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Failures of Engagement: Lessons Learned from a Citizen Science Pilot Study

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Citizen science is growing in popularity, but little research addresses participant learning outcomes. We describe the Chicago Area Pollinator Study (CAPS), which relied on citizen scientists to gather information about urban bee diversity and abundance. Based on pre- and post-CAPS participant surveys, we determined that citizen scientists collected an impressive amount of data and enjoyed the experience but did not achieve the educational goals we hoped for. We detail our failure to effectively engage citizen scientists in the learning process, and we make specific recommendations for creating the types of dynamic and mutually successful projects that scientists and citizens deserve.

This is the story of a citizen science failure obscured by a scientific success.

In summer 2009, we helped develop a citizen science investigation of bee diversity and abundance called the Chicago Area Pollinator Study (CAPS). Our research team collected bees in community gardens and forest preserves throughout Chicago and the surrounding suburbs once per month in July, August, September, and October 2009. We also recruited households to collect bees in their yards on those same dates. Thanks to the help of citizen scientist participants, we collected 1,146 bees representing 65 species from our residential, community garden, and forest preserve sites.

During the project design phase, we worked with a bee expert to create a streamlined research protocol for collecting bees in colored bee bowls and handling them in our lab. Staff from the Education Department at Lincoln Park Zoo helped us to translate this advice into a simple collection protocol and educational pamphlet for participants. Every collected bee was washed, dried, pinned, sorted, labeled, and recorded in the Discover Life online database. Based on these data, the research team compiled a species list for Chicago area Anthophila (Apoidea) and is analyzing the data to understand how scales and types of urban land use affect bee abundance and diversity.

In short, the project was a success.

But was it?

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Although most of our participants reported being satisfied with the CAPS experience and half reported they would like to participate in CAPS the following year, we have reservations about the success of the citizen science component of the project. From surveying our participants before and after CAPS, we discovered that they did not achieve the knowledge, attitudinal, and behavioral goals we had hoped for. And we realize now that they did not achieve these goals because we failed to effectively engage our citizen scientists and bring them into the collaborative research effort.

We offer our experience here in hopes that other small, start-up citizen science projects can learn from our mistakes to create the types of dynamic and mutually successful projects that scientists and citizens deserve.

BACKGROUND

Citizen science, under the umbrella of Public Participation in Scientific Research (Bonney, Ballard et al., 2009), engages nonscientist citizens in the collection of data for scientific research and is an increasingly common approach to ecological research. By engaging laypeople, scientists can increase sample sizes while sampling locations that are otherwise inaccessible (like the private yards we relied on in CAPS; Bonney, Cooper et al., 2009). Although there was initial skepticism about whether citizens could effectively and accurately contribute to scientific projects, citizen-collected scientific data gained credibility throughout the late 1980s and early 1990s as collection protocols improved (Lee, 1994). Today, citizen science is a widely accepted tool for collecting a broad scope of data.

Citizen science projects fall on a continuum of engagement. The CAPS project was a "citizen volunteer" (Clark & Illman, 2001) or "contributory" (Bonney, Ballard et al., 2009) project, whereby citizens gather data for a research study initiated and guided by scientists. This mode of citizen science is less citizen centered than projects driven by the "citizen scientist" (a citizen who evaluates science) or "citizen activist" (a citizen who defines and drives a research project) but is attractive to researchers with minimal resources who seek to extend data collection efforts and those who hope to impact citizen learning outcomes (Clark & Illman, 2001). Because contributory projects generally involve nonscientists mostly in the aspect of data collection, they have been criticized for the fact that scientists usually control the citizen-collected data (Lakshminarayanan, 2007). Still, Cooper, Dickinson, Phillips, and Bonney (2008) assert that citizen science can "change public perception of the value of science to individuals and society," and they advocate for sharing data from citizen science projects in a user-friendly way.

The Cornell Lab of Ornithology (CLO) offers some of the best examples of mutually beneficial citizen science research. Because of the logistical challenge of gathering lots of data across very large areas, researchers at CLO have relied on citizen science data to study large-scale biological patterns (e.g., Caruana et al., 2006; Cooper, Hochachka, Butcher, & Dhondt, 2005; Cooper, Hochachka, & Dhondt, 2005; Cooper, Hochachka, & Dhondt, 2006; Hames, Rosenberg, Lowe, Barker, & Dhont, 2002; Hochachka et al., 2007). Meanwhile, they have studied citizen science participants themselves and found that these projects contribute to participant learning about science and the scientific process (Bonney, 2007; Brossard, Lewenstein, & Bonney, 2005; Evans et al., 2005; Krasny & Bonney, 2005; Trumbull, Bonney, Bascom, & Cabral, 2000; Trumbull, Bonney, & Grudens-Schuck, 2005). CLO researchers have shown that both scientists and citizens benefit from these types of projects.

We hoped that CAPS would have this same dual impact: netting high-quality bee data for the research team while providing participants with a positive and consequential learning experience. Based on the available literature and the expertise provided by Lincoln Park Zoo, we designed a program with our dual goals in

mind. To educate participants, we created a clear and simple research protocol and a full-color, highly researched, colloquially written information sheet about bees for the citizen science collection kits. We created a Google group and a blog for our citizen scientists. We answered inquiries about the project. We learned all we could about bees and worked to share our enthusiasm with participants.

We assumed that the effort we put into program design would pay off for both our participants and for us. We assumed, like other citizen science project designers, that this project would effect educational, attitudinal, behavioral, and scientific outcomes in our participants (Cooper, Dickinson, Phillips, & Bonney, 2007). We wanted to document these outcomes, so we set about creating surveys about the knowledge, attitudinal, and behavioral impacts of participation in CAPS. By surveying participants before and after with an online survey, we hoped to discover whether participation in CAPS would: promote wildlife-friendly behavior changes; positively shift attitudes about bees, urban habitats, and science; and improve knowledge about bees, ecosystem services, specimen collections, and urban wildlife habitat. We expected it would.

METHODS

In May and June 2009, CAPS researchers solicited participants for the summer-long CAPS. Sixty-one individuals or families (representing 61 different collection sites) agreed to participate in the project. Participants ranged from college students to young families to retired adults, all of whom had some connection to CAPS researchers. Some participants had a science background, but many did not. In early July 2009, CAPS researchers e-mailed all participants asking them to complete an online survey with questions about demographic information and their knowledge of, attitudes about, and behavior towards bees (Appendix). We asked that participants complete the pre-CAPS survey before opening their CAPS collection kit to be certain that their answers were not influenced by the educational information in the packet. After multiple follow-up e-mails, 47 individuals completed the online pre-CAPS survey.

Thirty-four of those 61 initial participant families or individuals (55.7%) completed at least one of the four separate bee collections in July, August, September, and October 2009. After the last collection, we asked participants to complete a post-CAPS survey. This post-CAPS survey repeated the same knowledge, behavior, and attitude questions from the presurvey and included a series of questions for program feedback. After multiple reminders, 30 individuals completed the post-CAPS survey.

In both surveys, we asked participants for the last four digits of their cell phone numbers as unique identification numbers to match pre-CAPS and post-CAPS responses. All matched data (25 respondents) were used for testing our hypotheses. The majority of survey questions were Likert items, which asked respondents to indicate how strongly they agreed or disagreed with a number of statements related to our learning outcomes: about their knowledge of and behaviors and attitudes towards bees. Although Likert item survey questions have been criticized for their subjective nature and their lack of contextualization of terms, as well as for the possibility of respondents to mislabel confusion as neutrality (Siegel & Ranney, 2003), we adopted this common approach to survey design because it allowed us to create a quickly designed, answered, and analyzed survey with precise and reliable results (Oppenheim, 2000). We analyzed matched responses using the Wilcoxon Signed-Rank test, following Pratt's (1959) approach to tied data in R (Version 2.14.1; R Development Core Team, 2011).

As Cooper et al. (2007) detailed, "Most citizen science projects have an underlying, testable assumption that engagement of the public in the process of research has scientific, educational, attitudinal, and behavioral outcomes," and our hypotheses were based on

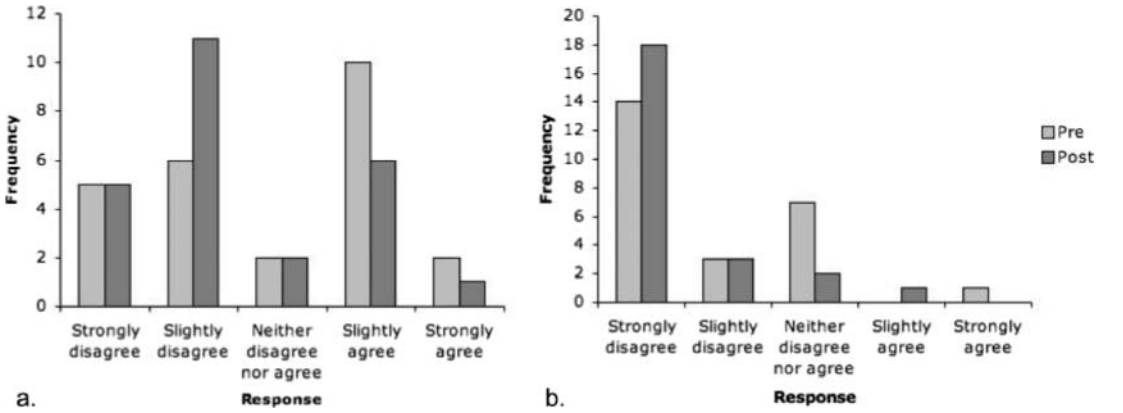

Fig. 1. Responses to Likert-item questions on the survey before and after participating in CAPS. a. "I am fearful of bees." b. "I think bees are dangerous in urban landscapes."

those assumptions. We hypothesized that participation in CAPS would: (a) promote wildlife-friendly behavior changes; (b) positively shift attitudes about bees, urban habitats, and science; and (c) improve knowledge about bees, ecosystem services, specimen collections, and urban wildlife habitat in our citizen science participants. Our goal was to use pretesting and posttesting of participants to clearly document the extent to which these tasks were accomplished and, in turn, help other citizen science programs evolve to better meet the needs of citizens, scientists, and society.

RESULTS AND DISCUSSION

Our results will be useful to other citizen science programs, but not for the reasons we initially thought.

Of the Likert items on the survey, responses for only one question were significantly different pre- and post-CAPS (Wilcoxon Signed-Rank test, $Z = 1.9858$, $p = 0.047$). Participants were asked to rate their response to the statement "I am fearful of bees" (Q23) on a 5-point scale from "strongly disagree" to "strongly agree." The most common response before CAPS was "slightly agree" ($n = 10$) and the most common response after CAPS was "slightly disagree" ($n = 11$; Fig. 1a), which suggests that people were less afraid of bees after participating in CAPS. We think this attitude shift occurred because people were engaged in attracting bees to their yards and then interacted with bees as part of the project. A similar statement "I think bees are dangerous in urban landscapes" (Q26) elicited more instances of strong disagreement after CAPS (Fig. 1b), but the difference was not statistically significant (Wilcoxon Signed-Rank test, $Z = 1.7258$, p-value $= 0.08438$).

Responses to the rest of the questions illustrated ways that we did not teach or engage participants. In one question, we asked respondents to "name as many different types of bees" as they could. There was a statistically significant change in the mean and median number of real bee types (Q41) named before and after CAPS (Paired *t*-test, $t = -2.2205$, $df = 24$, p-value $= 0.036$). This indicates that participants did learn new types of bees by participating in CAPS. However, the median and mean were still very low after CAPS (3 and 2.64, respectively), considering that participants collectively sent in more than 48 bee species in 15 different genera. Responses to the question also revealed a misconception that we never corrected: participants were just as likely to name wasps as bees before and after CAPS. This is not

surprising because we failed to include any information about the differences between bees and wasps in our educational materials. We realize now that we could have taught participants the difference between bees and wasps by, for example, writing a blog post about this misconception and sharing it with participants.

Participants received links to bee identification Web sites in their collection kits, but the CAPS project itself did not create any customized bee guides. We think the number of bees named by participants could have been increased considerably by including a printed bee guide or by sending regular species features to participants via e-mail or our blog. Post-CAPS we received some useful suggestions such as requests for bee identification guides "like baseball cards" and more "learning about pollinators." Even better, we could have moved from education to engagement: by not just delivering factual content about bees, but by engaging participants more fully in the research process. To do that, we should have quickly reported to participants about the bee species they collected. This level of accountability would have served to educate participants about urban pollinators, and would also have served to make participants connect more deeply with the research study and demonstrate the value of their involvement. Unfortunately, bees were not processed and identified until long after the collections ended, so participants did not get feedback about the species of bees they actually collected or whether they collected any bees at all. In this way, we failed to engage our participants in the results of their own collections.

In addition to these questions about factual knowledge, we asked survey questions about participants' behaviors around and attitudes towards bees. Except as noted above for fear of bees, we did not find any statistically significant changes in behaviors or attitudes among CAPS participants, which is consistent with the common findings of gains in content knowledge but not inquiry (Trumbull et al., 2005) or attitudes towards science and the environment (Brossard et al., 2005). There were some encouraging trends that were not significant, such as more people wanting bees using their yards after CAPS (Q19), more people more strongly disagreeing with the idea that bees are dangerous in urban landscapes (Q26), and most people continuing to strongly disagree that bees are a nuisance after CAPS (Q28). These are positive, though not very clear or strong, outcomes from participation in CAPS. And yet CAPS did not seem to inspire participants to learn more about bees (Q25), nor did it inspire participants to consider themselves as advocates for urban wildlife including pollinators (Q29). We realize now that we failed to offer participants ways to get inspired, involved, and active: ways to actually advocate. We suspect this lack of engagement was more detrimental to the overall educational goals than a simple deficit of factual educational content. After all, inspired participants would likely have been motivated to pursue facts on their own (regardless of whether they were provided directly) and may also have been motivated to support scientific research more broadly.

Our project fell short in its failure both to engage CAPS participants and to understand the significance of this engagement for participants' perceptions of science. Although post-CAPS respondents had just contributed to a 4-month long scientific study about bee diversity and abundance, the frequency of respondents who "strongly agreed" with the statement "I think it's important that nonscientists get involved in scientific research" (Q30) decreased post-CAPS (Fig. 2a). At the same time, the frequency of respondents who "neither disagreed nor agreed" with the statement increased. Participants seemed less sure about whether or not they valued involvement in a project like CAPS, even though they overwhelmingly agreed both before and after that "scientific research is important to my daily life" (Q32; Fig. 2c). In addition, CAPS may have prompted some participants to feel that scientists themselves are not interested in involving nonscientists in scientific research. When asked to respond to the statement "I think scientists are interested in involving nonscientists in scientific research"

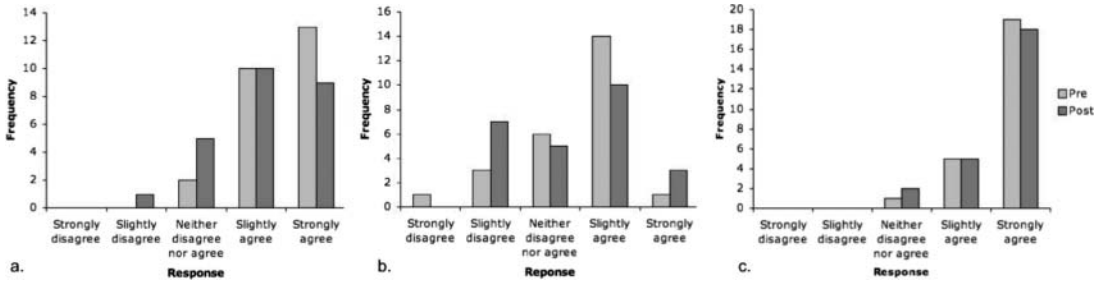

Fig. 2. Responses to Likert-item questions on the survey before and after participating in CAPS. a. "I think it's important that nonscientists become involved in scientific research." b. "I think scientists are interested in involving nonscientists in scientific research." c. "I think that scientific research is important to my everyday life."

(Q31), the frequency of matched respondents "strongly" or "slightly" disagreeing increased post-CAPS, while the frequency of matched respondents "strongly" or "slightly" agreeing decreased post-CAPS (Fig. 2b). While not statistically significant changes, these trends indicate that we should have paid much closer attention to the need to serve as scientific ambassadors to citizen scientist participants.

This idea that we missed an opportunity to serve as ambassadors for the scientific community is perhaps our biggest regret. We connected with 61 individuals and families throughout the Chicago area who were interested enough to sign on to our study. Only 34 of those families remained engaged enough to submit at least one bee collection and only 30 individuals completed a post-CAPS survey. And even those people still reported minimal content knowledge gains, modest shifts in attitudes, and potentially negative shifts in their perceptions of the involvement of nonscientists in scientific research. And what of the participants who we lost entirely? What would they say?

In our minds, a successful citizen science project would achieve knowledge, attitudinal, and behavioral changes. We now realize that with all the work we were doing to set up the program and its assessment, we did not spend enough time formulating and implementing a plan by which our citizen scientists would actually achieve these goals. Once the project began, we were so consumed collecting additional bee specimens at community gardens, sorting and recording the inundation of bee samples from participants, and beginning the process of washing, sorting, pinning, labeling, and identifying bees that there simply was not any spare time to revisit the educational goals. Managing the specimens and data overshadowed engagement with participants.

Without surveying our participants before and after CAPS, we might not have realized the extent to which they did not learn or engage with the project. Although we conceived this project hoping to provide documentation of the positive outcomes of citizen science participation, we ended up learning some hard lessons about what we could have done better (Table 1).

We think that our project's shortcomings offer important lessons for future citizen science projects, especially those undertaken by small, newly established projects like CAPS that lack the resources and visibility of larger programs. Crucially, if we had not surveyed our participants before and after, we might not have realized just how much we did not teach or engage them.

In our failure to engage our citizen scientists, we missed a critical opportunity to educate them about bees. We also, more significantly, missed a chance to serve as ambassadors for scientific research: to offer a chance for citizens to identify with the aims of our research and to feel that this research—*their* research—matters.

Table 1
Suggestions for Coordinators of Similar Projects

- Think about what your participants will get out of the experience. What do you want them to get out of it? How will you ensure that they do? How will you know?
- Find out what your participants know and think! Survey them before and after. Even better—also survey a control group of nonparticipants. Work with a social scientist to design the survey and pretest it. Don't forget to get approval from your Institutional Review Board, which supervises research on people.
- Plan and schedule your outreach/educational activities along with the data collection. For example, decide who will write about particular topics and when information will be shared.
- Enlist the expertise of science educators who specialize in making science more easily understandable for the public.
- Use other forms of social media to keep participants updated and engaged (e.g., Facebook, Twitter, Google+, Pinterest). You can even use a social media aggregator to update all of them at once. These are often free, full-color multimedia that are capable of instant communication and real time broadcasting.
- Even if your project does not rely on participant identification of species (which most projects admittedly do), create a customized ID guide.
- Create ways for participants to view data they contributed. Share results—even just preliminary ones—as soon as possible.
- Ask for feedback from participants about how to improve the project. Make it easy for them to offer feedback, and accept it humbly and graciously.

CONCLUSION

As a pilot project, CAPS was a scientific success: participants collected useful data that contributed to an important list of Chicago area bees. But we take the difficult lessons learned from this project seriously. We hope that future citizen science coordinators will, as well. After all, we know these lessons are important because we pretested and posttested participants. Because of that, we know how the project changed—or, more often, failed to change—participants, and we have given much thought to why these outcomes were what they were.

We cannot stress enough that citizen science coordinators need to attend to their citizen scientists and not just their data. Project coordinators should rely on the growing literature about citizen science design, including Bonney, Cooper et al. (2009), and Cronje, Rohlinger, Crall, and Newman (2011). They should consider what they hope their citizen scientists will learn and creatively deliver the relevant content. Even citizen science projects with well-designed questions, goals, technological infrastructure, and sharing of results often lack clear methods for assessing the experience of their participants (e.g., Gallo & Waitt, 2011; Kolok, Schoenfuss, Propper, & Vail, 2011; Lee, Quinn, & Duke, 2006). Researchers should survey citizen scientists before and after participation to find out whether their learning objectives were met. They should remain accountable to citizen science participants, responding to them about the ongoing scientific research as promptly as possible and offering participants ways to get inspired, involved, and active. They should work proactively to address the needs and concerns of participants finding themselves immersed—many for the first time—in the scientific process. They should take seriously their roles as ambassadors for the scientific community among a lay audience.

We have the sense that increased outreach to participants in future projects would go a long way towards improving both content acquisition and buy-in of the project itself. By utilizing the various strategies suggested previously (Table 1), future projects could likely see demonstrable improvements in participants' attitudes towards bees, urban wildlife, and the scientific endeavor.

Crucially, our failures demonstrate that a job poorly done—and poorly done for compelling and common reasons—can potentially do as much harm as good. Our message is to design, implement, and cultivate citizen

science projects with citizens—and not just data—in mind. A successful citizen science project—especially one with limited resources—needs to plan very carefully about what outcomes it hopes to achieve, how it will teach towards and assess those outcomes, and how it will remain accountable to its citizen scientist participants so that citizen scientists get back at least as much as they put in. The mistakes we made were made in good faith but made nonetheless.

As miscommunication deepens between scientists and the general public, and the stakes of public action about scientific research grow higher, citizen science practitioners are positioned to bridge the growing public/science divide (Bonney, 2004). Careful and thoughtful design and implementation matter not only for citizen science participants but also for rallying financial and argumentative support for science itself.

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APPENDIX

List of questions asked in the presurvey and postsurvey of participants in the Chicago Area Pollinator Study.

DEMOGRAPHICS/ABOUT THE PARTICIPANTS

Question 5. What is your age?
Question 6. What is your gender?
Question 7. How many people are in your household?
Question 8. What is the age of the oldest member of your household?
Question 9. What is the age of the youngest member of your household?
Question 10. What is the highest level of education you completed?
Question 11. What was (or is) your major subject or focus of study in school?
Question 12. How did you hear about CAPS (the Chicago Area Pollinator Study)?
Question 13. What are your reasons for participating in this study? (Choose all that apply.)
Question 14. What features does your yard contain? (Choose all that apply.)
Question 15. Roughly how large is the yard where you will be collecting bees?

BEHAVIOR

Question 33. When landscaping my yard, I pay specific attention to using native plants.
Question 34. I use pesticides in my yard to keep weeds and harmful insects out of my yard.
Question 35. I would kill a bee if it were disrupting my time outdoors.
Question 49. Have you ever visited Lincoln Park Zoo?
Question 50. If yes, in the last 24 months, how often have you visited Lincoln Park Zoo?

ATTITUDE

Question 19. I want bees using my yard as habitat.
Question 23. I am fearful of bees.
Question 24. I think scientific research is important for learning more about wildlife.
Question 25. I want to learn more about bees.
Question 26. I think bees are dangerous in urban landscapes.
Question 27. I think bees are an important part of our food chain.
Question 28. I consider bees a nuisance.
Question 29. I consider myself an advocate for urban wildlife.
Question 30. I think it's important that nonscientists become more involved in scientific research.
Question 31. I think scientists are interested in involving nonscientists in scientific research.
Question 32. I think that scientific research is important to my everyday life.
Question 39. How important are the services provided by bees?
Question 43. Why do you think you are being asked to collect bees?
Question 44. How important are specimen collections for understanding urban wildlife?
Question 45. How necessary is it to kill bees for this study?
Question 46. I think that declining bee populations are a significant problem.
Question 47. I am worried that collecting bees for this study will contribute to the decline of bee populations.

KNOWLEDGE

Question 16. Which animals use your yard as habitat?
Question 17. Which features of your yard do you think attract these animals?
Question 18. My yard contains habitat suitable for bees.
Question 20. Bees are the only pollinator in the Chicagoland area.
Question 21. Lincoln Park Zoo studies the interaction between humans and wildlife in an urban ecosystem.
Question 22. All bees live in family groups, called colonies.
Question 36. Have you ever heard the term "ecosystem services"?
Question 37. How would you describe ecosystem services?
Question 38. Do you think that bees provide ecosystem services?
Question 40. Can other animals provide the same services that bees do?
Question 41. Name as different kinds of bees as you can (up to 10).
Question 42. Which parts of your yard do bees use? (Choose all that apply.)
Question 48. What, in your words, are CAPS scientists trying to study?
Question 51. Have you, prior to CAPS, heard of the Urban Wildlife Institute at Lincoln Park Zoo?

FEEDBACK (Post-CAPS survey only)

Question 52. How much time did you spend participating in CAPS?
Question 53. How satisfied are you with your experience participating in CAPS?
Question 54. Would you like to participate again next year?
Question 55. How easy to follow were the instructions that were sent out in the collection kits?
Question 56. How easy was it for you to use the Google group?
Question 57. How accessible were CAPS researchers when you had questions?
Question 58. Did your collection kit contain everything you needed to complete this project?
Question 59. Did you visit the CAPS blog?
Question 60. How many times have you visited the CAPS blog?

Question 61. Did you find the blog useful?

Question 62. What changes could be made to the blog in future years to make it more useful?

Question 63. Please let us know why you didn't visit the blog.

Question 64. In your opinion, what were the most valuable aspects of participating in CAPS?

Question 65. What suggestions do you have for improvement in organization, communication, project materials, or otherwise?