it appeal. Then give an interactive experience. The museum is unique in that respect. People are there by choice. They're going to activities by choice. It's a lot different than lots of other educational opportunities" (Subject 9). Another respondent shared, "Engagement in science has lots of different hooks. The coolness of underwater is a good hook. I'd seen it before, but this drove it home" (Subject 5). Finally, two respondents learned that **the public was able to engage** with the material. Subject 10 shared, "There's a higher tolerance for specific information than I would have expected. A lot of people I encounter in the work

want a lower level of literacy for science. These people wanted specifics and technical information, not the lowest common denominator." Subject 11 described, "I learned that they are as serious as scientists are. They have talent and interests. Some might choose to be scientists. Most will not. I welcome opportunities to be engaged and deepen the appreciation of the role of science in daily life."

III. Respondents found networking with peers, seeing the public's interest in science, and their own enjoyment to be unexpected benefits of public engagement with science.

Finding 6 from the motivations section showed that scientists' outreach experiences generally met their expectations of learning from and educating the public. The interview also asked scientists about anything they may have gotten out of the events that they had not expected. Three themes emerged from their responses: (1) scientists appreciated networking with peers (4 of 10 responses[37]); (2) scientists were surprised how interested the public was in the subject matter (3 of 10 responses); and (3) scientists were surprised that they enjoyed the experience as much as they did (2 of 10 responses).

Four interviewees describing the unexpected benefit of **networking** with other scientists during the event. One said, "[There was] a lot more opportunity to interact with science experts [than I had expected]. Building professional connections. I wasn't expecting that. Often I'm the one person who translates science. It's interesting to be sitting next to others who do the same thing. It's a benefit" (Subject 2). Another shared, "Some years students had more conversations with museum staff. That was valuable, and of interest. It's nice when they can hear what others do with science degrees. It offers good diversity, hearing from the science staff" (Subject 1).

Three of the ten responses described being pleasantly surprised at **seeing the public was interested** in the science. Subject 8 shared, "I didn't expect that these topics would have so much influence from the public, that the public would have so much to say about them." Another described the value of a topic that fit well with public interests, saying, "The community level environmental problem lent itself to discussion. The discussion was more than I'd hoped for" (Subject 6).

The third trend in the responses to this question was that two of the ten responses to this question described being surprised that they had **enjoyed their participation**. The first described a positive experience, saying, "Normally you think of yourself as giving out information. Although, I should know better. It's more complex than that. For example, last time we had self-inflating balloons. A young girl said hers wasn't inflating. She held it to her ear, and I could show her things. That's what's really satisfying. Give someone an interactive experience. It's more than yes and no. It's seeing into the experience. It's very satisfying" (Subject 9). The second scientist who mentioned enjoying the PES experience shared, "So it really pushed me to speak the language of science in very lay terms. I was able to translate things in a digestible way. That was a great experience" (Subject 8).

[37] One respondent did not provide an answer to this question, saying that there was nothing unexpected about the event.

In addition to these three themes, several scientists' responses did not fall into any clear patterns. One noted that there had been unexpected interpersonal dynamics that required special training. This person described, "Sometimes you have 'usual suspects' who go to lots of these events, and are very comfortable voicing their opinions. It discourages others from participating just because they're new. Now I'm used to it. We put effort in place training facilitators to make sure everyone's voice is heard and everyone is comfortable" (Subject 3). Another described the unexpected complexity, "It's hard to untangle. There are many aspects of the project." This person emphasized power dynamics, saying, "All the politics that go into it—that's new" (Subject 5). The last respondent was surprised about some of the logistical factors of the event, sharing, "I was surprised how much time the activity took" (Subject 10).

IV. Scientists felt museums could add networking, try innovative formats, and enhance recruitment to make outreach more valuable for scientists.

To gather data that could inform future enhancements to museum-led outreach activities, the interview asked scientists an open-ended question about what they thought museums could do to make outreach more valuable for them. There was a wide range in the scientists' responses, but three themes emerged, each of which were mentioned by three of the eleven interviewees: (1) museum outreach could include more networking for scientists; (2) museums could experiment with innovative formats for their outreach; and (3) museums could more actively recruit scientist volunteers.

The scientists who recommended that museums **provide networking opportunities** discussed benefits of individual scientists meeting others interested in PES as well as that networking increased organizational-level support and promotion. At the individual level, one interviewee said, "Sometimes it could be good to bring several scientists together, even if we didn't know them before" (Subject 8). In terms of organizational connections, Subject 1 shared, "We're small. [The museum] partners with a lot of smaller organizations with niche specializations. For events like this, they could highlight the organizations more. Sharing links to the organizations' websites and that sort of thing." Subject 7 noted a desire to be connected to "a good donor base or community that the museum is a part of."

Three interviewees suggested that museums **try new formats for outreach**. One scientist was very specific, calling for targeted outreach with high school students, saying, "It would be interesting to have more layered engagement with high school age students. Not just PIs but working with the next level up—college and grad students, helping the transition in skillset that students need at the next level. It's something that is best related by people who are in it or did it recently" (Subject 10). Another called for a broader approach, saying, "Maybe more general outreach. Sometimes it's so focused. What if it was just general people in the lobby with different topics to discuss?" (Subject 3). The third wished for a willingness for risk-taking without a specific suggestion, hoping museums could have, "a willingness to take risks and do creative exhibits and engagements" (Subject 7).

The third theme, which was also mentioned by three of the eleven respondents, was that museums could **do more active recruiting of scientists**. One scientist noted that scientists might not initially think of working with museums, but they could be interested if they knew about it. This person described, "Look for opportunities where scientists are already looking to do outreach: people as scientists are more likely to do outreach on hot topics they're working on at the time. There are different funding opportunities that require outreach and education, but most scientists haven't used museums" (Subject 6). A second echoed the importance of matching recruitment to scientists' topics, saying, "Let scientists know there are activities within their area of expertise…There needs to be outreach to let people know. People aren't aware" (Subject 9). Another respondent explained that it might be necessary to convince scientists of the importance of this work, saying, "I know a lot of people who have good messages and deliver those messages well, but they say they're always too busy. I don't understand. I don't know the answer. Maybe if you can help make people see that community service is valuable to the community. It's not just a thing for them to do; it's helping other people" (Subject 4).

In addition to the themes described above, two scientists also mentioned that museums could **take care of more logistics.** One of these scientists said, "Probably the administrative component of it—taking care of the room, settings, all that stuff. That makes it easier. It's great when I can just be responsible for the content and don't have to worry about equipment. Taking care of promotion for the event" (Subject 8). Two others suggested **creating ongoing opportunities for engagement** beyond single events. One said, "[It's preferable] if it gives it a longer lifetime. Not just displays. Having materials that we've done as podcasts, feed into instructional materials. Not just one-offs. Keep it going" (Subject 5). Finally, two respondents thought museums could **gain a better understanding of the public's interests and share that with scientists.** One of these individuals said, "[Museums could do] more research about what will resonate with the public. It helps the scientists!" (Subject 2).

Conclusion

The front-end evaluation for the Multi-Site Public Engagement with Science (MSPES) project investigated scientists' motivations for and benefits of participating in public engagement with science activities. Several themes and considerations emerged across the findings, which translate into a series of recommendations for PES organizers, as described below.

The scientists in this study emphasized the importance of a PES event connecting them to the target audience they wish to reach. Scientists repeatedly mentioned characteristics of the target audience as being primary motivators for participation in PES activities, and in some cases the appropriate target audience needed to be involved for the scientists to consider participating in the event at all. The respondents in this study reported that an event's ability to meet their expectations was largely impacted by the audience in attendance, that venues having the ability to attract their target audience was an attractive feature, and that the type of interaction they most valued depended on the target audience. Specific audience characteristics that scientists sought were a large number of public participants, a diverse group, and, in some cases, children. This emphasis on target audience may merit additional attention and dialogue, to make sure scientists' goals for target audiences align with organizers' abilities to attract those groups. It could also be valuable for sites to provide equity and leadership training, to help scientists better interact with the audiences they wish to reach, many of whom they are not accustomed to working with on a daily basis.

Respondents often described their goals for PES and the benefits they received from PES in terms of their ability to contribute to society by serving the public's needs. The results show that scientists most frequently described their reasons to participate in museum-led outreach as extrinsic motivators such as the impact they hoped to make on the public. Similarly, responses about what was valuable from PES participation tended to center around the ability to contribute to society. Specific interests in serving the public included sharing knowledge, spreading a love of science, counteracting misconceptions about science, and generally giving back to the community. In general, these ideas are framed in a positive light and are not contradictory to PES models. Occasionally, responses reflected a deficit-model approach that aimed to focus the engagement around a one-way transmission of information, and a motivated desire to change public perceptions. Given the fact that this study selected people who had already been involved in PES, it is notable that some of this deficit model is present; it may be even more prevalent in the broader population of scientists. This suggests that PES organizers should be clear in explaining their goals, and provide training or support, when needed, to help scientists provide the type of two-way interactions the organizers hope for.

While it was not always the first language scientists used, respondents found the two-way learning and interaction of PES to be appealing. Mutual learning is a theoretical cornerstone of PES, but, as described above, many of the interview responses tended to emphasize the scientists' contribution to society, rather than a clear articulation of two-way interaction. This may be due to the fact that scientists' learning is more complex than the content and appreciation of science that they hope the publics will gain. Instead, scientists benefit from learning the publics' perspectives, learning how to communicate, and hearing feedback from the interactions. Despite

interview data less frequently describing mutual learning, the survey data showed that, when prompted with language about two-way PES, respondents found this type of interaction to be highly valuable. This is highly encouraging for event hosts, suggesting that the PES model aligns with scientists' goals, even if it is not the vocabulary they are most likely to use. Again, training and support may be especially valuable in helping guide these scientists towards PES interactions, and towards shaping their field's sense of what outreach can be. The selective group of respondents for this study may bias the responses towards authentic PES, but it is nonetheless suggestive that there are scientists who are ready to embrace mutual learning, even if they are not yet aware of, or used to, the types of descriptions of this work that are common in the scholarship.

Museums should not overlook logistical factors when organizing an event. Even among scientists who highly value PES, the results of this study show that basic factors need to be taken care of before participation can take place. In order to take part in outreach, scientists looked for logistics to be manageable and for the topic of the event to be relevant to their own work. Outreach venues were preferred if they attracted a diverse audience, and had a positive reputation in the community. Scientists emphasized that they needed to have the time to participate. Some scientists described the need for museums to actively recruit scientists—even though there may be general interest, the scientists may not be actively looking for these opportunities, and they may need to have the benefits of participation laid out for them. While this may feel like extra effort for organizers, it may be well worth it. When possible, reaching out to scientists early in the planning process may help to identify times that work for them, and make sure they have buy-in; this may even help attract others if the scientist can share information about the event with other colleagues or students.

PES is defined by interaction between scientists and publics, but scientists also value interacting with other professionals. Three of the findings in this study highlight the fact that respondents found benefit in networking—whether with other scientists, museum staff, or other professionals involved in the event. While this is not a core aspect of a traditional PES model, there may be simple ways for organizers to involve some of this relationship-building into a PES event. For example, scientist trainings could include facilitated engagement or unstructured time for socializing. At a pilot-year Building with Biology training, volunteers practiced simplifying their messaging by introducing themselves to other scientists with an 8-word explanation of their research. This type of simple icebreaker could help scientists build valuable professional or academic connections, while simultaneously preparing them to interact with the public during the PES event.

Overall, this study uncovers potentially useful information about experienced PES scientists' experiences, in terms of why they participate and what they get out of it. The findings can be applied by PES organizers to foster meaningful experiences for scientists, potentially building lasting partnerships that benefit the scientists, museums, and publics in mutual fashion.

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Online Survey Instrument, Front end evaluation

Online survey front page

Thank you for your willingness to complete this online survey! The purpose of this survey is to get feedback from scientists who have participated in outreach activities organized by museums.

Please complete this survey before your interview.

How long will it take?

- The survey should take about 5 minutes to complete.
- The survey includes some questions about your experiences with outreach activities and your motivations for participating in them.

Information about your participation:

- This survey is optional, and you can skip any questions or stop at any time.
- Your survey responses will be confidential. Your responses will be analyzed and presented as aggregate findings, and your name will never be associated with specific responses.
- The information you provide will help us understand why scientists decide to participate in outreach activities.

Thank you for participating!

Please contact Liz Kunz Kollmann at ekollmann@mos.org with any questions.

Survey questions

We are interested in your feedback about outreach events during which you have interacted with the public. If you have participated in these types of events both as a member of the public and also as a scientist participant, please answer the following questions based on events you have participated in as a scientist.

1. Have you participated as a scientist in the following types of activities as part of an outreach event?

Activity Type	*Yes/No*
Lecture or stage presentation	
Hands-on activity	
Discussion or deliberation with the public	
Answering questions from the public	
Media event (TV/radio/website/movie)	
Citizen science (involving public participants in the research process as data collectors or analyzers)	

2. When deciding to participate in an outreach activity, how important are the following?

Item	*1* *Not Important*	*2* *Somewhat Important*	*3* *Important*	*4* *Very Important*
The date and time				
The topic of the event				
The type of activities at the event				
The organizer of the event (museum, school, business, etc.)				
Other scientists' approval of my participation				
Friends and family members' approval of my participation				

3. How important is it to you that your participation in outreach meets the following goals?

Item	*1* *Not Important*	*2* *Somewhat Important*	*3* *Important*	*4* *Very Important*
Spread a love of science				
Have scientists and non-scientists learn from one another				
Develop my communication skills				
Address social and ethical implications of scientific research				
Show the public how research money is being spent				
Help me learn how research impacts the community				
Counteract misconceptions about science				
Expand exposure to my own work				
Provide the opportunity to interact with a diverse audience				

4. Please select ONE of the following outreach events that you participated in.
    - Chemists Celebrate Earth Day
    - Endless Table
    - In-APP-Propriate PQ Forum
    - Let's Talk About Food Safety
    - Let's Talk About Sustainable Seafood
    - NASA Asteroid Forum
    - National Chemistry Week
    - Planning for Healthier Cities Forum
    - Rising Tide Forum
    - World Wide Views on Global Warming
    - Other (please describe)

5. Please think specifically about the event you selected in question 4. How much do you agree or disagree with the following statements about that event?

Characteristic	*1* *Strongly Disagree*	*2* *Disagree*	*3* *Neither Agree nor Disagree*	*4* *Agree*	*5* *Strongly Agree*
The event included people of varied backgrounds and scientific expertise.					
I contributed perspectives, ideas, values, and/or knowledge to this event.					
Non-scientist participants contributed ideas, values, and/or knowledge to this event.					
Public participants and scientists learned from each other at this event.					
My interaction with the public has informed the way I think about the topic.					
This event addressed the societal and/or ethical implications of science.					

You have reached the end of this survey. Thank you so much for your feedback. It will help us understand why scientists participate in outreach activities. We look forward to hearing more about your outreach experience during your interview.

Interview Instrument, Front end evaluation

Introduction

- **Thank you** so much for agreeing to talk to me today. [Note: introduce yourself]

- **Background:** This interview is part of a front-end evaluation for the Multi-Site Public Engagement with Science project. We are hoping to learn more about the benefits and motivations you associate with participating in outreach activities, and the role museums can play in organizing those activities.

- **Timing:** The interview should take less than one hour.

- **Audio recording:**
    - [If agreed to be audio recorded] Over email, you agreed to be audio recorded. The purpose of recording this interview is so that any quotes can be accurately portrayed for our analysis. Is that still ok with you?

- **Confidentiality:** Everything you say in this interview is confidential. Data gathered from this interview will be analyzed and presented as aggregate findings, and your name will never be associated with specific responses.

- **Participant rights:** At any time, you may choose to not answer a question or to stop the interview completely.

- Do you have any **questions** so far?

[TURN ON AUDIORECORDING]

Interview Questions

Museum-Led Event Questions

1. On your survey you answered some questions about the [event name] you participated in. Could you start by telling me how you interacted with the public during that event?

2. What did non-scientists do at the event?

3. What were your motivations for participating in this event?

4. What did you expect to get out of your interaction with the public at this event?

5. How did your interaction with the public meet your expectations?

6. What, if anything, did you get out of the experience that you didn't expect?

7. What, if anything, did you learn from the public during this event?

General Motivations and Benefits

8. Now I have some general questions about your experiences with outreach. Overall, what would you say you value most about participating in outreach?

9. On the survey you noted that [goal] was [importance] for outreach events. Could you explain why you felt that way?

10. What other goals do you feel are important for outreach activities to achieve? Please explain.

11. [If indicated other participation on survey] On your survey, you indicated that you had participated in [types of activities, including dialogue/deliberation if applicable] at outreach events. Do you value participating in one type of activity more than the other(s)? Why?

12. On the survey you noted that the organizer of an outreach event--be it a museum, school, business, or other venue--was [importance] when deciding whether or not to participate. Are there any characteristics of organizers or venues that make one more attractive than another?

13. On the survey you indicated that [factor] was [importance] when deciding to participate in an outreach event. What about [factor] makes you more likely to participate?

14. What other factors need to be present for you to participate in an outreach opportunity?

15. What do you think museums could do to make outreach more valuable for scientists? [Probe: What could museums do to motivate more scientists to participate in outreach?]

Conclusion

16. We've reached the end of the interview. Is there anything else you'd like to add about why you participate in outreach or what you get out of it?

Thank you so much for talking with me today. Your feedback will help us improve outreach activities for future participants. We truly appreciate your participation, and wish you all the best with your future outreach!

Appendix H: Testing evaluation methods for hands-on activities designed for public engagement with science

About

This document describes the process and outcomes of testing different approaches to evaluation data collection for a multi-site public engagement with science (PES) effort, focusing on public participants who engaged with hands-on activities during a public event. It reflects on the process, protocols, and instruments that were used during the testing phases. These materials may be valuable for other evaluators or PES practitioners who want to critically consider different methods for gathering information about their programs.

Background

One goal of the Multi-Site Public Engagement with Science (MSPES) project, also known as Building with Biology, was to test different methods of evaluating PES activities. Building with Biology developed activity kits that promoted PES between scientists and members of the public through two types of learning experiences: hands-on activities and discussion programs called forums. This document focuses on approaches to evaluating public experiences with hands-on activities, which were designed to be facilitated by scientist volunteers at events that were open to public visitors of all ages. For more information about the Building with Biology project and kit, see www.buildingwithbiology.org.

In 2015, the Building with Biology evaluation team had the opportunity to conduct a pilot year of data collection before selecting an approach for the full period of implementation in 2016, when 200 kits were distributed across the country. For both years, evaluators trained data collectors at sites around the country who gathered data according to the protocols that the evaluation team had developed. Limited capacity for evaluation at these sites constrained the feasibility of options that could be implemented in a multi-site approach. Thus, this appendix reviews approaches that worked in this multi-site context, assessing the following questions:

- Which methods, tools, or questions are best at producing data that can be used to measure impact achievement?
- Which methods, tools, or questions do practitioners feel produce the best information to guide and inform their practice?
- Which methods, tools, and questions do evaluators and practitioners feel can be best implemented across multiple sites? Which ones do they feel can most easily be used by non-evaluators?

The evaluation team does not feel that the approaches discussed in this document are comprehensive of all valuable methods for evaluating PES. Depending on a study's evaluation questions and capacity, other methods might be appropriate. The results of the pilot testing were useful for the Building with Biology evaluation team's decision about which data collection method would be replicated in 2016, but there was no clear "best" approach that would apply for all PES events. This section of this Appendix provides some guidance for matching suitable evaluation approaches to different PES event types.

Testing Phase One: Family Science Days

In February 2015, evaluators conducted their first test of data collection methods. The test took place at the Family Science Days event during the American Association for the Advancement of Science (AAAS) conference in San Jose, CA. Family Science Days is a free public event involving exhibits, hands-on interactions, presentations, and other science-related activities for families. At this event, Building with Biology educators facilitated prototypes of the hands-on activities that were ultimately distributed in the pilot kits later that summer.

Professional evaluators gathered data from Family Science Days attendees who interacted with the hands-on activities. The goals for this evaluation were to gather formative evaluation data about how the activities could be improved and to test different approaches to data collection. The evaluators tried three approaches, the details of which are below:

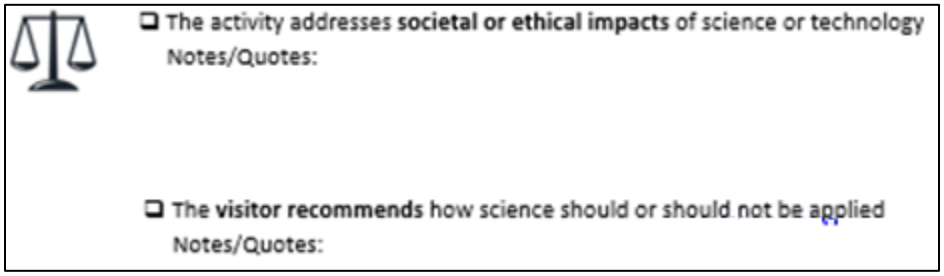
1. Observations
2. Distribution of cards with a link to an online survey and a sign with a QR code
3. Voting activity that collected email addresses, which were used to send an email with a link to an online survey

1. Observations

Rationale: The evaluation team wished to do observations to get detailed information about PES interactions for each activity. One benefit of observations was that the data collector was able to gather information about both the facilitator and the public participants. Another benefit was that there was no added time burden for the participants, compared to being asked to fill out a survey.

Instrument: The observation form used for this event is provided at the end of this document. It includes:

- Basic information about the number and type of participants and facilitators
- Dwell time with the activity
- Counts and descriptions of three focal activities for the participants and facilitators (see example in image below):
    i. Sharing knowledge, values or ideas
    ii. Asking questions
    iii. Addressing societal and ethical impacts of science and technology
- Open-ended notes



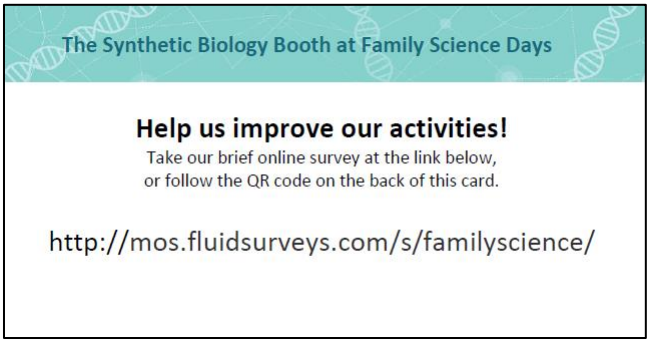
The observation form included three intended PES behaviors, tracking whether or not the visitors and facilitators did them and, if so, describing the interaction.

Outcomes: The evaluators were able to capture rich descriptive information about the activities using the observation form. This formative information was valuable to the activity developers as they refined their prototypes. Because the formative evaluation was focused largely on promoting rich PES experiences, the observation was useful in tracking and providing detail about these interactions. However, observations did not provide any data about the participants' learning, values, or interest, since these rely on participant report. These factors were important for the goals of the national Building with Biology evaluation, and evaluators were concerned that observation was time-intensive and would require significant training to gather comparable data across sites. As such, the team determined that this would not be a suitable approach for replication at all of the pilot sites or during the 2016 evaluation period.

2. *Distribution of cards with a link to an online survey and a sign with a QR code.*

Rationale: Whereas the observations were time-intensive for data collectors, the evaluation team wished to explore data collection methods that required less involvement of the data collector. This would be particularly valuable when gathering data from sites that did not have an evaluator on staff, and may have had limited overall staff capacity. For example, if a small museum with only 2-3 paid staff wished to host a Building with Biology event, it might not be possible to dedicate a person to exclusive data collection activities. This method passively led participants to an online survey. The online medium provided the advantage of having questions with branching logic (whereby later questions depend on a respondent's answers to previous questions), which is difficult to do on a paper form.

Instrument: Evaluators simultaneously tested two approaches to recruiting people to complete the online survey. The first was a simple distribution of a card that had a link and QR code that led to the survey (see image below). This was an attractive option because an activity facilitator could distribute the card at the end of an interaction, even if a dedicated evaluator was not available. The second approach (a sign with a QR code that led to the survey) stood alone, and required no active data collection. The sign was positioned on the activity table in plain view of the participants.



The business card directed visitors to the online survey.

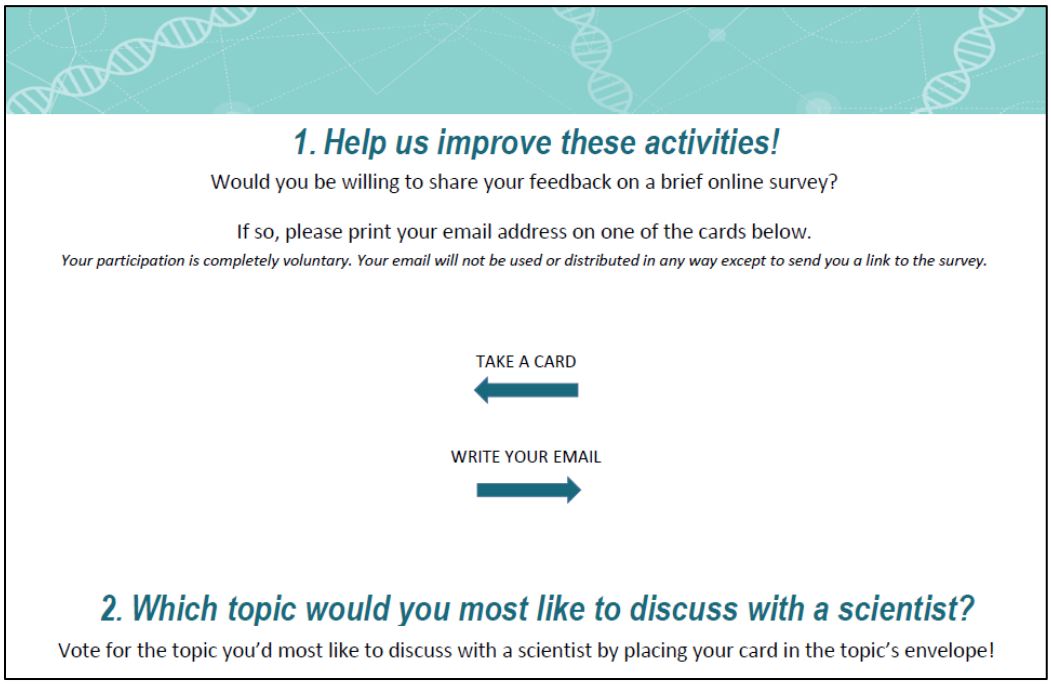
This sign was positioned on the table so participants could visit the online survey.

Outcomes: This approach required little effort from a data collector, but it generated almost no data. Participants did not complete the effort to go to the survey, and the evaluators had no way of reminding them afterwards, as the participants left no contact information. Overall, it was clear that this approach would not gather enough data to be feasible for the national evaluation of Building with Biology events. Furthermore, there would be no way of knowing how representative of the overall population experiencing the activities the sample had been.

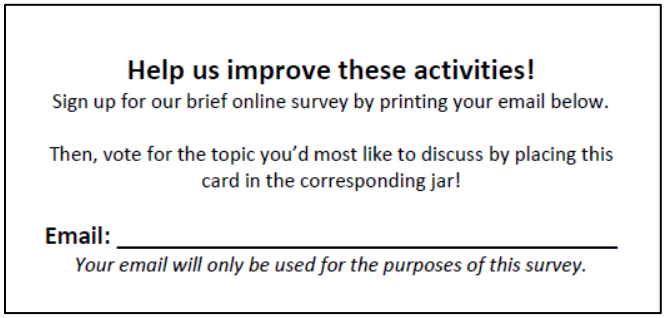
3. *Voting activity which collected email addresses, which were used to send an email with a link to an online survey*

Rationale: This method was a second attempt to explore data collection that required minimal expertise and time from the data collector. It involved two methods of directing people to an online survey. As with the previous version, an online survey was preferable to a paper survey because the team wanted formative evaluation data that required branching logic.

Instrument: The data collection was centered on two large posters: one had instructions (see image below) and the other had illustrations and brief descriptions of five synthetic biology topics (gene drives, de-extinction, mosquito engineering, lab-cultured meat and milk, and 3-D bio printing). There was an envelope for each topic, and people could "vote" for the topic they would most like to discuss with a scientist by placing a business card (see image below) in the corresponding envelope. Visitors would write their email address on the card, which evaluators used to send a link to an online follow-up survey (see end of this document). Evaluators also sent a follow-up email to remind the participants to fill out the survey.



This poster provided instructions for the voting. On the left side, where it says "Take a Card," there was an envelope with voting cards (see below). On the right side, where it says "write your email," there was an envelope full of pencils.



This was the voting card that people used to sign up for the survey and vote on a topic.

Outcomes: This approach offered two levels of data: the counts from the voting and the results of the online survey. Both types of data were successfully gathered with minimal evaluator involvement (evaluators did casually direct adult visitors to the poster). The amount of data was small, and there was a drop-off, with more votes than online surveys. It was hard to make generalizations about this data collection method, because it was only used for two hours. The survey gathered self-report information but lacked the richness of the observation. The evaluation team determined that the self-report survey was valuable, but that a data collection approach with more involvement of a data collector was preferable to ensure a sufficient quantity of data was gathered from a systematic sample. The team decided to continue exploring embedded evaluation approaches which made the process more enjoyable for visitors.

Testing Phase Two: Pilot Data Collection (2015)

In the summer of 2015, eight Building with Biology sites around the country received kits that contained prototype hands-on activities. Each site was required to host an event that involved scientists leading the hands-on activities with members of the public, and to participate in the evaluation. The evaluation team developed protocols for three types of data collection that the sites would test, and assigned 2-3 sites to each method. Then, the evaluation team provided in-person data collection training prior to the events so that at least one person at each site knew how to gather the data using her or his assigned method. Data collectors were also required to complete human subjects training. The complete protocols are at the end of this document, with brief descriptions and a summary comparison below.

At this stage of the evaluation, some formative evaluation data was still of interest, but the evaluators also wished to test questions that would be used for data collection the following year. Many of the evaluation questions for the 2016 impact evaluation relied on self-report, so the evaluation team determined that a survey was the best way to gather data about these evaluation questions, which included:

- How can we improve the activities so that they work better?
- What do public participants learn from their PES experiences?
- What do public participants learn from each other?
- Does participation in a PES event increase the public's interest in public engagement or science topics?
- What follow-up behaviors does participation in a PES activity prompt from public audiences?

- Why do publics decide to participate in PES activities?
- What do publics value about their participation in PES events?
- How do publics feel their participation in the events personally benefits them?
- Who are the members of the public who attend these events?

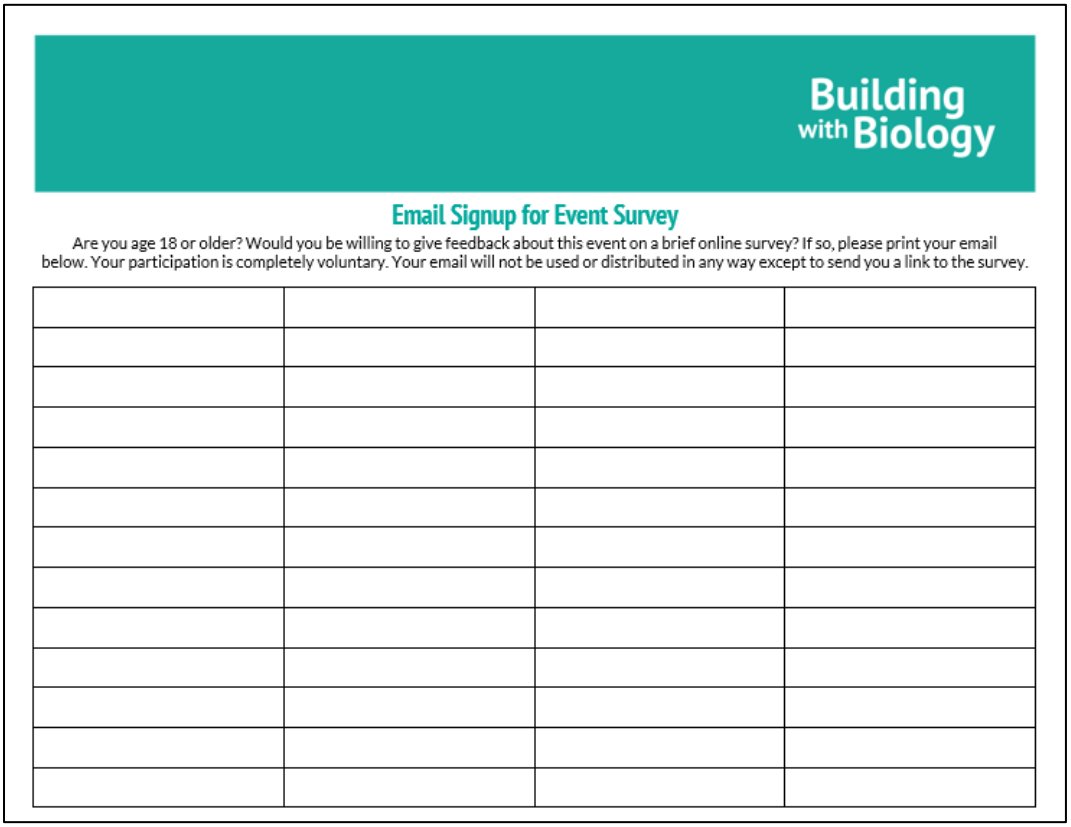
The three data collection methods that were tested during the pilot phase were:

1. Collection of visitor email addresses which were used to send a link to an online survey
2. Paper surveys
3. A passport activity that culminated with a paper survey

1. Collection of visitor email addresses which were used to send a link to an online survey

Rationale: This method grew out of the voting activity that was tested at Family Science Days, which had shown some success. The idea was that data collectors would gather email addresses from public participants so the evaluation team could send them a link to the online survey as well as a reminder email if they did not fill out the survey promptly. As with Family Science Days, using an online survey offered the option of creating an instrument that included branching logic.

Method and instrument: Based on the test at Family Science Days and evaluators' other experiences with similar approaches, the evaluation team expected that more people would provide email addresses than would fill out the survey. Evaluators hoped that each site would generate at least 20 surveys. To accommodate for the drop off between emails and survey responses, the team asked each site to gather at least 50 email addresses from adult visitors to the Building with Biology event. The evaluators provided a sign-up sheet for this purpose (shown below). Data collectors then scanned the completed sheet and sent it to the evaluation team both by email and in hard copy, using an addressed and pre-paid envelope that the evaluation team had provided. The evaluation team then emailed the people who had signed up with an initial invitation to the survey and a follow up, if they did not complete it promptly. A copy of the survey is provided at the end of this document.



Building with Biology

Email Signup for Event Survey

Are you age 18 or older? Would you be willing to give feedback about this event on a brief online survey? If so, please print your email below. Your participation is completely voluntary. Your email will not be used or distributed in any way except to send you a link to the survey.

This sheet was used to gather visitors' emails so evaluators could send them an online survey.

Outcomes: Two sites tested this data collection method. The first site had a professional evaluator do the data collection, and was able to collect the 50 emails as requested. This took 6 hours of dedicated data collection time. In the end, only 15 of the expected 20 online surveys were completed, representing a 30% response rate and 2.5 surveys per hour. The data collector rated this method as being "somewhat difficult" on a 4-point Likert scale of very difficult, somewhat difficult, somewhat easy, and very easy. The second site was only able to gather 9 emails, which generated 2 online surveys. This represents a 22% response rate. The data collector was not able to report how many hours the data collection took or how difficult it was. However, some level of difficulty can be assumed since the target of 50 emails was not reached.

2. *Paper surveys*

Rationale: The evaluation team wished to compare survey data collection with a paper survey versus an online survey, and the majority of survey questions were the same on both surveys to facilitate comparison. There was also a feeling that it might feel less obtrusive for a data collector to gather surveys directly, rather than asking for contact information that some visitors might not wish to provide, due to a fear that their email might be shared or used to send them unwanted mail. This approach also limited the need to approach more people than needed; rather than collecting 50 emails and hoping that resulted in 20 surveys, the data collector would know exactly when she or he got the 20th completed survey.

Method and instrument: Data collectors for this method approached one adult visitor from participating groups using a continuous random sampling method near the exit of the event space. Visitors were asked if they were willing to complete a paper survey about their experience, and if they agreed they were given the survey on a clipboard or directed to a desk or suitable writing surface. The survey was one page, front and back. Data collectors were expected to gather 20 surveys, which they then scanned, emailed, and mailed to the evaluation team for data entry, analysis, and reporting. The survey instrument is provided at the end of this document.

Outcomes: Three sites were assigned to do data collection with paper surveys. The first site rated this method as "very difficult,"[38] and collected 9 surveys in 6 hours of data collection, resulting in an average of 1.5 surveys per hour of data collection. The second site gathered 1.25 surveys per hour, dedicating 12 hours to data collection and resulting in 15 surveys. This data collector indicated that the method was "somewhat difficult." The third site did not report a difficulty rating or the amount of time spent gathering data, but they gathered 11 surveys. Similar to the email addresses, no site was able to gather the target of 20 surveys.

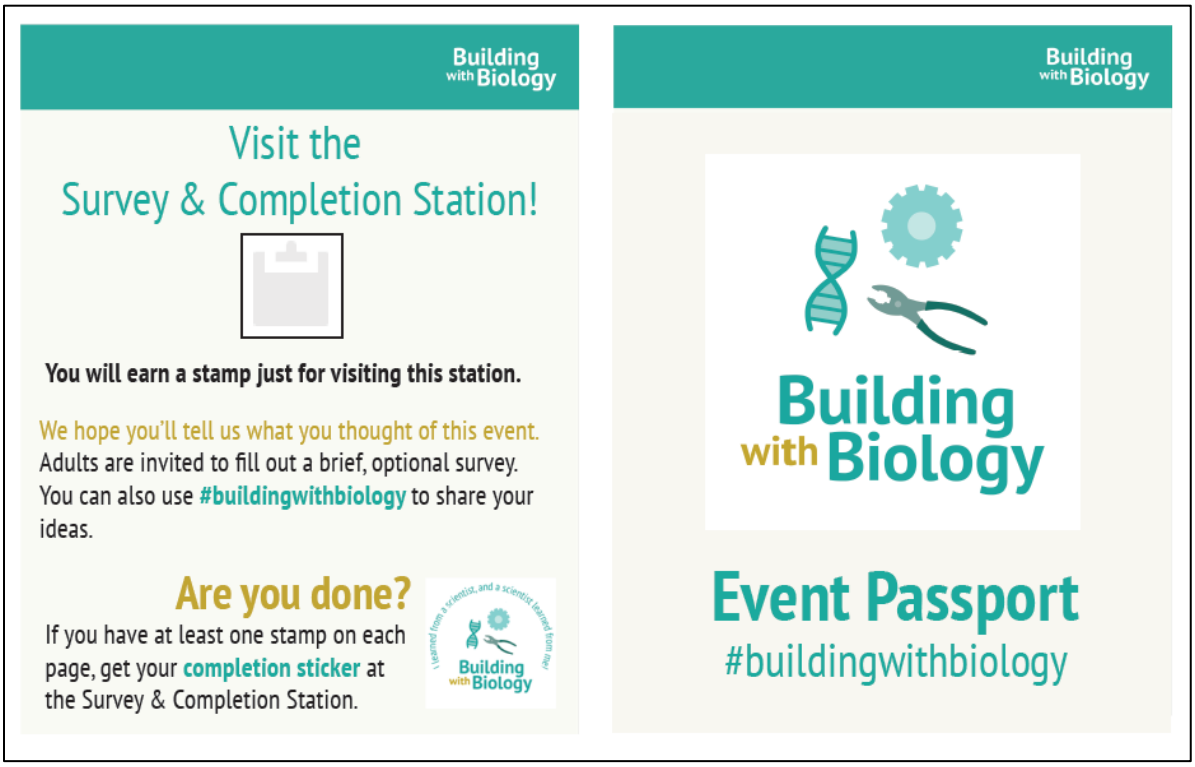
3. *A passport activity that culminated with a paper survey*

Rationale: The third method for data collection was derived from the Family Science Days experience that suggested embedded data collection might be promising. Rather than a voting activity, evaluators used a passport activity because it was expected to enhance the visitors' experience by promoting authentic PES engagement, providing a take-home memento from the event, and integrating data collection into the experience.

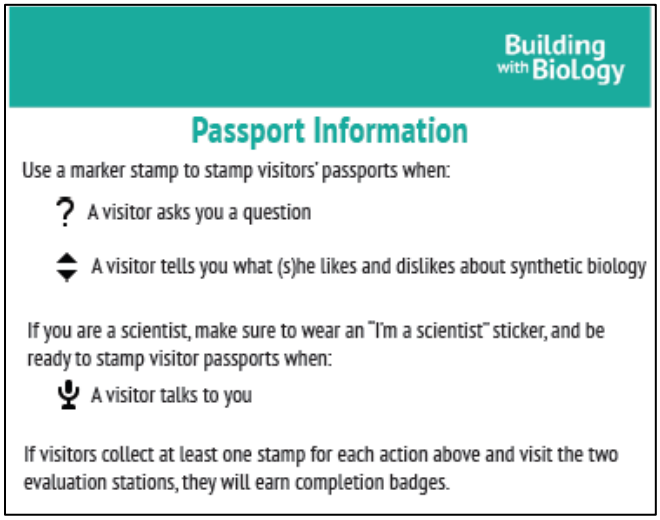
Method and instrument: When visitors arrived, data collectors offered them passports to use during their Building with Biology experience. The evaluators asked data collectors to distribute 100 passports to visitors of all ages. Passports encouraged visitors to: 1) ask a volunteer a question, 2) tell a volunteer what they thought was good or bad about synthetic biology, 3) talk to a scientist, 4) post on a graffiti board that asked visitors how they thought synthetic biology could change their future, and 5) visit the Passport Survey & Completion Station. When visitors went to the Passport Survey & Completion Station, data collectors asked

[38] Data collectors were asked to indicate the difficulty of their data collection method on a 4-point Likert scale of very difficult, somewhat difficult, somewhat easy, and very easy.

one adult in each group to complete a paper survey, but stamped all visitors' passports whether or not they filled out the survey. All visitors received stickers and were able to take home their passports. This method required training activity facilitators as well as data collectors, as the facilitators needed to have stamps (which the evaluation team provided), and had to be ready to stamp visitors' passports when they did the encouraged actions. As shown below, the evaluation team provided passport sites with many materials, including passports and paper surveys, postcards, stickers, signs, and stamps.



The cover (right) and back (left) of the passport. The full passport is at the end of this document.


Building with Biology

Passport Information

Use a marker stamp to stamp visitors' passports when:

? A visitor asks you a question

A visitor tells you what (s)he likes and dislikes about synthetic biology

If you are a scientist, make sure to wear an "I'm a scientist" sticker, and be ready to stamp visitor passports when:

A visitor talks to you

If visitors collect at least one stamp for each action above and visit the two evaluation stations, they will earn completion badges.

Activity facilitators received these postcards so they knew to stamp visitors' passports.

Visitors received these completion badges (stickers) when they finished their passports.

Evaluators provided passport sites with signs for the passport pickup and completion stations.

Outcomes: Three sites collected data with the passport method. The first site gathered the most surveys of any site across all the methods; they received 18 surveys in 12 hours of data collection, for an average of 1.5 surveys/hour. This site rated the data collection as "somewhat easy." The second site rated it as "somewhat difficult, and gathered 14 surveys in 12 hours of data collection, for an average of 1.2 surveys/hour. The third site collected 7 surveys but did not report how many hours they spent or how difficult the data collection was.

Reflecting on the pilot evaluation methods

After collecting data from the three methods from the pilot sites in 2015, evaluators assessed the most effective method for collecting data during the distribution of 200 kits across the country in 2016. Logistical factors limited the data collection to the use of one single method. While the pilot data collection was highly informative, it is important to note that each method was only used at two or three sites, and not every site provided full details about how the data collection had gone. Thus, no statistical comparisons were computed and the final decision was made based on a subjective weighting of which factors mattered most in terms of fitting the project's evaluation questions and logistical constraints.

The evaluation team considered a number of characteristics of the data collection methods when making this choice. Three of the factors were site-level considerations (see descriptions and summary table below):

- *Total number of surveys collected*: Evaluators wanted to make sure that the data collection effort would gather a sufficient amount of data from each participating site. At the pilot sites, the number of surveys ranged from 2 (email collection and online surveys) to 18 (passports and paper surveys). The median number of surveys was the same for both paper surveys and passports (11), which was higher than the median number for email collection and online surveys (8.5).

- *Number of surveys per hour of data collection*: Since the evaluators would be depending on data collectors from other sites, it was important that the amount of time required to collect the data be feasible. While email collection and online surveys generated the highest median survey per hour rate (2.5), only one pilot site reported this metric for this method, and that site had used a professional data collector who was accustomed to this type of data collection.

- *Data collectors' perceived difficulty*: The evaluators asked each data collector from the pilot sites to report how difficult they thought the data collection had been. Ratings ranged from somewhat easy (passports) to very difficult (paper surveys). Again, the sample sizes are very small, but evaluators' discussions with the data collectors supported these ratings.

Site-level Considerations for Comparing Data Collection Methods

	Median # Surveys	Median Surveys/Hour	Difficulty ratings
Email collection and online surveys (n=2 sites)	8.5	2.5	Somewhat difficult
Paper surveys (n=3 sites)	11	1.4	Somewhat difficult, very difficult
Passports with paper surveys (n=3 sites)	11	1.4	Somewhat easy, somewhat difficult

In addition to site-level considerations that are limited by the small sample size of pilot sites, the evaluation team looked at three factors of data quality from the surveys that were gathered. Sample sizes at the survey level are also relatively small, and again no statistical comparisons are appropriate. Descriptions of the survey-level factors are as follows (also see summary table below):

- *Average response rate for quantitative questions*: This metric looked at the proportion of close-ended questions that were answered on each survey (participants were able to skip questions if they wished). Across the three survey methods, this value was similar and was quite high, ranging from 92% (emails and online survey) to 95% (paper surveys). As such, this factor was not a major determining factor when selecting a data collection method for 2016.

- *Average response rate for qualitative questions*: It is somewhat common for survey respondents to skip open-ended questions, as these often have a higher perceived rate of difficulty for the respondent. In the three pilot methods, the average response rate for qualitative questions ranged from 44% (emails and online survey) to 62% (paper surveys). The evaluators considered the 44% to be low, and found the difference between the two paper surveys interesting, given the fact that the surveys were nearly identical.

- *Average number of words per qualitative response*: When people respond to open-ended questions on surveys, their responses are often brief, lacking the depth of personalized articulation that is so valuable in qualitative data. Thus, the evaluators looked at the average number of words that were included in the qualitative responses across the three methods. Curiously, while the open-ended response rate was lowest among respondents to the online survey, those who did respond had the highest average number of words (17.6), which was twice the average length as the passport survey (8.8).

Survey-level Considerations for Comparing Data Collection Methods

	Average quantitative response rate	Average qualitative response rate	Average words/qualitative response
Email collection and online surveys (n=17 surveys)	92%	44%	17.6
Paper surveys (n=35 surveys)	95%	62%	11.2
Passports with paper surveys (n=39 surveys)	93%	55%	8.8

In summary, the data collectors recognized trade-offs between the methods. The small number of surveys collected from the email and online survey method, combined with its perceived difficulty, led the evaluation team to rule out this approach. In selecting between the paper surveys and the passports, another factor ultimately played in, which was that the kit development team included the passports in all kits for 2016 (in 2015, the evaluators had created and distributed the passports, which was a notable amount of work). Due to this project-level decision and the fact that the pilot data collectors rated the passport and paper survey

approach as the simplest, the evaluation team chose to replicate this method in 2016. Additional details are on the following pages. Results from the pilot phase of data collection are provided at the end of this appendix.

Reflecting on the pilot evaluation survey questions

Many of the questions were exactly the same across all three survey versions, which allowed the comparisons discussed above. In several cases, however, there were slight variations. In particular, the online survey was slightly longer than the paper surveys because it was not restricted by the physical limitations of one double-sided piece of paper. The differences and considerations about them include:

- *Multiple wordings of the open-ended learning question*: The online survey asked two open-ended questions about learning: "What, if anything, did you learn from participating in the event?" and "What, if anything, did you learn from interacting with these scientists?" The results showed similar patterns of responses to both questions, so in 2016 the evaluators opted to only ask the more general wording of the first question, which asked about the event as a whole.
- *Asking about pros and cons together or separately*: On the paper surveys, evaluators asked whether visitors considered the "pros and cons" of synthetic biology. The online survey split these up and used slightly different wording ("I considered the benefits of synthetic biology." and "I considered the risks of synthetic biology.") Valuable data resulted from the online survey, showing that visitors were more likely to report having learned about the benefits than the risks. This helped the kit development team balance the presented information so that it represented multiple perspectives. In 2016, the evaluators decided to replicate the wording from the online survey, asking about risks and benefits separately.
- *Retrospective pre/post questions*: While all instruments were completed after the Building with Biology pilot events, the online survey asked visitors to retroactively indicate their level of interest in certain activities before the event *and* after the event. The paper surveys simply asked visitors to rate how much they had learned. Evaluators valued the retrospective data's information about pre-interest, and decided to use the retrospective question format again in 2016. However, the team decided that pre-information would be more valuable about visitors' knowledge about synthetic biology rather than their interest in future actions. Thus, the retrospective question was used for the questions about learning on the 2016 survey.
- *Asking about a single respondent or group experience:* The passport survey asked questions about "you and your group members," while the other two instruments only asked about the single respondent. There was confusion about how to answer questions about multiple people, as different group members may have had different experiences. Thus, the evaluators opted to use the language about the single respondent in 2016.

Full Implementation: Data Collection with Passports and Paper Surveys in 2016

As described at the end of the previous section, for Building with Biology's national implementation in 2016, the evaluation team ultimately decided to collect data about public participants' experiences with hands-on activities using a passport that culminated with a paper survey. As with the pilot phase in 2015, the evaluation questions for this stage of the evaluation were:

- What do public participants learn from their PES experiences?
- What do public participants learn from each other?
- Does participation in a PES event increase the public's interest in public engagement or science topics?
- What follow-up behaviors does participation in a PES activity prompt for public audiences?
- What do publics value about their participation in PES events?
- How do they feel their participation in the events personally benefits them?
- Who are members of the public who attend these events?

To address these questions, the evaluation team determined that data was not needed from all 200 sites. Initially, the goal was to select a cohort of 25 sites to participate in an evaluation capacity building effort that would provide training about evaluation in exchange for sites' agreement to collect data from their public visitors. To the evaluators' pleasant surprise, recruiting sites was not difficult, and more sites volunteered than the team was able to accommodate! In the end, 43 sites participated in the data collection effort. Evaluators selected sites to represent diversity of geography, institution type, and institution size.

The evaluation capacity building effort consisted of several training requirements to ensure systematic data collection. Any person involved in data collection or data management was responsible for:

- Completing the *Protecting Human Research Participants* training from the National Institutes of Health (https://phrp.nihtraining.com/users/login.php) or submitting an up-to-date certificate of completion from a comparable course
- Reviewing the written instructions in the *Evaluation of Public Impacts Data Collection Guidelines* (see page 54)
- Participating in an online workshop, *Evaluating the Public's Experiences at Building with Biology Events*, or watching the workshop recording and meeting virtually with an assigned mentor from the evaluation team (a recording of this online workshop can be found https://vimeo.com/198569803)
- Watching the *Building with Biology Evaluation and Data Collection* training video (https://vimeo.com/album/3828071/video/169711008)
- Devoting full attention to data collection during the event, with the goal of collecting at least 20 surveys, and then mailing the data to the evaluation team after the event

The Building with Biology evaluation team mailed each participating site all of the physical materials they needed for the evaluation which were not already included in the Building with Biology kit. This included copies of the survey, signage, business cards about the evaluation, and a pre-paid, pre-addressed envelope that the sites used to mail the data back to the evaluation team after their events. Once all of the data was collected, the

evaluation team completed the data entry and analysis, and prepared individual site reports (see example at the end of this appendix) for each participating site as well as the aggregated Building with Biology Participant Impact Evaluation Report.

Overall, the passport and paper survey approach generated an amount and quality of data that pleased the evaluation team. However, as described in the methods section of the Building with Biology Participant Impact Evaluation Report, there are a number of questions and limitations about this approach. For instance, there was no way of ensuring fidelity to the prescribed data collection approach, and linking the survey to the passport may have biased the sample if the passport appealed to some audiences more than others. One potential affordance of a passport effort is that sites might be able to estimate their attendance numbers by tracking how many passports were distributed.

Reflections

In considering lessons learned from the testing of methods that took place during this project, the evaluation team has identified several recommendations:

- *Many methods can be valuable for evaluating PES.* Even after testing a range of methods for evaluating Building with Biology activities, evaluators were left with difficult questions about what the best approach would be for the final year of data collection, because there were so many factors to consider. The evaluation team's testing was only focused on one component of the project: public participants who interacted with the hands-on activities. The team used another approach to study the forum dialogue and discussion activities (paper surveys). Rockman Et Al led the summative evaluation for this project, and found it useful to gather data about event hosts and scientist volunteers through a combination of other methods, including site visit observations, online surveys, and interviews. A research team led by Drs. Gretchen Gano and Mahmud Farooque also gathered data about this project using observations, paper surveys, and artifacts that participants created as part of their Building with Biology experiences. Thus, even within this one project, a range of methods were used, which all generated valuable data. Other projects might wish to explore even more.

- *Passive data collection may not be sufficient.* This resource shares pros and cons from the current study, but does not intend to prescribe a certain approach will always be preferable for evaluating other PES events. As described above, there are many valuable ways to gather data about PES. In general, the testing for Building with Biology methods raised more trade-offs than clear preferences of one method over another. One exception was the passive data collection that the evaluators tested at Family Science Days. This method (a sign with a QR code that directed to an online survey and handing out cards with links to the online survey) did not generate enough data to be worthwhile. It is possible that other contexts would be more effective for this method, but the evaluators would caution sites about relying on this method. Another concern is that people who would take the effort to respond are likely to be those with strong (positive or negative) opinions, rather than a more systematic random sample.

- *Selecting a method should focus on the project's logistical considerations and evaluation questions.* While this project set out to explore methods for PES, it quickly became clear that options for data collection were limited, because this was a multi-site data collection effort that depended on inexperienced data collectors. These logistical factors necessarily influenced the selection of a method. Another factor that influenced the method selection was the phase of the project, its associated goals, and the evaluation questions. Observation data was valuable during the formative stage of the Building with Biology project, but could not answer the later evaluation stage's questions about learning, interest, and participant interest. Thus, what worked well for this project might not be applicable in other PES settings that have different logistics and evaluation questions.

- *There is continued opportunity to explore embedded data collection methods for PES.* It was highly encouraging that the Building with Biology passport—which was originally designed as an evaluation

tool—was adopted by the educational kit development team and disseminated as a part of all kits. This shows a synergy between the goals of evaluators and educators. Because PES is defined by a mutual exchange of information, there may be natural ways of integrating evaluation that capitalize on participants' contributions through dialogue, the creation of artifacts, or other mechanisms. Evaluators may also wish to consider whether it makes sense to think of themselves within the mutual learning ecosystem of PES: if an evaluator is learning from a participant (through the data she or he provides), how can the participant also be learning from the evaluator?

- *Evaluators should consider whether it makes sense to gather data from multiple audiences*. Another thing to consider about the fact that PES is defined by interaction between multiple audiences is whether an evaluation can truly capture PES by looking at a single audience. For example, this document focuses on public participants in hands-on activities, but does not discuss ways of gathering data about the scientists with whom the public interacted. In the Building with Biology project, the reason for this was that the summative evaluators were focused on evaluating the scientists' experiences while the internal team gathered data about the public. Because these two teams worked collaboratively throughout the process, they were able to gather complementary data that does show the impacts of PES on multiple audiences. If an evaluation group is looking to study a future PES event, it is encouraged that they find ways of measuring outcomes from all participating audiences to be able to describe both sides of the mutual learning.

Methods testing: Online survey for Family Science Days

Email Invitation

Dear Family Science Days Participant,

Thank you for visiting the Synthetic Biology Booth at Family Science Days. We hope you enjoyed your experience. When you visited our booth, you indicated that you might be willing to participate in a follow-up survey about your experience. If you would no longer like to participate, please disregard this email.

How long will it take?

- The entire survey should take about 5 minutes to complete.
- The survey includes some questions about your experience at the booth, your thoughts about synthetic biology, and some demographic questions to help put your responses into context.

Information about your participation:

- To take this survey, you must be 18 years of age or older.
- This survey is optional, and you can skip any questions or stop at any time.
- Your survey responses will be anonymous, meaning that your name and email address will never be associated with your responses.
- The information you provide will be used to improve experiences for visitors who participate in the National Science Foundation-funded Multi-Site Public Engagement with Science project.

Please find the survey here: [add link of duplicated survey]

Please complete this survey by February 28.

Thank you for participating and helping us improve our activities! Please contact Liz Kunz Kollmann at ekollmann@mos.org with any questions about this email or the survey.

Thanks,
[museum evaluator name]

Front Page

Thank you for your willingness to complete this online survey! The purpose of this survey is to get feedback from people who visited the Synthetic Biology Booth at Family Science Days on February 14, 2015.

Please complete this survey by February 28.

How long will it take?

- The entire survey should take about 5 minutes to complete.
- The survey includes some questions about your experience at the booth, your thoughts about synthetic biology, and some demographic questions to help put your responses into context.

Information about your participation:

- To take this survey, you must be 18 years of age or older.
- This survey is optional, and you can skip any questions or stop at any time.
- Your survey responses will be anonymous, meaning that your name and email address will never be associated with your responses.
- The information you provide will be used to improve experiences for visitors who participate in the National Science Foundation-funded Multi-Site Public Engagement with Science project.

Thank you for your willingness to participate and your efforts to improve our project!

Please contact Liz Kunz Kollmann at ekollmann@mos.org with any questions about the survey.

Survey Page 1

Thank you for visiting our booth about synthetic biology at Family Science Days! Your feedback on this survey will help us improve our activities for future use.

Definition: Synthetic Biology is an emerging field of research where researchers construct new biological systems and redesign existing biological systems. Experts in the fields of chemistry, biology, computer science, and engineering work together to create reusable, systematic methods for increasing the speed, scale, and precision with which we engineer biological systems. In a sense, synthetic biology can be thought of as the development of a biology-based "toolkit" that enables improved products across many industries, including medicine, energy and the environment.

1. **Do you find this definition confusing?**
    - Yes
    - No

2. [Branching – If answered yes to question 1]: **What about this definition do you find confusing?**

3. **What changes could we make to improve this definition?**

4. **Before visiting our booth, how much had you heard about synthetic biology?**
    - I hear about it all the time.
    - I hear about it often.
    - I have heard about it a few times.
    - I have never heard about it.

5. **After visiting our booth, how would you rate your confidence in your ability to do each of the following?** (select: not at all confident/somewhat confident/confident/extremely confident)
    - Name a product that uses synthetic biology.
    - Identify at least one way synthetic biology will impact your life.
    - Describe synthetic biology to a friend.

6. **How would you rate your interest in synthetic biology on a scale of 0 to 10?** (0=no interest, 10=extreme interest)

Survey Page 2

We are going to be holding a series of forum events across the country during which scientists and members of the public will get to discuss the societal and ethical implications of synthetic biology with each other. Here are some of the topics we're considering:

- Mosquito engineering: Should we release genetically modified mosquitoes with malaria-killing bacteria?
- Gene drives: Should we select which genes are inherited by future generations?
- Lab-cultured meat and milk: Should we eat foods created in a lab?
- 3-D bio printing: Should we print living organisms?
- De-extinction: Should we bring back species that are no longer found naturally?

7. **Please rank your interest in discussing these potential topics with scientists from 1 (most interested) to 5 (least interested).**
   - Mosquito engineering
   - Gene drives
   - Lab-cultured meat and milk
   - 3-D bio printing
   - De-extinction

8. **What other synthetic biology topics would you like to discuss with scientists?**

9. **Is there anything else you'd like to add about the Synthetic Biology Booth at Family Science Days?**

Survey Page 3

The following optional questions help us understand the audience for our activities.

10. **What is your age?**

11. **What is your gender?**
    - Male
    - Female
    - Other

Observation form for Family Science Days, Methods testing

DATA COLLECTOR: _____ DATE: _____ GROUP#: _____

Observation Form

Start time: _____ **End time:** _____ **Total time:** _____

Activity Name or Brief Description: _____

Facilitator Characteristics: Indicate the number of each type of facilitator(s).

No. of facilitators: _____

Facilitator type (check all that apply): ❑ Scientist ❑ Volunteer ❑ Student

❑ Museum Educator ❑ Non-Museum Educator ❑ Other: _____

Visitor Characteristics: Indicate the group type and the number of visitors in each age group.

No. of adults: _____

No. of children/youth: _____

Group seems to be (circle one): School or tour group Family or friend group

Intended Behaviors: Check the boxes and take notes below about the following actions of interest.

❑ **Facilitator shares** knowledge, values, or ideas with visitor
Notes/Quotes:

❑ **Visitor shares** knowledge, values, or ideas with facilitator
Notes/Quotes:

?

❑ **Facilitator asks** visitor a question
Notes/Quotes:

❑ **Visitor asks** facilitator a question
Notes/Quotes:

❑ The activity addresses **societal or ethical impacts** of science or technology
Notes/Quotes:

❑ The **visitor recommends** how science should or should not be applied
Notes/Quotes:

Observations: Describe the conversation and behaviors of the facilitator and group members.

Methods testing: Paper survey from pilot year

Event Survey

Are you 18 or older? If so, help us improve the Building with Biology event and activities! Participation is voluntary, and all responses are anonymous. If you are under 18, ask an adult to do this survey for you.

1. Thinking about your experience at this Building with Biology event, how much do you agree or disagree with each of the statements below? (Please check)

	Strongly disagree	Disagree	Agree	Strongly agree
I shared my views about synthetic biology.				
I learned about viewpoints different from my own.				
I considered the pros and cons of synthetic biology.				
I am more informed about synthetic biology now than I was before this event.				
I enjoyed this event.				

2. Were you aware that some of the people facilitating activities at this event were scientists?

☐ Yes ☐ No ☐ Unsure ☐ Other (please explain):

3. What, if anything, did you learn from interacting with these scientists?

4. What, if anything, did you learn from participating in the event overall?

5. **How much did this event increase your interest in the following activities?** (Please check)

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology				
Learning how synthetic biology is connected to my daily life				
Talking to a scientist about the impacts of scientific research in my community				
Sharing my views about synthetic biology with friends and family				

6. **What, if anything, did you value about your participation in the Building with Biology event?**

7. **What, if anything, would you change to improve this event for you and your group members?**

8. **What applications of synthetic biology would you like scientists and engineers to work on?** (Please check all that apply)

☐ Agriculture ☐ Fuel ☐ Software
☐ Electronics ☐ Medicine ☐ Other: _____
☐ Food ☐ Personal Care ☐ None of the above

9. **How do you think synthetic biology might change your life in the future?**

10. What question would you most like to ask a scientist about synthetic biology?

11. About how many activities do you think you visited at this event? (Please check one)

☐ 0-1 ☐ 2-5 ☐ 6 or more

12. What is your age? _____ 13. What is your gender? _____

14. Who visited the museum with you today? (Please check one)

- ☐ I am here alone.
- ☐ I am here with a school or tour group.
- ☐ I am here with family or another social group that includes children/youth and adults.
- ☐ I am here with family or another social group that includes adults only.

THANK YOU for completing this survey! Your input will help us improve future events.

Methods testing: Passport survey from pilot year

Passport Survey

Are you 18 or older? If so, help us improve the Building with Biology event and activities! Participation is voluntary, and all responses are anonymous. If you are under 18, ask an adult to do this survey for you.

7. **Thinking about your experience at this event, how much do you and your group members agree or disagree with each of the statements below?** (Please check)

	Strongly disagree	Disagree	Agree	Strongly agree
I shared my views about synthetic biology.				
I learned about viewpoints different from my own.				
I considered the pros and cons of synthetic biology.				
I am more informed about synthetic biology now than I was before this event.				
I enjoyed this event.				

8. **Were you and your group members aware that some of the people facilitating activities at this event were scientists?** (Please check)

☐ Yes ☐ No ☐ Unsure ☐ Other (please explain):

10. **What, if anything, did you and your group members learn from interacting with these scientists?**

11. **What, if anything, did you and your group members learn from participating in the event overall?**

12. How much did this event increase your group's interest in the following? (Please check)

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology				
Talking to others about the impacts of scientific research in my community				
Learning how synthetic biology is connected to my daily life				

13. What, if anything, did you and your group members value about your participation in the event?

14. What, if anything, would you change to improve this event for you and your group members?

15. What applications of synthetic biology would you and your group members like scientists and engineers to work on? (Please check all that apply)

☐ Agriculture ☐ Fuel ☐ Software
☐ Electronics ☐ Medicine ☐ Other: _____
☐ Food ☐ Personal Care ☐ None of the above

16. How do you and your group members think synthetic biology might change your life in the future?

10. What question would you and your group members most like to ask a scientist about synthetic biology?

11. How many stamps did you collect on each page of your passport? (Fill in the boxes below)

Ask a volunteer a question	Write on the graffiti board	Tell a volunteer what's good and bad about synthetic biology	Talk to a scientist

12. What are the ages and genders of your group members? (Fill in the table below)

	Group member 1	**Group member 2**	**Group member 3**	**Group member 4**	**Group member 5**	**Group member 6**
Gender (circle)	Male Female Other	Male Female Other	Male Female Other	Male Female Other	Male Female Other	Male Female Other
Age (write in)						

THANK YOU for completing this survey! Your input will help us improve future events.

Methods testing: Passport from pilot year

Building with Biology

Building with Biology

Event Passport

#buildingwithbiology

Building with Biology

What is synthetic biology?

Synthetic biology uses new techniques combining biology and engineering to make new or modified things and materials.

About this event

In 2015, eight science museums across the United States are hosting Building with Biology events. During these events, scientists and members of the public will talk about the ways synthetic biology could impact society.

This event is supported by the National Science Foundation under Grant No. DRL-1421179.

Building with Biology

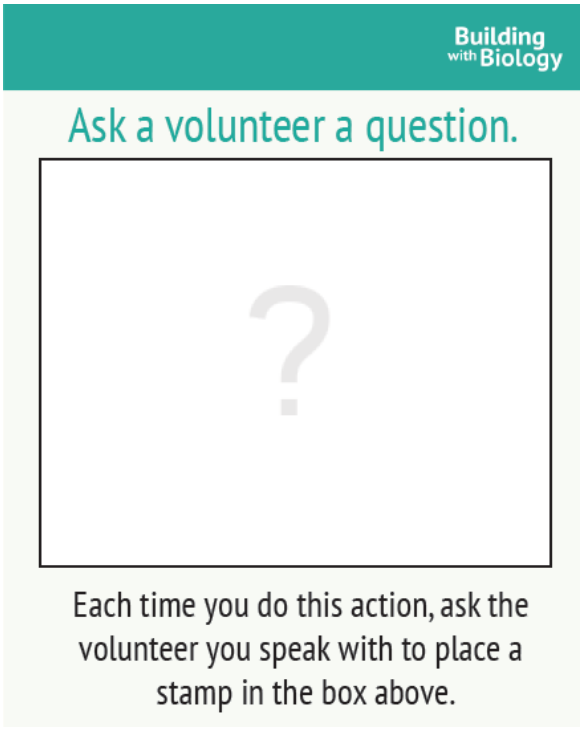
Using this passport

This passport will guide your interactions with the volunteers leading activities at this event.

Ask a volunteer to stamp your passport each time you:

- Ask a volunteer a question
- Answer the question on our graffiti board
- Tell a volunteer what you like and don't like about synthetic biology
- Talk to a scientist
- Visit the Survey & Completion Station

How many stamps can you collect? If you gather at least one stamp for each of the five actions, you will earn a completion sticker!



Building with Biology

Ask a volunteer a question.

Each time you do this action, ask the volunteer you speak with to place a stamp in the box above.

Building with Biology

How might synthetic biology change your life in the future?

Write your answer on a sticky note & put it on our graffiti board.

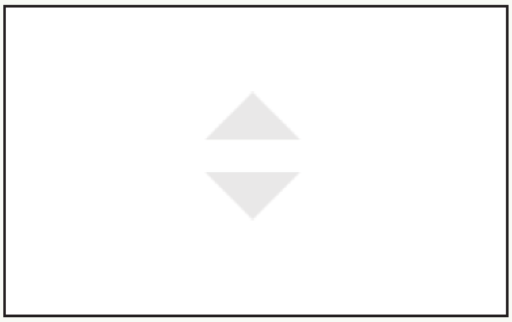
When you do this, ask the volunteer at the graffiti board to put a stamp in the box above.

Did you know?

Some of the volunteers at this event are professional scientists, researchers, and university students!

Building with Biology

Tell a volunteer what you like and don't like about synthetic biology.



Each time you do this action, ask the volunteer you speak with to place a stamp in the box above.

Building with Biology

Talk to a scientist!

Look for scientist volunteers wearing "I'm a scientist" stickers.

Each time you do this action, ask the scientist you speak with to place a stamp in the box above.

Building with Biology

Visit the Survey & Completion Station!

You will earn a stamp just for visiting this station.

We hope you'll tell us what you thought of this event. Adults are invited to fill out a brief, optional survey. You can also use **#buildingwithbiology** to share your ideas.

Are you done?

If you have at least one stamp on each page, get your **completion sticker** at the Survey & Completion Station.

Methods testing: Protocol for pilot year email collection

Data Collection Guidelines – Visitor Email Collection

Data Collection Goals and Timeline:

- Sites collect email addresses from 50 adult visitors to the Building with Biology events.
- No more than 3 days after the Building with Biology event, sites use the enclosed addressed and stamped envelope to mail the emails to the Museum of Science. A digital copy of the email signup sheet is sent to ktodd@mos.org.
- Preliminary findings will be shared at the in-person MSPES Results Meeting in Montréal on October 20, 2015.

Sampling and Eligibility:

Unit of Measure: Individual adult visitor (age 18 or older)
Sampling Location: Building with Biology event
Age Range: Adults age 18 and older
Sampling Method: Approach every other individual adult visitor to cross an imaginary line

Equipment/Supplies Needed:

- Email Signup for Event Survey sheets
- Pens or pencils
- Evaluation Information cards

Action Checklist:

- ☐ Identify at least one data collector who has completed human subjects training and can be available to collect email addresses during the Building with Biology event.
- ☐ Have the data collector read this protocol document thoroughly.
- ☐ Develop a plan for data collection during your event (time, location, etc.).
- ☐ Collect email addresses from at least 50 adult visitors.
- ☐ Scan the email addresses and send them to ktodd@mos.org no more than 3 days after your event.
- ☐ Use the enclosed envelope to mail the email signup sheets to the Museum of Science no more than 3 days after your event.

Planning:

- Designate a data collector to gather email addresses during a period of your event when you expect a steady flow of people.

- **The data collector needs to have completed human subjects training**, and the Museum of Science must have a copy of his or her completion certificate.
- We recommend planning to collect email addresses for at least 2 hours in order to meet the requirement of 50 email addresses.
- The data collector should stay with the sign-up sheet to tell people about the opportunity, ask them to sign up if they are willing, and answer any questions.
- If you leave your email collection to the end of the day, you may not be able to meet the requirement.
- Identify an area of the Building with Biology event with regular traffic flow. The entrance or exit may be good choices. Ideally, find a table space where visitors will be able to write easily. If no table space is available, the data collector should stand in a designated area with the clipboard.

Email Collection Information:

- The data collector should approach the second adult to pass an imaginary line at the place of data collection.
- The data collector should use the script below to describe the evaluation and ask visitors to sign up.
- Official informed consent will be part of the survey.
- The data collector should count the number of email signups and make sure at least 50 adults provide their emails.
- If the data collector is unsure whether the visitor is age 18 or older, the data collector should ask.
- The data collector should encourage visitors to write legibly.

Introductory Script:

Hi, my name is [Name], and I work here at [museum name]. We are trying to get feedback about the Building with Biology event, and we would like to know what you think about it. Would you be willing to provide your email so we can send you a brief online survey?

[If yes] Thank you! You can expect to see the email in the next week.
[If no] Have a great day!

Survey Information:

- Visitors will receive an email with a link to an online survey no more than one week after the event.
- The visitor's email address will not be used for any purposes other than sending the link to the survey.
- The survey will take about 10 minutes.
- All data collected on the survey will be anonymous. The visitor's name will never be associated with the data.
- The data will help us improve Building with Biology events for future participants.

- The survey should not make the visitor uncomfortable; there are no expected risks.
- Evaluation Information cards should be available at your Building with Biology event. These cards provide contact information in case visitors have any questions about the evaluation.
- Additional questions should be directed to Liz Kunz Kollmann at ekollmann@mos.org.

Refusal/Termination Information:
Thank visitors even if they choose not to participate.

Data Management:
Once the email addresses have been collected, scan them and email them to ktodd@mos.org. The paper sheets should then be mailed to the Museum of Science so they can be entered, stored, and destroyed in accordance with IRB protocols. **It is very important that sites mail the email addresses within 3 days of the event so the Museum of Science Research and Evaluation Team can enter them and send the digital surveys to the visitors while the event is still fresh in their minds!**

Methods testing: Protocol for pilot year paper surveys

Data Collection Guidelines – Visitor Survey

Data Collection Goals and Timeline:

- Collect paper surveys from at least 20 visitor groups at your Building with Biology event.
- No more than 3 days after the Building with Biology event, scan the surveys and send them to ktodd@mos.org. Mail paper surveys to the Museum of Science in the enclosed envelope.
- Preliminary findings will be shared at the in-person MSPES Results Meeting in Montréal on October 20, 2015.

Sampling and Eligibility:

Unit of Measure: Each visitor group with at least one adult is eligible to complete one survey
Sampling Location: Exit of Building with Biology event
Sampling Method: Approach every other individual adult visitor to cross an imaginary line
Age Range: Adults age 18 or older
Group Type: Adult only groups, adults visiting alone, and family groups with at least one adult

Equipment/Supplies Needed:

- Paper copies of Event Survey
- Location with a flat writing surface such as a table, desk, or clipboard
- Pens or pencils
- Envelope for completed surveys
- Evaluation Information cards

Action Checklist:

- ☐ Identify at least one data collector who has completed human subjects training and can be available to collect surveys during the Building with Biology event.
- ☐ Have the data collector read this protocol document thoroughly.
- ☐ Develop a plan for data collection during your event (time, location, etc.).
- ☐ Collect surveys from at least 20 groups with at least one adult visitor.
- ☐ Scan the surveys and send them to ktodd@mos.org no more than 3 days after your event.
- ☐ Use the enclosed envelope to mail the surveys to the Museum of Science no more than 3 days after your event.

Planning:

- Designate a data collector to gather surveys during a period of your event when you expect a steady flow of people to be completing their visit.
- **The data collector needs to have completed human subjects training**, and the Museum of Science must have a copy of his or her completion certificate.
- We recommend planning to do data collection for at least 2 hours in order to meet the requirement of 20 surveys.
- If you leave your data collection to the end of the day, you may not be able to meet your target.
- Identify an area near the exit of the Building with Biology event where visitors can complete the survey in a comfortable environment that is out of the flow of traffic. If possible, provide a space to sit. If you do not have a clipboard, make sure there is a desk or suitable writing surface.

Survey Information:

- The data collector should approach every other group (group being defined as a collection of people including at least one adult) to cross an imaginary line near the exit of the Building with Biology event.
- The data collector should use the script below to gather verbal informed consent from an adult member of the group who will fill out the survey.
- If it is unclear whether a guest is age 18 or older, the data collector should ask.
- If the group consents, the data collector should hand over the survey and pen/pencil and direct the group to a suitable place to complete the survey.
- The data collector should step aside while the group completes the survey.
- Each group should complete one survey, no matter how many people are in the group.
- When the group is finished, the data collector should thank the group and collect the survey and pen/pencil.
- The data collector should fill in the header of the survey with his or her initials, site name, time, and survey number (i.e., 1-20). Completed surveys should be stored in an envelope, away from visitors' reach.
- Repeat the process to collect surveys from at least 20 groups.
- A digital copy of the survey is also available for sites that have kiosks or tablets for data collection. In this case, the data collector should provide the same informed consent language but use the technology instead of the paper survey. The link to the survey is: http://mos.fluidsurveys.com/s/buildingwithbiologypaper/
- Evaluation Information cards should be available at your Building with Biology event. These cards offer contact information for any visitors who have questions about the evaluation.
- Additional questions should be directed to Liz Kollmann at ekollmann@mos.org.

Introductory Script:
Hi, my name is [Name], and I work here at [name of museum]. We are trying to get feedback about the Building with Biology event you just experienced, and we would like to know what you think about it. Would you be willing to fill out a brief survey about your experience? It should only take about 5 minutes. Your answers will be anonymous, you can quit at any time, and you can choose not to answer a question if you want. It shouldn't make you uncomfortable at all, and it would help us design activities that will be more fun for you and everyone else in the future. Would that be okay?

[If yes] Thank you!
[If no] Have a great day!

Refusal/Termination Information:

- Thank visitors even if they choose not to participate.
- Be sure to collect at least 20 complete surveys. Any incomplete surveys should still be sent to the Museum of Science, but these incomplete surveys do not count towards the requirement of 20 surveys.

Data Management:
Once a group returns the survey, use the header on the survey to record researcher initials, site name, time, and survey number (i.e., 1-20). After the event, scan the paper surveys and send them to ktodd@mos.org. All paper surveys should also be mailed to the Museum of Science in the enclosed envelope so they can be entered, analyzed, stored, and destroyed in accordance with IRB protocols.

Data Collection Guidelines – Passport

Data Collection Goals and Timeline:

- Sites offer passports to at least 100 visitors at the Building with Biology events.
- No more than 3 days after the Building with Biology event, sites use the enclosed addressed and stamped envelope to mail the surveys to the Museum of Science. A digital copy of the data is sent to ktodd@mos.org.
- Preliminary findings will be shared at the in-person MSPES Results Meeting in Montréal on October 20, 2015.

Sampling and Eligibility:

Unit of Measure: Each individual visitor may get a passport

Age Range: Any age may complete the passport, but only adults may complete the survey. Children may get a passport stamp for the survey if an adult completes the survey for them.

Equipment/Supplies Needed:

- Event Passports
- Marker stamps – 1 for each station
- Passport Surveys
- Envelope for completed paper surveys
- Pens or pencils
- "I'm a scientist" stickers
- Completion stickers
- Signs and sign stands for passport distribution station and passport completion stations
- Passport postcards – 1 per station
- Evaluation Information cards

Action Checklist:

- ☐ Identify and train at least one person who can distribute passports.
- ☐ Identify at least one data collector who has completed human subjects training and can be available to collect surveys at the passport completion station during the Building with Biology event.
- ☐ Have the data collector read this protocol document thoroughly.
- ☐ Train volunteers about stamping passports at the event.
- ☐ Identify and train at least one person to provide passport stamps for visitors who complete the graffiti board (depending on your setup, roles could be combined).

- ☐ Set up each activity station with a stamp marker, a passport postcard, and an "I'm a scientist" sticker (as applicable).
- ☐ Set up the graffiti board and ensure someone can stamp passports for it during the event.
- ☐ Distribute passports to guests, tracking how many passports are distributed.
- ☐ Provide guests with completion stickers when they visit the Survey & Completion Station if they have finished their passports.
- ☐ Collect paper surveys at the Survey & Completion Station (only adults can complete this survey).
- ☐ Scan all paper surveys following the event and send to ktodd@mos.org.
- ☐ Use the enclosed envelope to mail the surveys to the Museum of Science no more than 3 days after your event.

Overview:

Visitors will receive passports and earn stamps for completing a series of actions at the events. If a visitor earns at least one stamp for each action, he or she will earn a completion sticker. There will be five actions that earn stamps:

5. Asking a volunteer a question.
6. Putting a post-it on the graffiti board with their answer to a question.
7. Telling a volunteer what's good and bad about synthetic biology.
8. Talking to a scientist.
9. Visiting the Survey & Completion Station. *NOTE: The data collector should invite all adult visitors to fill out the survey, but completing the survey is optional. Visitors can receive a stamp simply for visiting this station. Children are not eligible to complete the survey, but adult members of their group can fill out the survey for them.*

Planning:

- Designate a person to explain and distribute passports to visitors at the beginning of the event. This person should track how many passports are given to visitors. This number will need to be reported to the Museum of Science.
- NOTE: Your kit includes 100 passports. You are welcome to print additional copies using the files you will receive by email.
- Designate a person to manage the survey data collection and give out completion stickers. **This person needs to have completed human subjects training**, and the Museum of Science must have a copy of his or her completion certificate.
- Designate and train a person who will manage the graffiti board and stamp visitors' passports when they put sticky notes on the graffiti board.
- It may be possible for these roles to be combined or shared with other roles, depending on the format and schedule of your event.

Volunteer orientation:

- At your volunteer orientation, you will need to tell volunteers about the passports.
- Each volunteer will need to be prepared to stamp visitors' passports if:
  - Visitors ask the volunteer a question
  - Visitors tell the volunteer what they think is good or bad about synthetic biology
- Volunteers who are scientists should wear "I'm a scientist" stickers at the event. These volunteers should be ready to stamp passports if:
  - Visitors talk to the scientist volunteer
- The person at the graffiti board will need to stamp passports if:
  - Visitors post on the graffiti board about how they think synthetic biology will change their future

Setup:

- Make sure every activity station has a stamp marker.
- Make sure every volunteer knows about the passport program and is ready to provide stamps as applicable.
- Give "I'm a scientist" stickers to volunteer scientists and ask them to wear them visibly.
- Set up the entry station with blank passport booklets and the Get Your Passport Here sign and sign stand.
- Set up the passport exit station with the Passport Survey & Completion Station sign and sign stand, paper surveys, pens/pencils, envelope for completed surveys, and stickers.

Passport Information:

- Offer passports to every individual entering the event.
- Describe the program, saying that the passport encourages conversations with scientists and volunteers, and gathers their feedback about synthetic biology and the event. If a visitor completes the passport, he or she will receive a completion sticker.
- Participation in the program is optional.
- Throughout the event, visitors will have discussions with volunteers at their activities and will collect their passport stamps.
- At the Survey & Completion Station, the data collector should ask adult visitors for consent to complete the survey using the script below. Only adults can fill out surveys. If a visitor is under 18, an adult can fill out the survey for the child. The survey is optional, so visitors can receive a stamp just for visiting this station.
- The data collector should step aside while the participants complete the survey.

- When the visitor is finished, the data collector should thank the participant, collect the survey, and give the visitor a passport stamp. If the visitor chose not to do the survey, the data collector should still provide a passport stamp.
- After collecting the survey, the data collector should fill in the header of the survey with his or her initials, the site, the survey number, and the time.
- Completed surveys should be placed in the enclosed envelope, out of visitors' reach.
- If a visitor has collected all of the passport stamps (or all but the survey stamp), the visitor may receive a completion sticker.
- Visitors may take their passports home.

Informed Consent Script:
Hi, my name is [Name], and I work here at [name of museum]. We are trying to get feedback about the Building with Biology event, and we would like to know what you think about it. Would you be willing to fill out a brief survey about your experience? It should only take about 5 minutes. Your answers will be anonymous, you can quit at any time, and you can choose not to answer a question if you want. It shouldn't make you uncomfortable at all, and it would help us design activities that will be more fun for you and everyone else in the future.

[To participant]: Would you be willing to participate?
[If yes] Thank you!
[If no] Have a great day!

Refusal/Termination Information:

- Thank visitors even if they choose not to participate.
- Because the survey is optional, visitors can still get the passport stamp and earn a completion sticker even if they choose not to do the survey.
- If the participant starts the survey but does not complete it, please still send it to the Museum of Science.

Data Management:
Once an individual returns the survey, the data collector should use the header on the survey to record researcher initials, site name, time, and survey number. Paper surveys should be scanned and sent to ktodd@mos.org. All paper surveys should be sent to the Museum of Science in the enclosed envelope so they can be entered, analyzed, stored, and destroyed in accordance with IRB protocols.

Methods testing: Public context document for pilot year

Pilot Events – Summer 2015

Data Collected from Visitors at Building with Biology Events

Introduction

In the summer of 2015, the Multi-Site Public Engagement with Science—Synthetic Biology project (DRL 1421179) held a series of eight Building with Biology pilot events which were designed to foster Public Engagement with Science (PES) about synthetic biology by having scientist volunteers interact and have discussions with the public through hands-on activities and forums. The events took place at:

- Arizona Science Center (Phoenix, AZ)
- Chabot Space and Science Center (Oakland, CA)
- Museum of Life and Science (Durham, NC)
- Museum of Science, Boston (Boston, MA)
- New York Hall of Science (New York, NY)
- Pacific Science Center (Seattle, WA)
- Science Museum of Minnesota (Saint Paul, MN)
- Sciencenter (Ithaca, NY)

This summary document shares evaluation findings from these pilot events that describe their impacts on public participants and offer data about potential areas for change when the events are replicated at 200 sites in 2016. The document focuses specifically on the experiences of public visitors to the Building with Biology events who interacted with hands-on activities. The document addresses the following evaluation questions:

- What do publics learn from their PES experience?
- What do publics learn from scientists?
- Does participation increase public participants' interests in PES or synthetic biology? If so, how?
- What follow-up behaviors does participation prompt in public audiences?
- What do publics value about their participation in PES?

To learn more about what evaluation can say about volunteers' experiences or the forums, please see the separate documents about those topics.

Data collection

During the Building with Biology pilot events in 2015, sites collected data from public visitors through one of three survey methods. The reason for the variety in methods was to pilot data collection for next summer and understand the methods that might work the best when Building with Biology is expanded to 200 sites in summer 2016. The Passport Survey was a paper survey that visitors completed at the event as part of a passport activity. The Event Survey was a stand-alone paper survey that visitors filled out at the event. The Online Visitor Survey required data collectors to gather email addresses from visitors so the survey could be sent after the event. This document summarizes data from all three surveys. Each of the three surveys was slightly different. Some questions were asked on only one survey, while some questions were on all three. Throughout the document, we will use the following symbols to indicate which surveys' data are being shared:

- The Passport Survey (n=33) will be marked by a superscript P: ^{P}
- The Event Survey (n=34) will be marked by a superscript E: ^{E}
- The Online Visitor Survey (n=18) will be marked by a superscript O: ^{O}

In some cases, there were slight wording variances in the questions because of the time that the survey was collected or to test different questions. In terms of the timing of survey implementation, the Online Visitor Survey was completed after the event, so questions were in the past tense. The Passport Survey and Event Survey were completed at the event, so those questions were in the present tense. In terms of testing different questions, the Passport Survey asked respondents to consider the experiences of other group members while the Online and Event Surveys asked only about the individual's experience. The Evaluation Team reviewed the data and found that there were no notable differences in the responses based on the different question wordings, so data have been combined for this document. Additionally, the surveys asked multiple questions (11 and 12) about learning. The reason for this was to understand if there were any differences in what publics learned from the events as opposed to the scientists. The Evaluation Team will be revisiting all of these questions to make final determinations about the best wording choices for the summer 2016 data collection.

Data analysis

Quantitative data from this survey were analyzed descriptively using counts, percentages, and averages as appropriate. Qualitative data were coded inductively or, when possible, using pre-defined code lists developed from prior evaluation of PES projects. These pre-defined code lists make it easier to compare responses within and across surveys. For example, the two questions in the learning section of this document ask visitors to use their own words to describe what they learned from scientists and from the event overall. While the two questions are different and the individual responses were different, the

data were coded based on their thematic content, as defined by the same code lists for both questions. This means that you can compare how, for instance, 12 visitors noted they learned facts about synthetic biology from scientists, whereas 5 visitors noted that they learned facts about synthetic biology from the event overall.

Themes within the data

These data present several descriptive themes that will be further explored through additional data collection in 2016. The themes are listed below, with the relevant question number(s) from the data in parentheses for reference. You will also find boxes in this document with questions to consider based on these themes:

- Visitors to Building with Biology events had a range of experiences, but most found the events enjoyable and reported increased interest in follow-up behaviors about synthetic biology (2, 3, 6 – 9).
- Visitors reported learning about synthetic biology and how it interacts with society. To a lesser degree, they learned about the scientist volunteers. This learning about synthetic biology was also seen from forum respondents, but forum participants rarely mentioned learning about the significance of synthetic biology and did not discuss learning about the benefits of synthetic biology (10 – 12, compare to forum data question 6, 7).
- Overall, visitors valued learning and interacting with experts (13).
- While visitors reported learning from the events, some of the data suggest that visitors were less likely to feel like they contributed to the events (6).
- One survey question asked visitors whether they considered the benefits of synthetic biology. All respondents agreed that they had considered these benefits. However, when visitors were asked whether they considered the risks of synthetic biology or weighed its pros and cons, not everyone agreed. Therefore, visitors seemed to consider the benefits of synthetic biology more than they weighed pros and cons or considered the risks of synthetic biology (5).
- Some visitors valued the event as a positive experience for children, whereas some felt the event could be improved for younger audiences (13, 14).
- Visitors who interacted with the hands-on activities valued different things from forum participants. While both groups valued access to information and experts, those who interacted with hands-on activities valued the positive experience for children and the topic of synthetic biology, two topics that forum participants did not mention valuing. In contrast, forum participants most valued hearing diverse viewpoints, which was much less prominent among visitors to the hands-on activities (13, compare to forum data question 8).

Questions to consider

These data raise several questions to consider as the 2016 Building with Biology events are planned:

- How could the events be adjusted so they increase visitors' balanced consideration of the pros, cons, risks, and benefits of synthetic biology?
- How could the activities, or the way they are facilitated, be improved so they offer visitors more opportunities to share their views about synthetic biology?
- How could the activities, or the way they are facilitated, be adjusted so they offer visitors more opportunities to learn about viewpoints different from their own?

How do we want to address data that suggest Building with Biology events could be improved for children in a way that does not negatively impact public engagement with science goals?

Authorship

This document was created by the multi-institutional evaluation team for the Multi-Site Public Engagement with Science project. Members of this team include Sarah Cohn (Science Museum of Minnesota), Elizabeth Kollmann (Museum of Science, Boston), Angie Ong (Spotlight Impact), Sarah Pfeifle (Museum of Science, Boston), and Katie Todd (Museum of Science, Boston). Any questions about this document or the evaluation of this project should be directed to the team leader, Elizabeth Kollmann, at ekollmann@mos.org.

Presentation of data

The following sections present data collected from public participants at the eight Building with Biology pilot events that were held in the summer of 2015. Data are organized by theme.

Visitors represented a range of ages, genders, and group types.

Demographics of survey respondents

1a. What is your age? [E, O]

	Responses (n=44)
Minimum	18
Maximum	68
Mean	43.4
Standard deviation	11.5

Demographics of group members

1b. What are the ages of your group members? [P]

	Responses (n=85)
Minimum	2
Maximum	72
Mean	25.1
Standard deviation	19.3

1c. What is your gender? [E, O]

	Responses (n=46)
Female	63%
Male	37%

1d. What are the genders of your group members? [P]

	Responses (n=85)
Female	58%
Male	42%

1e. Who visited the museum with you today? [E, O]

	Responses (n=48)
I am here with a group that includes children and adults	73%
I am here with an adult-only group	23%
I am here alone	4%

Most groups engaged with at least two activities.

2. How many activities do you think you visited at this event? [E]

	Responses (n=30)
0-1	7%
2-5	60%
6 or more	33%

3. How many stamps did you collect on each page of the passport? [P] (n=26)

This question asked about four actions for which passport holders could earn stamps. Visitors could do the actions multiple times and collect as many stamps as they wished, except that the graffiti board was designed so that most visitors would only do that action once. This table shows the percentage of passport survey respondents who did each action, and the average number of times respondents did the actions.

Talk to a scientist	
Respondents who got a stamp	96%
Average number of stamps collected	4.4
Ask a volunteer a question	
Respondents who got a stamp	96%
Average number of stamps collected	3.4
Tell a volunteer what's good and bad about synthetic biology	
Respondents who got a stamp	85%
Average number of stamps collected	2.4
Write on the graffiti board	
Respondents who got a stamp	73%
Average number of stamps collected	1.1

Most respondents knew that some of the volunteers were scientists.

4. Were you aware that some of the people who facilitated the activities at this event were scientists? [P, E, O]

	Responses (n=84)
Yes	90%
No	4%
Unsure	6%

Respondents considered the benefits of synthetic biology, but some did not consider the pros and cons or the risks.

5. Thinking about your experience at this event, how much do you agree or disagree with each of the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
I considered the pros and cons of synthetic biology. (n=63) [P, E]	5%	10%	67%	19%
I considered the benefits of synthetic biology. (n=18) [O]	0%	0%	67%	33%
I considered the risks of synthetic biology. (n=18) [O]	0%	17%	56%	28%

? Question to consider: How could the events be adjusted so they increase visitors' balanced consideration of the pros, cons, risks, and benefits of synthetic biology?

Visitors enjoyed the events but some did not feel like they contributed.

6. Thinking about your experience at this event, how much do you agree or disagree with each of the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
I enjoyed this event. (n=84) [P, E, O]	2%	1%	37%	60%
I would recommend this event to others. (n=18) [O]	0%	0%	50%	50%
I would come to another event like this. (n=18) [O]	0%	0%	50%	50%
I shared my views about synthetic biology. (n=83) [P, E, O]	6%	17%	51%	27%

? Question to consider: How could the activities, or the way they are facilitated, be improved so they offer visitors more opportunities to share their views about synthetic biology?

Groups felt the events increased their behavior and future interest in synthetic biology activities.

7. Since the Building with Biology event, have you done any of the following? (Check all that apply) [o]

	Responses (n=18)
Paid more attention to references to synthetic biology in print, TV or radio	90%
Explained what synthetic biology is to others	60%
Discussed the pros and cons of synthetic biology	60%
Searched for more information about synthetic biology	40%
Knowingly purchased products that used synthetic biology	20%

8. How would you rate your interest in the following activities? [o]

	Not at all	Somewhat Interested	Interested	Extremely Interested
Learning how synthetic biology is connected to my daily life				
Before participating in this event (n=18)	6%	28%	44%	22%
After participating in this event (n=16)	0%	25%	38%	38%
Sharing my views about synthetic biology with friends and family				
Before participating in this event (n=18)	17%	39%	33%	11%
After participating in this event (n=16)	6%	31%	25%	38%
Checking out news stories (online, TV, and/or print) about synthetic biology				
Before participating in this event (n=18)	6%	39%	39%	17%
After participating in this event (n=16)	0%	25%	38%	38%
Talking to others about the impacts of scientific research in my community				

Before participating in this event (n=18)	11%	39%	28%	22%
After participating in this event (n=16)	0%	13%	50%	38%

9. How much did this activity increase your group's interest in the following activities?

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology (n=63) [P, E]	2%	22%	46%	30%
Learning how synthetic biology is connected to my daily life (n=63) [P, E]	2%	13%	41%	44%
Talking to a scientist about the impacts of scientific research in my community (n=33) [E]	9%	21%	24%	45%
Sharing my views about synthetic biology with friends and family (n=32) [E]	3%	19%	38%	41%
Talking to others about the impacts of scientific research in my community (n=30) [P]	3%	20%	60%	17%

Visitors learned from interacting with scientists and participating in Building with Biology events.

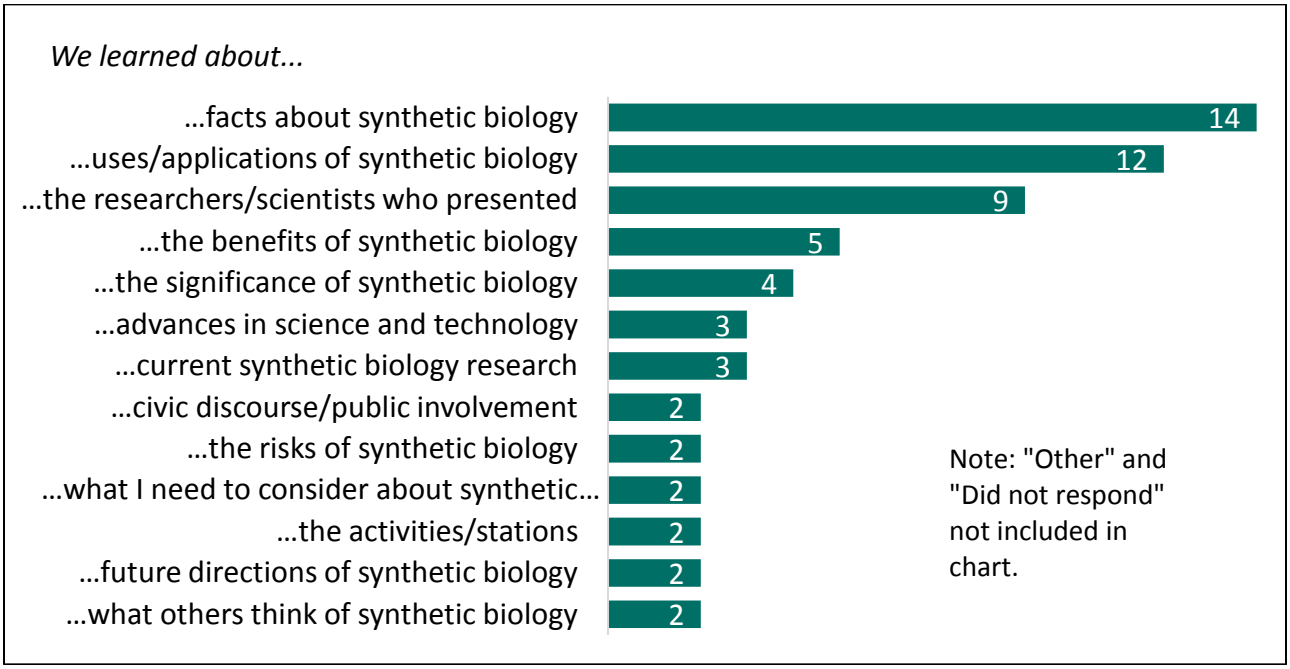
10. Thinking about your experience at this event, how much do you agree or disagree with each of the statements below?

	Strongly disagree	Disagree	Agree	Strongly agree
I am more informed about synthetic biology now than I was before this event. (n=82) [P, E, O]	5%	2%	49%	44%
I learned about viewpoints different from my own. (n=84) [P, E, O]	4%	10%	52%	35%

? Question to consider: How could the activities, or the way they are facilitated, be adjusted so they offer visitors more opportunities to learn about viewpoints different from their own?

11. *What, if anything, did you and your group members learn from interacting with these scientists? (n=58)* [P, E, O]

This open-ended question was coded using an existing code list. The chart here shows the number of responses per theme, and the table below lists example quotations for each coded theme. In some cases, a single response may be counted in more than one code.

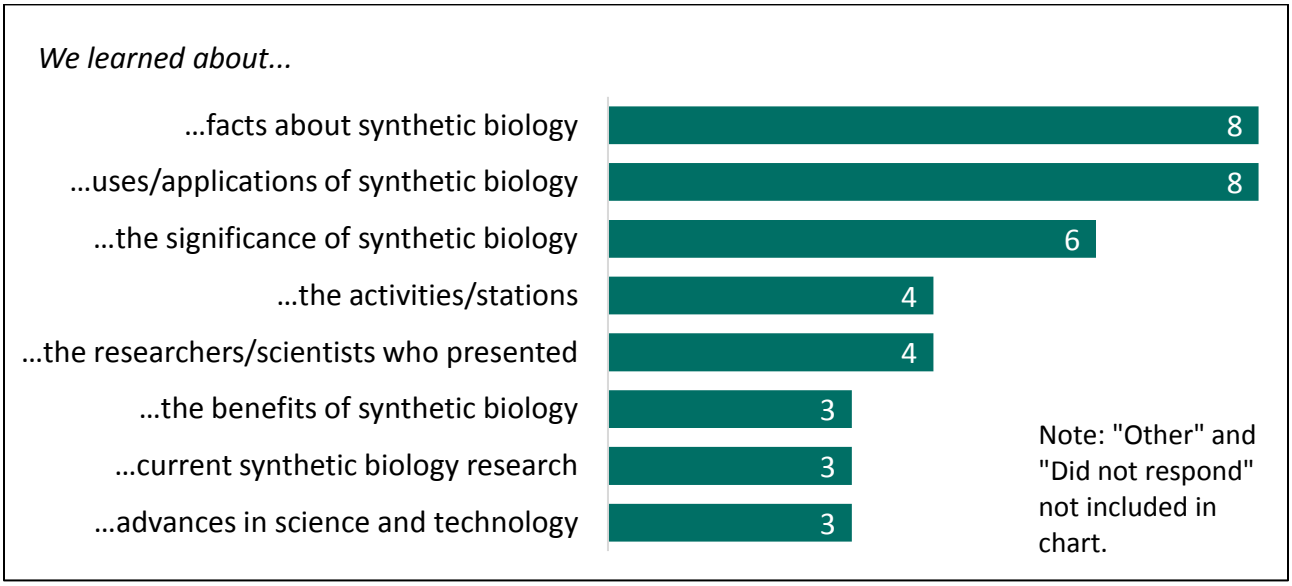


Code	Example Quotes
Facts about synthetic biology	"About different genes, and genome hybrids and disease fighters."
Uses/applications of synthetic biology	"The role synthetic biology can play in vaccines."
Researchers/scientists who presented	"Their devotion and passion for experimentation."
Benefits of synthetic biology	"It sounds like there is a lot of potential for good."
The significance of synthetic biology	"We can change problems we thought were unchangeable."
Advances in science or technology	"The different things scientists can do; great for career exploration. Also, being a scientist is fun!"
Current synthetic biology research	"It was great hearing about the diversity of projects that involve bioengineering."
Civic discourse or public involvement	"The field is fascinating and needs more attention (and resources) from the public."

Risks of synthetic biology	"There are many pros but the cons of GMO is dangerous."
What I need to consider about synthetic biology	"That I am uncomfortable with aspects related to food. Would like more explanation about pros and possible harms due to GMOs."
The activities/stations	"Fun projects. Most designed for older than our kid (2 yr)."
Future directions of synthetic biology	"How it will be used in the future."
What others think of synthetic biology	"I got to think about different viewpoints."

12. What, if anything, did you and your group members learn from participating in the event overall? (n=52) [P, E, O]

This open-ended question was coded using an existing code list. The chart here shows the number of responses per theme, and the table below lists example quotations for each coded theme. In some cases, a single response may be counted in more than one code.



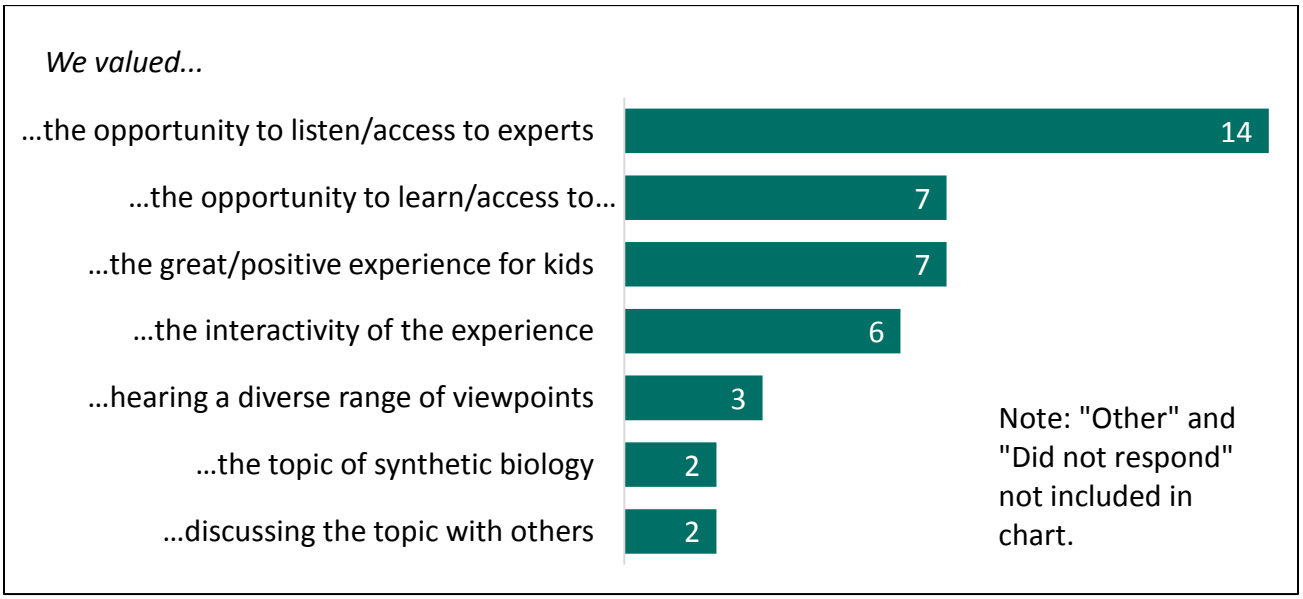
Code	Example Quotes
Facts about synthetic biology	"Counter culture labs 3-D printing tobacco and carrot cells."
Uses/applications of synthetic biology	"Quite lot of applications which I was not aware about."
The significance of synthetic biology	"We already use synthetic biology in a lot of common products."
The activities/stations	"Hands on learning- helpful to the kids."

The researchers/scientists who presented	"Interesting what the scientists want to accomplish with their projects and getting options from them (the visitors) and synbio scope."
The benefits of synthetic biology	"You can use synthetic biology to benefit the world."
Current synthetic biology research	"E.coli is used in much of current research. RNA can snake configurations for more than one function. Research is on a cusp of new possibilities."
Advances in science and technology	"Real progress is being made."

Visitors valued learning from the events and the positive experience for children.

13. What, if anything, did you and your group members value about your participation in the event? (n=42) [P, E]

This open-ended question was coded using an existing code list. The chart here shows the number of responses per theme, and the table below lists example quotations for each coded theme. In some cases, a single response may be counted in more than one code.



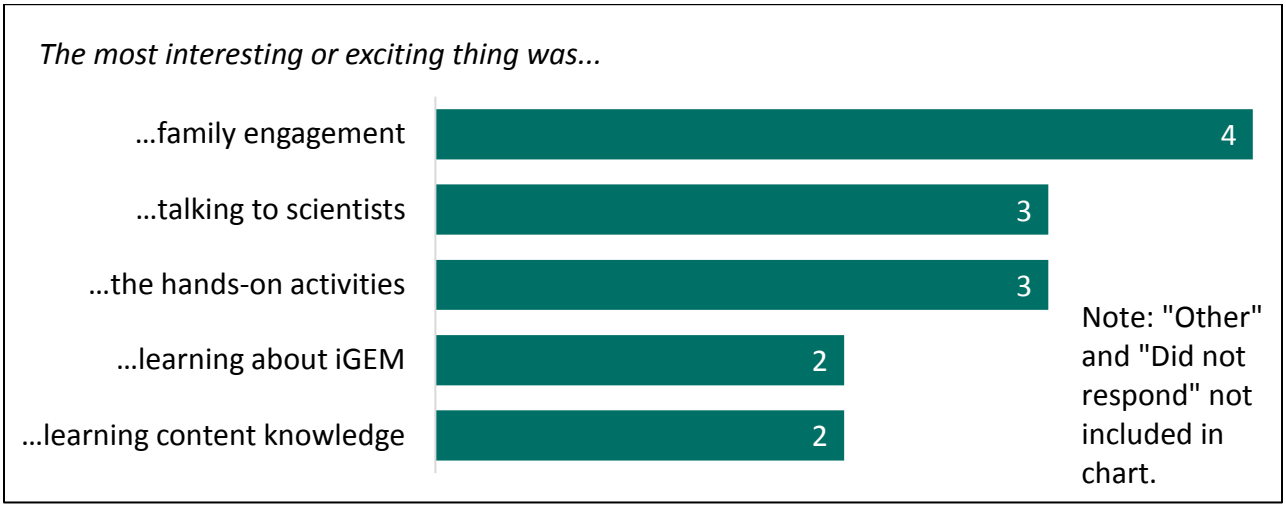
Code	Example Quotes
Opportunity to listen/access to experts	"Speaking with the individuals who did hands on activities with the kids."
Opportunity to learn/access to information	"Learning new material."

Great/positive experience for kids	“Great for kids to interact with real scientists.”
The interactivity of the experience	“I feel the interaction part was strongly better than what I've seen before.”
Hearing a diverse range of viewpoints	“Great ideas from kids.”
The topic of synthetic biology	“Learned about home based synthetic biology.”
Discussing the topic with others	“I enjoyed the variety of activities and the conversations with well-trained volunteers.”

Respondents found different aspects of the event to be interesting and exciting.

14. What was the most interesting or exciting thing you did at this event? (n=12) [o]

This open-ended question was coded by theme. The chart here shows the number of responses per theme, and the table below lists example quotations for each coded theme. In some cases, a single response may be counted in more than one code.

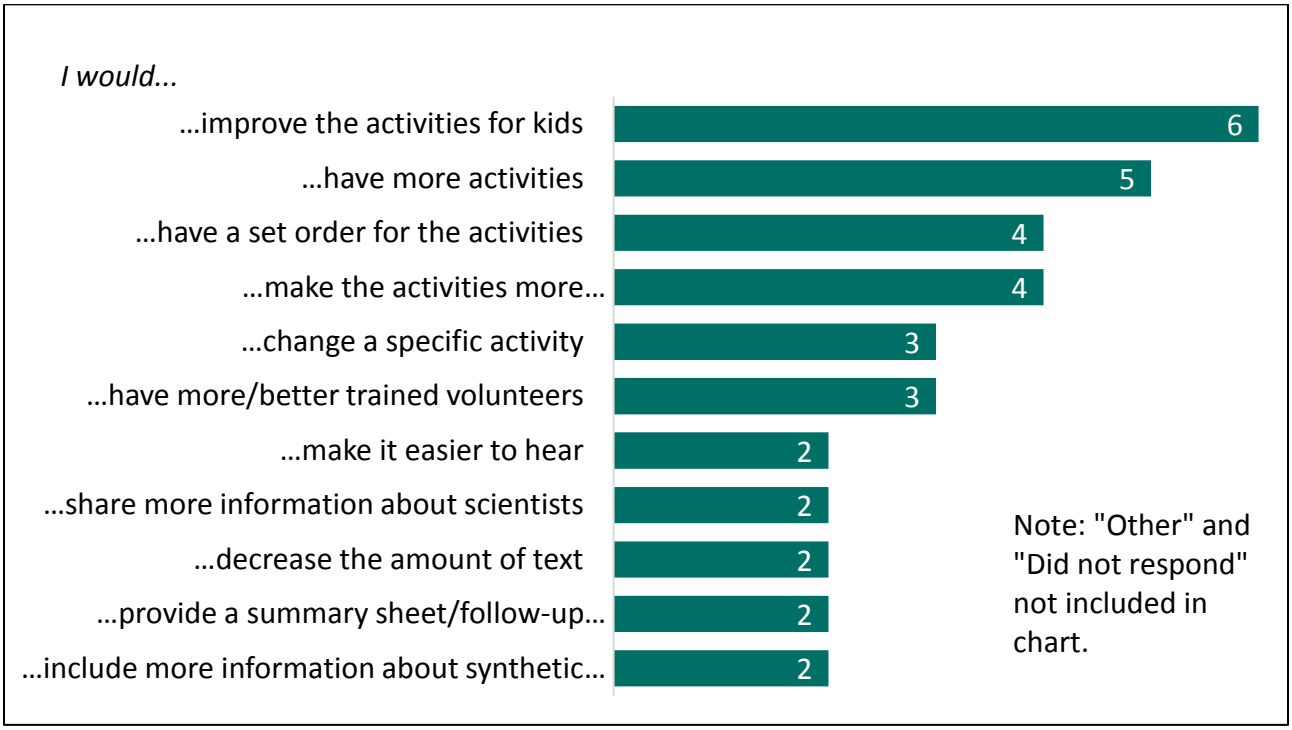


Code	Example Quotes
Family engagement	“Son was engaged”
Talking to scientists	“I enjoyed talking to scientists about their research in person!”
The hands-on activities	“Interactive activities with kids”
Learning about iGEM	“Learned about the iGEM program”
Learning content knowledge	“Learning about viruses”

Respondents offered some suggestions about how the events could be improved.

15. What, if anything, would you change to improve this event for you and your group members? (n=50) [P, E, O]

This open-ended question was coded by theme. The chart here shows the number of responses per theme, and the table below lists example quotations for each coded theme. In some cases, a single response may be counted in more than one code.



? Questions to consider: How do we want to address data that suggest Building with Biology events could be improved for children in a way that does not negatively impact public engagement with science goals? Might we be able to market the events for a more suitable audience, or would we want to change the activities or facilitation such that they were more appropriate for children and family groups?

Code	Example Quotes
Improve activities for kids	"Please make the stations more child friendly (don't use so many scientific words)."
Have more activities	"Offer more variety."

Have a set order for the activities	"I would re-arrange the order of some of the booths. There were some that would make sense clustered together."
Change a specific activity	"More games/ engaging props."
I have a suggestion for a specific activity	"Timeline of Genetic Manipulation. Delete 1953 Watson & Crick. Replace with Rosalind Franklin."
Have more/better trained volunteers	"Have the Volunteers more prepared."
Make it easier to hear	"Difficult to hear and really focus/ learn due to noise all around."
Share more information about scientists	"Personal stories of scientists. Share info about scientists."
Decrease the amount of text	"Many tables also had too much text."
Provide a summary sheet/follow-up information about follow-up.	"A summary sheet/link to useful websites to take away."
Have more information about synthetic biology	"I didn't make the connection that the biology this event was talking about was synthetic biology."

The Multi-Site Public Engagement with Science—Synthetic Biology project and its Building with Biology events are funded by the National Science Foundation (DRL 1421179). This document has been created by the project's Evaluation Team. Any opinions, findings, or conclusions in this material are those of the authors, and do not necessarily reflect the views of the National Science Foundation.

Methods testing: Passport survey from 2016

Data Collector Initials: _____ Survey Number: _____ Site Name: _____ Time: _____

Building with Biology

Building with Biology Survey

Are you 18 or older? If so, please tell us about your experience!
Participation is voluntary. All responses are anonymous.

1. How many times did you do each of the following activities? (Please check)

	Not at all	Once	More than once	Unsure
Talk to a scientist	☐	☐	☐	☐
Ask a volunteer a question	☐	☐	☐	☐
Share your ideas on the graffiti board	☐	☐	☐	☐
Tell a volunteer your thoughts about synthetic biology	☐	☐	☐	☐
Try a hands-on activity (drawing, playing a game, etc.)	☐	☐	☐	☐

2. What, if anything, did you learn from participating in this event?

3. How much did you know about the following topics BEFORE the Building with Biology event, and how much do you know AFTER the event? (Check one 'BEFORE' and one 'AFTER' for each topic)

	BEFORE the event, I knew...				AFTER the event, I know...			
	Nothing	A little	Some	A lot	Nothing	A little	Some	A lot
Facts about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Applications of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
Societal aspects of synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐
What other people think about synthetic biology	☐	☐	☐	☐	☐	☐	☐	☐

4. How much did this event increase your interest in the following? (Please check)

	Not at all	A little	Somewhat	A great deal
Checking out news stories (online, TV, and/or print) about synthetic biology	☐	☐	☐	☐
Learning about how synthetic biology is connected to my daily life	☐	☐	☐	☐
Talking to a scientist about the impacts of scientific research in my community	☐	☐	☐	☐
Sharing my views about synthetic biology with friends and family	☐	☐	☐	☐

OVER →

5. Thinking about your experience at this event, how much do you agree or disagree with each of the statements below? (Please check)

	Strongly disagree	Disagree	Agree	Strongly agree
I shared my views about synthetic biology.	☐	☐	☐	☐
I considered the benefits of synthetic biology.	☐	☐	☐	☐
I considered the risks of synthetic biology.	☐	☐	☐	☐
I learned about viewpoints different from my own.	☐	☐	☐	☐
I enjoyed this event.	☐	☐	☐	☐

6. What, if anything, did you value about your participation in this event?

7. What is your age and gender? If applicable, what are the ages and genders of your group members? (Fill in the table below)

	Example	YOU (person filling out this survey)	Additional group members (if applicable)			
			1	2	3	4
Gender (write in)	Female					
Age (write in)	52					

Even if you're new to the ideas in synthetic biology, your opinions can shape the development of its tools and applications. The next questions are from scientists who want to know what you think!

8. What applications of synthetic biology would you like scientists and engineers to work on? (Please check all that apply)

☐ Agriculture ☐ Fuel ☐ Software
☐ Electronics ☐ Medicine ☐ Other: _____
☐ Food ☐ Personal Care ☐ None of the above

9. How might synthetic biology change our lives?

10. What question would you most like to ask a scientist about synthetic biology?

Evaluation of Public Impacts

Data Collection Guidelines

Introduction

The purpose of this evaluation is to understand what public visitors over the age of 18 learn from the Building with Biology hands-on activities and what they find valuable about their participation. We have selected 50 sites to participate in this evaluation. The Building with Biology Evaluation Team will provide these sites with a box of evaluation materials, evaluation support, and training for one data collector from each site. This person will be responsible for collecting paper surveys from adult visitors at the end of a passport activity and sending the public evaluation data to the Evaluation Team electronically and by mail. The Evaluation Team will then analyze the data and send you an individual report about what your visitors learned and valued. At the end of the evaluation period, the Evaluation Team will also offer a webinar to share findings from all evaluation cohort participants.

NOTE: This document was prepared for sites that have been selected as participants in the Building with Biology public event evaluation. Nearly twice as many sites expressed interest in this evaluation as we were able to accommodate. If you are interested in evaluation but were not selected to be a part of the evaluation cohort, you are still welcome to use the protocols, attend the professional development opportunities, and use the surveys that the Evaluation Team has created. These resources are available at www.buildingwithbiology.org/project-evaluation.

Unfortunately, the Evaluation Team will not be able to send physical materials or analyze data for sites that were not selected to be part of the evaluation cohort. **Please do not mail us your data if you have not been selected as an evaluation site.**

This document outlines the details of the evaluation process, including:

- The data collector's responsibilities
- The support you will receive from the Evaluation Team
- Details about the evaluation materials
- Information about the data collection process
- How to prepare for your event

At the end of this document you will find a *Building with Biology Public Evaluation Overview* section that includes a checklist of action items for the evaluation and recruitment scripts.

The evaluation data collector

For the purposes of this evaluation, you will need to select *one person* who is responsible for five tasks. This person will need to devote the full duration of the event to evaluation tasks, so she or he should NOT be responsible for coordinating the full event or managing volunteers.

NOTE: If you are using your hands-on activities with the public on multiple days, the data collector only needs to collect data on one day (although you're welcome to do more).

The data collector is responsible for:

- ***Completing human subjects training***: The evaluation data collector needs to provide the Building with Biology Evaluation Team with a current copy of a completion certificate for a human subjects training course administered by either the National Institutes of Health (NIH) or the Collaborative Institutional Training Initiative (CITI). If the designated person has already completed this training, she or he can send an existing copy of the completion certificate. If the person does not have a current certificate of completion, she or he must take the free, 2-hour online course from the NIH, accessible at https://phrp.nihtraining.com/users/login.php. Completion certificates must be sent to Sarah Pfeifle at spfeifle@mos.org at least one week prior to your forum.
- ***Attending the Building with Biology public evaluation webinar***: The Building with Biology Evaluation Team will host an online webinar about this evaluation. While we hope the data collector will attend this webinar live, we understand that scheduling can be a challenge. If the data collector is unable to attend, we ask that she or he watch the recording of the webinar and speak with his or her Evaluation Team contact. The webinar will be Tuesday, June 14 at 1:00-2:00 ET. To learn more and register for the webinar, visit: http://www.surveygizmo.com/s3/2736656/Evaluating-the-Public-s-Experience-at-Building-with-Biology-Events
- ***Watching the Building with Biology evaluation video***: The Building with Biology Evaluation Team is producing a short video that summarizes data collection practices. In addition to attending the webinar, the data collector should watch this brief video. A link to the video will be emailed to you, and it will be available on www.buildingwithbiology.org/project-evaluation.
- ***Collecting data at the event***: This document provides additional detail about data collection, which will consist of a passport activity and collecting paper surveys from visitors at the end of their Building with Biology experience. The person collecting data should be able to devote complete attention to the evaluation for the duration of the event. If your site is hosting multiple events, you only need to collect data on one day.

- ***Mailing the collected data to the Evaluation Team***: After the event, the data collector will need to send all data to the Building with Biology Evaluation Team so the Team can analyze and report on the data. First, the data collector should scan or take a picture of: (1) paper surveys and (2) responses on your graffiti board. Digital files should be sent to Sarah Pfeifle at spfeifle@mos.org. Then, the data collector should place the surveys and worksheets in the addressed, pre-paid mailing envelope included in your evaluation materials and ship the envelope to the Museum of Science at the following address:

  Sarah Pfeifle
  Research & Evaluation Department
  Museum of Science, Boston
  1 Science Park
  Boston, MA 02114

If it is not feasible for all of these items to be completed by the same person, please speak with your Evaluation Team contact. It may be possible to share roles in a different way. The Evaluation Team will need a human subjects training certificate for all people collecting data.

Support from the Building with Biology Evaluation Team

Each site will have a designated contact from the Building with Biology Evaluation Team who will provide assistance throughout this evaluation. At this point, you should have received an email identifying your Evaluation Team contact. Please feel free to reach out to this person with any questions you have about the evaluation. Evaluation contacts include:

Elizabeth Kollmann	Sarah Pfeifle	Katie Todd	Gretchen Haupt
ekollmann@mos.org	spfeifle@mos.org	ktodd@mos.org	ghaupt@smm.org
617-589-0467	617-589-0202	617-589-4235	651-312-1757

You may also contact Elizabeth Kollmann, the Evaluation Team leader, should you have any issues or concerns with the evaluation study.

Materials

This evaluation depends on your use of specific supplies. Some of these supplies are included in your main Building with Biology kit. Others are in a separate box of evaluation materials. We also ask that you gather some pens and pencils at your site that visitors can use to fill out their surveys. The full list of materials you will need for the evaluation is printed below.

From your Building with Biology kit:

- 100 Event Passports (You can print additional copies at: http://bit.ly/BwBPassport)
- Marker stamps – 1 for each station
- "I'm a scientist" stickers
- Temporary tattoos
- Graffiti board
- Graffiti board sign stand (NOTE: you will replace the sign from your kit with a new one we provide in the evaluation box)

From your evaluation box:

- 20 *Building with Biology Surveys* (You may print more at: http://bit.ly/BwBsurvey)
- *Evaluation Surveys Envelope* for completed surveys
- Passport Station sign and sign stand
- Graffiti board sign (place this in the stand from your kit, replacing the sign from your kit)
- 25 *Evaluation Information* cards
- Pre-paid mailing envelope addressed to the Museum of Science

For you to gather at your site:

- Pens or pencils for survey completion
- Clipboards (optional)

NOTE: We provide 20 surveys in your evaluation box, and we hope you will be able to get 20 visitors to complete them. You are welcome to print more surveys from http://bit.ly/BwBsurvey if you would like. This would provide your site with more data for your individualized report, which will help you better understand your visitors' experiences. However, collecting more than 20 surveys is optional.

NOTE: Your evaluation kit includes a sign to go with your graffiti board. This sign has consent language on it to let your visitors know that you will be collecting their responses. You will need to use this sign rather than the sign included in your Building with Biology kit, which does not have consent language printed on it.

About the passports

This evaluation depends on your use of a passport activity that is included in your Building with Biology kit. The passport activity provides structure for the evaluation: once visitors complete the activity, they return to the Passport Station where they got their passports to fill out a paper survey (if they are adults) and receive a small giveaway (the temporary tattoos).

The Building with Biology passports are designed to encourage visitors to engage with the hands-on activities and talk with your volunteers. Visitors are encouraged to collect as many stamps as they can by asking activity facilitators to stamp their passports each time the visitors complete one of four actions:

10. **Talk to a scientist** about synthetic biology
11. **Share your ideas** about synthetic biology on the graffiti board *(Note: please use the graffiti board in your kit and make sure you have a volunteer at that station!)*
12. Find a volunteer and **ask a question** about synthetic biology
13. Talk to a volunteer about what you **like and don't like** about synthetic biology

NOTE: The passport does not include language prompting visitors to return at the end of their experience, so it is crucial that the person introducing and distributing the passports tells the visitors to come back when they are finished in order to fill out the survey (for adults only) and receive a temporary tattoo. The *Passport Introduction Script*, below, is for this purpose.

Your Building with Biology kit includes 100 passports. If you would like additional passports, they can be printed from the following link: http://bit.ly/BwBPassport

The passports in your kit are un-folded. To create a nice booklet, the sheets need to be folded top to bottom and then left to right so the stamp pages are inside. You can either do this ahead of your event or ask your visitors to do it themselves when they pick up their passports.

Preparing for your event

To make your evaluation run smoothly, it is important to prepare your volunteers for the passport activity and set up your materials before visitors arrive. The following sections guide these preparations.

Volunteer orientation

At your volunteer orientation, you will need to tell volunteers about the passports and prepare them to stamp visitors' passports. We recommend having sample passports and markers on

hand to show the volunteers during the orientation. A PowerPoint presentation slide about the passports is included in the orientation PowerPoint provided in your kit.
Each volunteer will need to be prepared to stamp visitors' passports if:

- Visitors **ask a question** about synthetic biology
- Visitors tell the volunteer what they **like and don't like** about synthetic biology

Let volunteers who are scientists know that they will be asked to wear "I'm a scientist" stickers at the event. These volunteers should be ready to stamp passports if:

- Visitors **talk to the scientist** volunteer about synthetic biology

Make sure the graffiti board will be facilitated during the event, as this activity is included in the passport. The volunteer(s) at the graffiti board will need to stamp passports if:

- Visitors **share their ideas** about synthetic biology on the graffiti board

If you have staff members or other people facilitating activities who will not be attending your Building with Biology orientation, make sure to train them about how to stamp passports.

Setup at the event

Prepare for your data collection by setting up your space with all the materials you will need. Before your visitors arrive, make sure every activity station has a stamp marker, and make sure every volunteer or staff facilitator knows to stamp visitors' passports. Give "I'm a scientist" stickers to scientists who are facilitating activities and ask them to wear the stickers visibly. While we do not require you to use all of the activities in the Building with Biology kit, make sure to use the graffiti board, and ensure that the activity will be facilitated by a volunteer who is trained to stamp passports for visitors who complete the activity. **The graffiti board is connected to the passport, and collecting visitors' responses from the graffiti board is part of this evaluation.**

When setting up the graffiti board, make sure you have both the poster and the sign stand. **You will need to replace the graffiti board sign that came with your Building with Biology kit. Please use the sign that was included in your evaluation box, instead of the one from your kit.** The version of the sign in your evaluation box includes consent language to tell your visitors that their responses will be collected.

To set up the Passport Station, find a location where you can offer passports to visitors as they enter the Building with Biology space and where they can return to fill out a survey and get their takeaway. Display the Passport Station sign visibly using the sign stand in your evaluation box. Make sure the Passport Station has your passports at it. We recommend folding the passports ahead of time so they are ready for use. Alternatively, your visitors can fold the passports as part of their activity. Ensure that your Passport Station has *Building with Biology Surveys*, pens or pencils, the *Evaluation Surveys Envelope* that you will use to store completed

surveys, *Evaluation Information* cards that you can give to visitors who have questions about the evaluation, and the temporary tattoos from your kit that you can use as take-away prizes for visitors. If you have clipboards, you can have visitors use them to fill out their surveys.

The Passport Station

You will need to set up a Passport Station at your event where you will distribute passports and collect surveys. The ideal location for the Passport Station would be near both the entrance and exit of the Building with Biology area. We recognize that not all sites are set up such that this is possible, but we hope you will do your best to find a location where visitors will receive their passports at the beginning of their experience and have a flowing path by which they return to complete a survey. Please feel free to discuss your setup with your Evaluation Team contact.

Data collection using the passport activity

Distributing passports

As people arrive at the event, use the *Passport Introduction Script* (see below) to introduce visitors to the activity. This Script encourages visitors to return to the Passport Station when they are done in order to complete a survey (if the visitor is an adult) and receive a temporary tattoo. Note that all adult visitors should be invited to fill out a survey at the end of their experience, whether or not they use a passport. Visitors of all ages can receive passports, and multiple people in one group can receive passports. If you are able to have multiple people at your Passport Station, the person distributing passports does not need to be the data collector who has completed human subjects training. **Note: Please record the time you start and stop distributing passports, and the total number of passports you distribute.** Your Building with Biology report will ask you to provide this information.

Collecting data at the Passport Station

When visitors return to the Passport Station at the end of their Building with Biology experience, the evaluation data collector should use the *Survey Informed Consent Script* (see below) to invite all adult visitors to complete the survey. When visitors consent to complete the survey, hand them a survey and a pen or pencil. If you have them, you can have your survey on a clipboard. Give the visitor space to complete the survey. When the visitor is finished, the data collector should thank the participant, check and collect the survey, and offer temporary tattoos to all group members. Visitors can take their passports home. After collecting the survey, the data collector should fill in the survey header with his or her initials, the site name, the survey number (i.e., if you collect 20 surveys, number the surveys 1 to 20), and the time.

Completed surveys should be placed in the *Evaluation Surveys Envelope* in your evaluation box, and the Envelope should be kept out of visitors' reach.

Passport Introduction Script

NOTE: It is important to invite all adult visitors to complete a survey, whether or not they do the passport activity. This will make your data more representative of your full audience.

Welcome to Building with Biology! This event is one of nearly 200 events across the country where you can try some activities and talk with scientists about the emerging field of synthetic biology. We have a passport activity that helps to guide your experience. You can use your passport to collect stamps for doing the different activities and talking to the scientists and volunteers. Would you like a passport today?

[**If yes**]: Great, thanks! Here you go. [*Distribute passport*] When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

[**If no**]: No problem. I hope you enjoy the activities! When you're done, if you come back to this station, we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

Survey Informed Consent Script

Thanks for participating in the event today! Here's the survey I was telling you about earlier. Will you spend a few minutes to give us feedback about the event so we can improve our future programs?

[**If yes**] Thank you!

[**If no**] Have a great day!

After the event

Once the event is over, the data collector should scan or take clear photographs of both sides of the surveys and the graffiti board responses that he or she collected. Send these digital files to Sarah Pfeifle at spfeifle@mos.org. Then, place all these materials in the addressed, pre-paid mailing envelope included in your evaluation materials and mail the envelope to:

Sarah Pfeifle
Research & Evaluation Department
Museum of Science, Boston
1 Science Park
Boston, MA 02114

The Evaluation Team will then enter your data, analyze it, and provide you with an individualized report sometime this fall or winter.

Building with Biology Public Evaluation Overview

Before the date of the event:

- ☐ Identify one data collector for the evaluation.
- ☐ Send the data collector's human subjects training completion certificate to spfeifle@mos.org at least **one week before your event**.
- ☐ Have the data collector attend the evaluation webinar on **Tuesday, June 14 from 1:00-2:00 ET**, or watch the recorded webinar and call/email your Evaluation Team contact.
- ☐ Have the data collector read this document thoroughly.
- ☐ Fold your passports (or decide that you will have your visitors fold them).

At your volunteer orientation:

- ☐ Tell volunteers about stamping passports at the event.
- ☐ Identify and train at least one person to facilitate the graffiti board.

Setup for your event:

- ☐ Set up each activity station with a stamp marker.
- ☐ Make sure all volunteers know about stamping passports.
- ☐ Give "I'm a scientist" stickers to scientist volunteers and ask them to wear the stickers.
- ☐ Set up the graffiti board and the graffiti board sign from your evaluation kit (NOT the sign from your Building with Biology kit).
- ☐ Set up the Passport Station near the entrance of the event with:
  - ☐ Passports
  - ☐ The Passport Station sign in its stand
  - ☐ *Building with Biology Surveys*
  - ☐ Pens or pencils for survey completion
  - ☐ The *Evaluation Surveys Envelope* for storing completed surveys
  - ☐ Temporary tattoos
  - ☐ *Evaluation Information* cards

During your event:

- ☐ Use Passport Invitation Script (see back of this page) when passing out passports.
- ☐ Record what time you start and stop distributing passports.
- ☐ Record how many passports you distribute.
- ☐ Use Survey Informed Consent Script (see back) to invite adult visitors to complete surveys.
- ☐ Collect paper surveys from adult visitors.
- ☐ Check for completion and fill in the survey headers when you receive surveys.
- ☐ Place completed surveys in the *Evaluation Surveys Envelope*, out of the reach of visitors.
- ☐ Offer temporary tattoos to visitors, whether or not they complete a survey.

*After the event – **within one week of your event**:*

- ☐ Scan or take pictures of surveys and graffiti board responses and send to spfeifle@mos.org.
- ☐ Mail data to the Evaluation Team using the envelope in your evaluation box.

Recruitment Scripts

First interaction with visitors: When visitors approach the Passport Station, use the Passport Introduction Script to welcome visitors to the event, offer them a passport, and ask adults to come back to complete a survey when they're done.

Passport Introduction Script: Welcome to Building with Biology! This event is one of nearly 200 events across the country where you can try some activities and talk with scientists about the emerging field of synthetic biology. We have a passport activity that helps to guide your experience. You can use your passport to collect stamps for doing the different activities and talking to the scientists and volunteers. Would you like a passport today?

[**If yes**]: Great, thanks! Here you go. [Distribute passport] When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

[**If no**]: No problem. I hope you enjoy the activities! When you're done, if you come back to this station we would love your feedback about the event on a brief survey. We also have some fun prizes for you.

Second interaction with visitors: When visitors return to the Passport Station at the end of their experience, invite all adult visitors (whether or not they used a passport) to complete the survey using the Survey Informed Consent Script. Offer temporary tattoos to all group members who would like them. The receipt of tattoos is NOT dependent on filling out a survey. After collecting a survey, fill in the header and store the survey in the *Evaluation Surveys Envelope*.

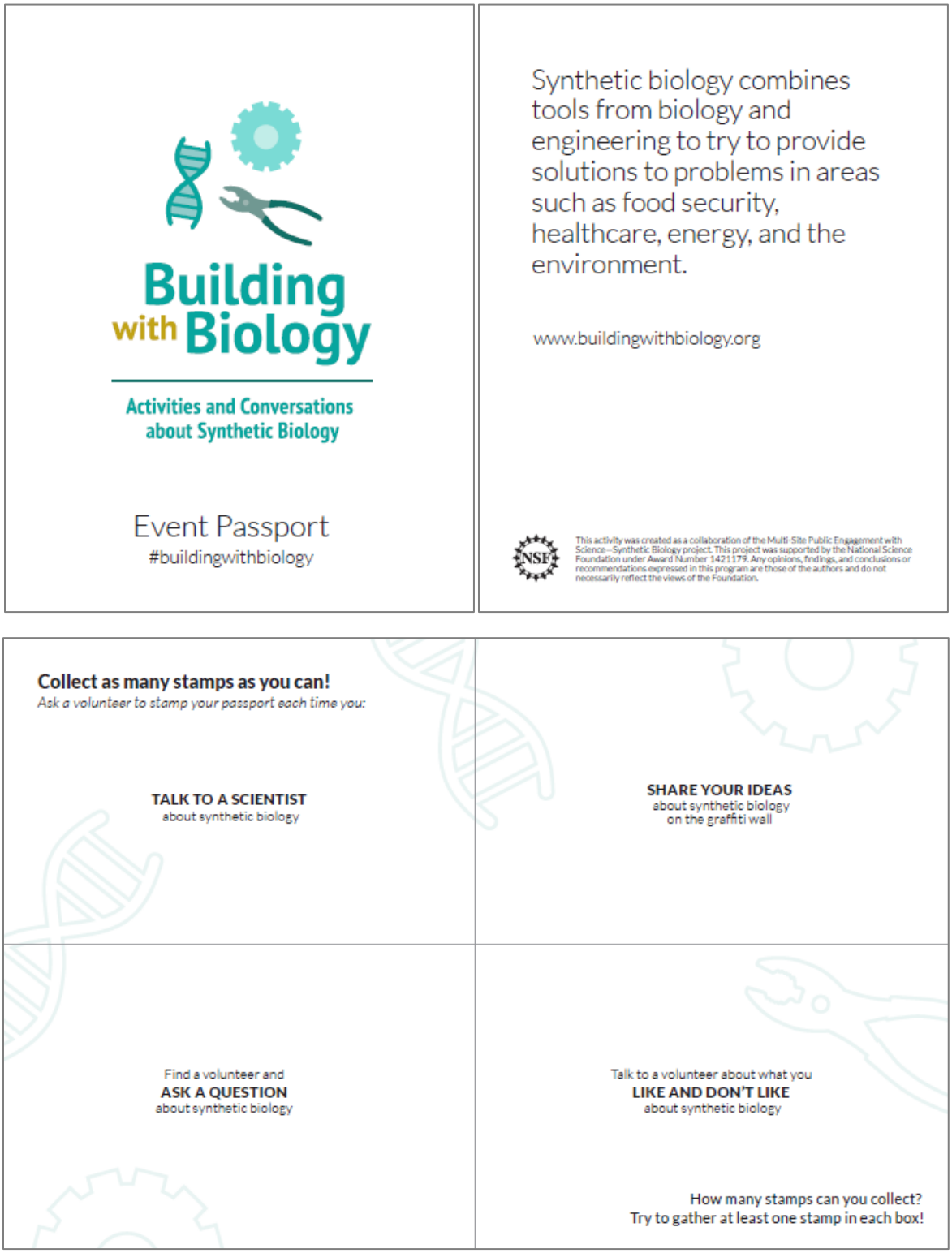
Survey Informed Consent Script: Thanks for participating in the event today! Here's the survey I was telling you about earlier. Will you spend a few minutes to give us feedback about the event so we can improve our future programs?

[**If yes**] Thank you!

[**If no**] Have a great day!

Consent signs: Please be sure to display the Passport Station sign at your table where you are collecting surveys, and the graffiti board sign at your graffiti board station. These signs include human subject protection and consent language that is required by this project's Institutional Review Board.

Methods testing: Passport for 2016



Methods testing: Example site-specific report from 2016

Building with Biology

Public Event Evaluation Report for the Museum of Science, Boston

The Multi-Site Public Engagement with Science—Synthetic Biology project and its Building with Biology events are funded by the National Science Foundation (DRL-1421179). This document has been created by the project's evaluation team. Any opinions, findings, or conclusions in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

About the Public Event Evaluation

In 2016, the Multi-Site Public Engagement with Science—Synthetic Biology project created 200 kits of hands-on activities designed to foster Public Engagement with Science (PES) about synthetic biology. These kits were distributed to sites across the country, where events provided opportunities for scientist volunteers to interact with and have discussions with the public using the kit activities.

Forty-three sites volunteered to participate in a coordinated evaluation effort of these events. A data collector at each site completed evaluation training and then collected data from members of the public using a passport activity that culminated in a paper survey for adult participants. The survey gathered information to answer the following evaluation questions:

- What do public audiences learn from their PES experience?
- What do public audiences learn from the scientist volunteers?
- Does participation increase public audiences' interest in PES or synthetic biology?
- What follow-up behaviors does particiation prompt in public audiences?
- What do public audiences value about their participation in PES?

This document summarizes the data collected at the Museum of Science, Boston. To see combined data collected across all sites, please refer to the summative report, which can be found at buildingwithbiology.org.

In many cases the findings in this document are listed as counts, whereas the summative report lists percentages. This is because the individual sites' sample sizes were small. In many cases a single response makes a large difference in a percentage, while it still only represents one person's experience. Thus, we listed counts for this site-specific document as they were more representative of the site-specific data. Any comparisons between the data in this document and the overall data compiled across the sites should be considered lightly due to the small sample sizes of the site specific data. The Museum of Science, Boston collected 30 surveys, representing 47 visitors. The hosts estimated that 600 total visitors attended the event, so the surveys represent the experiences of about 8% of event attendees.

Quantitative data were analyzed descriptively using counts. Qualitative data were coded inductively or, when possible, using pre-defined code lists developed from prior evaluation. These pre-defined code lists make it easier to compare responses within and across surveys.

Example quotations from the Museum of Science, Boston are included in figures within the body of this document. If you are interested in reading all of the open-ended responses collected from visitors at the Museum of Science, Boston, refer to the attached appendices.

This document was created by the multi-institutional evaluation team for the Multi-Site Public Engagement with Science--Synthetic Biology project. Members of this team include Gretchen Haupt (Science Museum of Minnesota), Elizabeth Kollmann (Museum of Science, Boston), Angie Ong (Spotlight Impact), Sarah Pfeifle (Museum of Science, Boston), and Katie Todd (Museum of Science, Boston). Any questions about this document or the evaluation of this project should be directed to the team leader, Elizabeth Kollmann, at ekollmann@mos.org.

Respondents

30 collected surveys

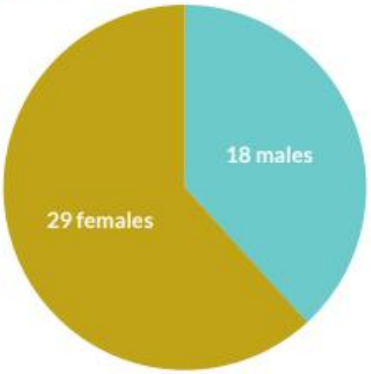
Completed surveys represent the experience of

47 total group members out of

600 estimated event attendees.

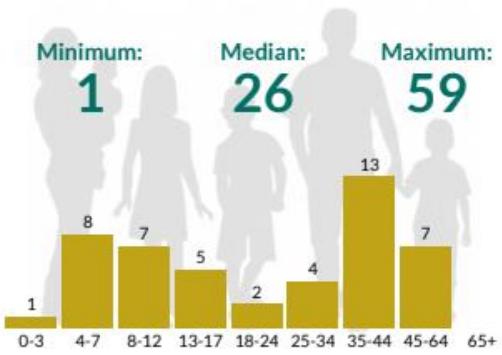
Gender

n=46, including all recorded group members.



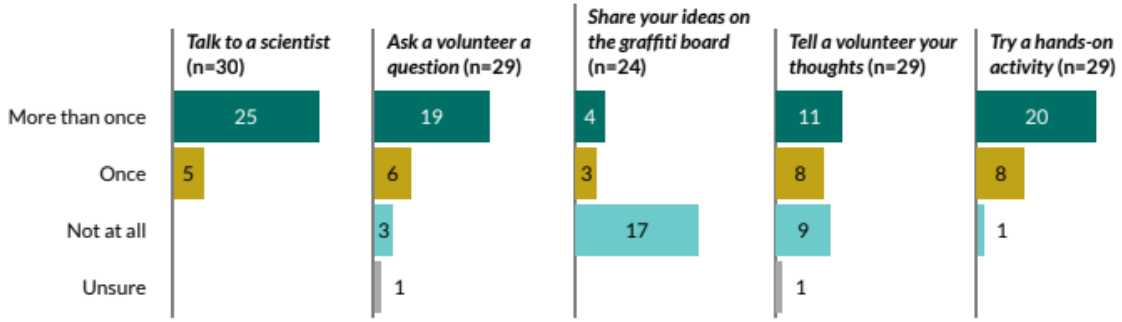
Age

n=47, including all recorded group members.

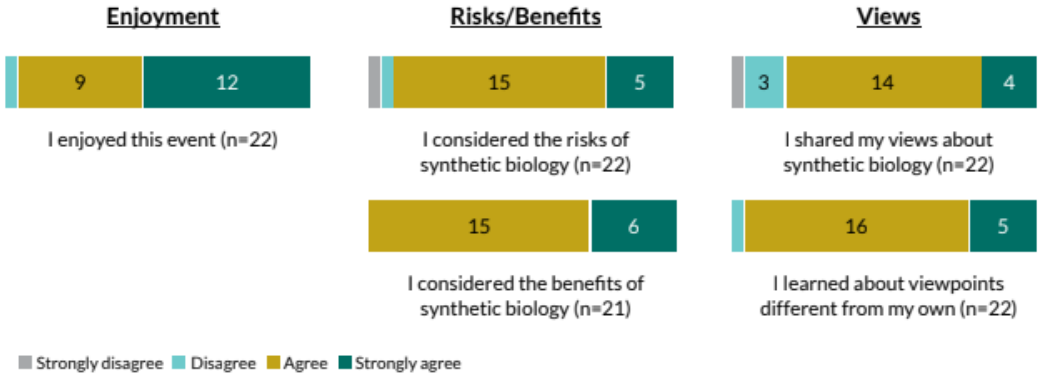


Experience

How many times did you do each of the following activities?



Thinking about your experience at this event, how much do you agree or disagree with each of the statements below?
For clarity, values of one are not labeled in the figures below.



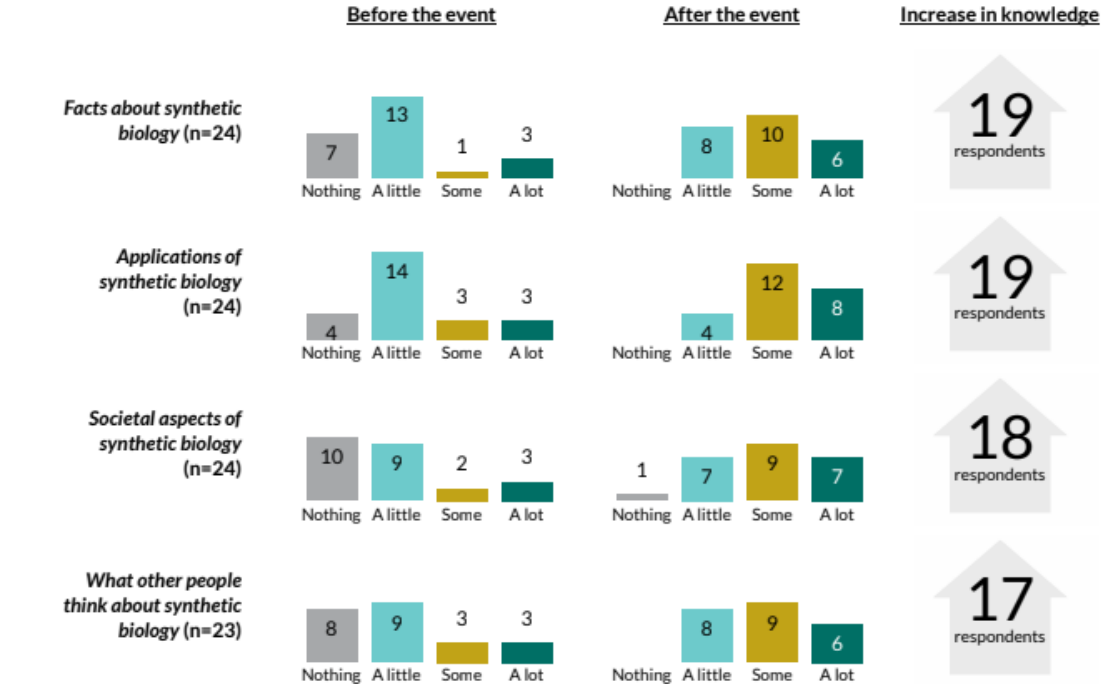
Learning

What, if anything, did you learn from participating in this event? (n=18)
This open-ended question was coded using an existing code list. The chart here shows the number of respondents per theme, and example quotations for each coded theme. In some cases, a single person's response may be counted in multiple codes. The chart below does not include surveys without responses, irrelevant responses, or "other" responses. However, the Appendix does show all responses to this question.

Code	Frequency	Example Quotes
Facts about science and technology	8	*"Using DNA from one organism to change properties of another."*
Uses / **applications** of science	4	*"To stop malaria"*
Future directions of science	2	*"Exciting new opportunities."*
The **complexity** of science	2	*"Complexity of the ethical considerations."*
The **significance** of science	1	*"Broadness of the field. Now different approach to problems."*
Current science **research**	1	*"A lot more going on today and not just promise for the future."*
Risks of science	1	*"some [DNA] is bad."*
Benefits of science	1	*"Some DNA is good"*
Societal aspects of science	1	*"That the science community is conscious about ethics."*
The **researchers** / scientists who participated	1	*"Cool to see the Wellsley team - almost like minecraft."*
A **positive attitude** towards science	1	*"fun family event."*
A lot of information	1	*"Lots of new things"*

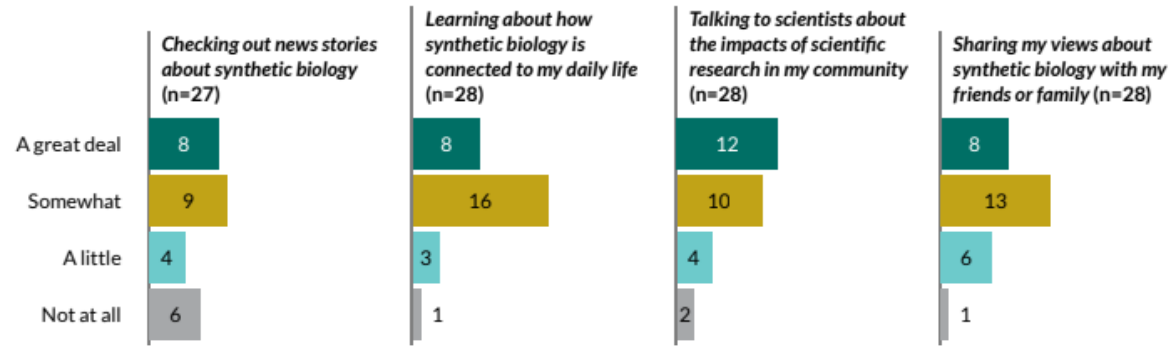
Learning

How much did you know about the following topics before the Building with Biology Event, and how much do you know after the event?



Interest

How much did this event increase your interest in the following?



Value

What, if anything, did you value about participating in this event? (n=9)
This open-ended question was coded using an existing code list. The chart here shows the number of respondents per theme, and example quotations for each coded theme. In some cases, a single person's response may be counted in multiple codes. The chart below does not include surveys without responses, irrelevant responses, or "other" responses. However, the Appendix does show all responses to this question.

Code	Frequency	Example Quotes
The opportunity to **learn**	3	*"The knowledge gained."*
The **access to experts**	2	*"the "scientists" were readily available to answer my qns."*
The **topic** of synthetic biology	1	*"This event taught me several ways synthetic biology is used."*
The opportunity to **share my opinions**	1	*"I felt like my opinion mattered."*
Elements of the **event format**	1	*"Awesome activities."*
Everything	1	*"Great event"*
The **interactive / fun** experience	1	*"Interactive games"*
Positive experience for **kids**	1	*"Opening my kids minds I topics we do not discuss at home"*

Appendix: Qualitative responses from visitors

This appendix shares all of the open-ended survey responses. This data is summarized in the previous pages.

What, if anything, did you learn from participating in this event? (n=18)

- About genetically modified organisms
- I learned about how synthetic biology can be used in the detection and treatment of disease and how it can be used for commercial purposes (perfumes).
- To stop malaria
- Broadness of the field. Now different approach to problems.
- Learned that there are many uses for yeast.
- More on DNA of yeast
- Complexity of the ethical considerations. Exciting new opportunities.
- Lots of new things, fun family event.
- That the science community is conscious about ethics.
- Yeast is a main ingredient for many of these experiments.
- Ask questions.
- There are many surprising uses for synthetic biology.
- Some DNA is good and some is bad. Learned what synthetic biology is.
- A lot disease, cells, blood, drug connect to each other
- DNA sequencing
- Cool to see the Wellsley team - almost like minecraft.
- A lot more going on today and not just promise for the future.
- Using DNA from one organism to change properties of another.

Appendix: Qualitative responses from visitors

This appendix shares all of the open-ended survey responses. This data is summarized in the previous pages.

What, if anything, did you value about your participation in this event? (n=9)

- This event taught me several ways synthetic biology is used.
- Great event.
- The knowledge gained.
- The scientist information given.
- I felt like my opinion mattered.
- Interactive games and the "scientists" were readily available to answer my qns.
- Unsure?
- Awesome activities.
- Opening my kids minds I topics we do not discuss at home