ILI

Lost Ladybug Project

Summative Evaluation Report

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Understanding, fostering, and promoting lifelong learning

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Executive Summary

The Lost Ladybug Project (LLP) is a citizen science project led by Cornell University's Department of Entomology and funded by the National Science Foundation. As a primarily web-based program (www.lostladybug.org), the Lost Ladybug Project empowers adults and children from across the United States to become citizen scientists by searching for ladybug species in their neighborhoods, photographing the ladybugs they find, and submitting them to the project scientists for identification, along with supporting data about the location and habitat where the ladybug was found. Since the inception of the project in 2008, a total of 13,365 ladybug specimens were contributed to the project (as of January 31, 2012). The priorities and audience focus for the project shifted over time, in step with shifts in outreach strategies, growing to encompass a greater degree of participation by adults.

Summative evaluation was conducted in the program's final year from youth and adult participants; evaluation was guided by the following overarching questions:

- To what extent has the program achieved its intended science learning impacts?
- How are learning outcomes different for different types of participants?
    - For lone adult participants?
    - For children 5 – 7 years old?
    - For children 8 – 12 years old?
- How does participation over multiple years relate to outcomes, attitudes, and motivations?
- What strategies might support or motivate sustained participation over multiple years?

Multiple methods were used to address these questions, including gathering data from adults, parents, youth, and educators who led groups in the project. To assess adult outcomes, evaluation used a quasi-experimental design, using a one-shot, pre-test / post-test approach with non-paired samples, as well as quantitative post-only measures for other indicators. The pre-test recruited prospective LLP participants via pop-up recruitment on the project website (n=50). The post-test was deployed via an online questionnaire sent to all email addresses associated with data submitted during the 2011 season (993); an overall response rate of 36% was achieved (n=353). Youth participating with classrooms or groups completed concept maps (5-7 year olds) and paper questionnaires (8-12 year olds). Facilitating educators also completed a questionnaire. Additional data on youth learning was collected from parents, via the online survey. Qualitative data were coded and quantified using coding rubrics developed for the project. Descriptive analysis presents trends and attributes of participant outcomes; non-parametric statistical analysis was used to compare data from pre/post tests, as well as relevant sub-groups of participants.

Key Findings

- **Overall, the Lost Ladybug Project showed achievement for each of its identified science learning impacts in knowledge, attitudes, and skills.**
- **Nearly all self-directed participants reported looking at and reading at least some of the information material about ladybugs on the LLP website. Similarly, more than three-quarters reported using some of the data-out features**; although these were mostly limited to review of pre-constructed data outputs: maps, tables, and images of data. Very few adults used the interactive data analysis tool (build your own pie chart).

- **Based upon educator reports, teachers implementing LLP with students or groups do not use the full set of curriculum materials provided by the project online.** Instead, teachers tend to select certain activities – primarily focused on the collection and submission of data – and possibly supplement with their own activities. LLP-produced lessons on ladybug species diversity and population dynamics seem to be used minimally, if at all, by participating teachers.

Adult Participants

- **Among adult participants, there were significant pre- to post- increases in knowledge scores about ladybug biology and species diversity.** Adults also self-reported these concepts as those most strongly learned from the project, especially issues of species diversity.
- **Adult data showed that the desire to contribute to scientific research and to conservation were two of the most powerful motivating factors** and two of the strongest factors of enjoyment for those who participated in the program. **Adults rated very high levels of confidence about the usefulness of their contribution and its importance to scientists.**
- As in any citizen science project, individuals' participation in the endeavor inherently demonstrate some abilities and skills in particular steps of the scientific process; in this case, data collection. **Data from project submissions show demonstration of strong skills in identification of species, with a 93% success rate among those who tried to identify their specimen (57% of all submissions).**
- **Adults demonstrated positive interest in participating in future citizen science projects. They also showed strong, positive attitudes about citizen science generally**; however, these attitudes were very strong in pre-participation data, and thus did not seem to be impacted by participation in this project specifically.
- **A relationship was found between multi-year participation and higher scores in measures of knowledge outcomes and attitudes about the value of their contribution to science**, as compared to one-time participants. It is likely that there is a reciprocal relationship between the factors of repeat participation and these attitudinal outcomes, with belief in the importance and value of an individual's contribution both enhancing motivation to continue to participate and that continued participation further enhances the belief in the value of contribution.

Child Participants

- **Children of all ages (5-12 years old) showed strong knowledge of ladybug biology vocabulary and concepts after the program**; average extent scores were 6.07 (range: 0 to 15), while average breadth scores were 2.07 (range: 0 to 4). Students demonstrated particularly strong conceptual knowledge in the area of ladybug biology; in fact, low extent scores overall masked the fact that many students' demonstrated biology knowledge included multiple sub-concepts of ladybug biology.
- **Children showed a clear understanding of the purpose of their role in the science process** and a strong feeling that their contribution would help scientists and, to a lesser extent, would help ladybugs.
- Although children did not self-report learning skills, **the adults who worked with them (parents and teachers) reported strong demonstration of skills among their children in both age groups, with skills of 8-12 year olds being stronger in a broader range of science skills.** For both age groups, the

skills most demonstrated related to data collection and understanding the purpose of the study. Skills around data analysis and drawing inferences were generally weakest overall, even among groups facilitated by a teacher.

- **Children's satisfaction with the program was high overall, with students most enjoying the tasks of data collection – searching for, finding, examining, and handling the ladybugs.** Youth were also very positive about doing something similar to this project in the future.
- **There was relatively little impact on family groups' likelihood of participating in outdoor or science activities;** those who are likely to participate in LLP already demonstrate high levels of engagement in these activities. This was also somewhat true for citizen science activities, with a substantial portion of the pre sample indicating that they had some previous engagement with citizen science activities. **However, of the three types of activities, likelihood of citizen science participation was reported to be positively influenced by LLP participation by almost half of family respondents.** There may be some limitations to this potential impact, but the LLP does show a positive influence on whether participants to take part in citizen science projects in the future.

Recommendations

- Adult participation and motivation will benefit from **sustained, ongoing communication about researchers' findings and hypotheses that are being generated from project data.** Adults are interested in and motivated by finding out about what scientists discover from their contributions.
- **Considering the lack of use of the interactive data-out features on the website, the project may want to examine and define its goals and desired usage for such features going forward.** If audience engagement with these features is a goal, a better understanding of the perceived benefits and motivations for this audience around data exploration may be needed.
- **Consider adding new features and resources that can reflect geographically localized information.** Additionally, greater adult-focused resources and content to provide for deeper engagement may be warranted.
- **New strategies or materials to support and motivate teachers/educators may be needed if the project intends for teachers to engage their students directly with the project's core science/biodiversity concepts,** going beyond a focus on the data collection and submission process.
- Students experienced disappointment when data collection challenges occurred, including not finding any ladybugs; **LLP could consider offering new support for teachers to try to transform disappointing experiences into teachable moments,** by highlighting the realistic part of the scientific process. In particular, **this provides an opportunity to teach that a lack of data *is* data, a core factor in understanding the nature of science**.
- As the project continues, **it may be possible to increasingly refine the tasks, lessons, or intended outcomes to be more specific to different age ranges of students.** In particular, 5-7 year olds seem best suited to learning about taking care during data collection; while 8-12 year olds are increasingly able to think about the purpose of a study, help plan a study, and identify patterns.

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Introduction

Project Background

The Lost Ladybug Project (LLP) is a citizen science project led by Cornell University's Department of Entomology and funded by the National Science Foundation, which uses ladybugs as a focal species to involve children, families, and adults in field science experiences to illustrate scientific concepts, including invasive species, biodiversity, and conservation. The project is designed to empower individuals and groups to participate in research as citizen scientists by searching for ladybug species in their neighborhoods, photographing the ladybugs they find, and submitting them to the project scientists for identification, along with supporting data about the location and habitat where the ladybug was found. Because ladybug species can generally be identified from a photograph of reasonable quality, the scientific staff of the Lost Ladybug Project is able to verify the species of submitted photographs, resulting in a large dataset from locations around the country that is increasing scientists' understanding of changing patterns in ladybug species populations. Program participants not only contribute data, but are able to see the results and identification of their specimens through tools on the Lost Ladybug Project website (www.lostladybug.org).

The program was designed to engage participants through two mechanisms, which provided different experiences to scaffold learning. One route, called Self-Directed Mode, occurred via the project website, where participants could access project materials, instructions, and science information about ladybugs, and participate in the program independently[1]. This mechanism proved to be highly successful at recruiting citizen science participants from the outset, as it quickly and continuously gained attention from national media venues, including stories with NPR, *Ranger Rick* magazine, *Scholastic* magazine, *American Girl* publications, and other national and local media outlets. This publicity drove substantial national traffic to the website, and the project maintained strong levels of participation (as measured through the submission of ladybug data) throughout the four years. In fact, with this success, greater emphasis and priority was placed on developing and supporting the growth of this robust network. Since the inception of the Lost Ladybug Project website in 2008, a total of 13,365 ladybug specimens[2] have been contributed to the project (as of January 31, 2012).

The other mechanism for participation was called Group Facilitated Mode. As proposed, this mechanism was planned to create a network of youth group leaders (e.g., 4H, Boy Scouts, school teachers, etc.) who were trained to lead a group of children to participate in the program (using a train-the-trainer model) and who implemented the program with their classes or groups. As implemented, however, while some group leaders received some level of training or support from LLP staff, most group leaders and teachers who participated were not directly trained by the project team. Rather, these educators learned about the project and its resources for teachers through various outreach efforts that were led by the project team (i.e., attendance at community fairs, school fairs, outreach to nature centers, etc.) or via the website (in a similar pathway as those in the self-directed mode). In the absence of training, educators had access to curriculum and lesson plan resources[3] and other outreach

[1] Basic instructions, as well as links to detailed protocols, can be found online at: http://www.lostladybug.org/participate.php.
[2] This number includes specimens collected through both self-directed and group-facilitated modes.
[3] Curriculum and lesson plan resources can be found online at: http://www.lostladybug.org/lesson_plans.php.

materials, including field guides, brochures, posters, bookmarks, activities, and a coloring book[4] via the project's website. In practice, with limited training opportunities for educators, the participation of group leaders within the project functioned in similar ways to the Self-Directed Mode. Educators navigated the available resources independently, using and adapting lessons, materials, and activities that they felt were most useful for their purposes and youth learners. As such, the types of lessons that supported the citizen science activities of youth varied widely across the groups and schools that implemented the project. The primary difference was that in group facilitated experiences, youth did participate as a group or class, and their experience was scaffolded by the guidance and decisions of the group leader or teacher.

In addition to the shift in implementation from a training network to a self-directed network supported by multiple resources and outreach, the emphasis on this mode decreased somewhat, as emphasis on the self-directed mode increased. In total, roughly 130 youth groups, schools, or classrooms were known to have participated in the project (by submitting data) over the life of the project[5]. Some of these represented teachers/leaders who participated with different classrooms/groups over multiple years.

Based upon results of formative evaluation of the 2009 and 2010 program years (Sickler & Messick, 2010; Sickler & Cherry, 2011), the project team built upon some findings and recommendations from formative evaluation to guide refinements to the program. For instance, as part of planned improvements for the project website, visitor feedback on usability of the submission pages guided a number of changes to make the forms and process more user-friendly. Another example was in response to findings that suggested participants (adult and youth) valued and were motivated by the feeling of contributing to real, important scientific research. To support this, program staff provided clear communication with past participants about the scientific results from their data via their website and a 2010 program newsletter.[6] This newsletter reported to participants some of the key scientific results coming out of their data and what science staff was doing in response to this data. Refinements made, such as these, focused on improving the program to continue on its course of recruiting and supporting participants' remote participation.

In addition to the shift in emphasis on the project's delivery mechanism, the project also experienced a shift in its target audiences and impacts after its initial roll-out. The Lost Ladybug Project was initially intended to impact children between the ages of five and 12, with possible secondary impacts on their adult facilitators. However, project participation data and subsequent formative evaluation data (Sickler & Messick, 2010) revealed that a majority of participants were, in fact, adults participating individually (without children). The prevalence of this unanticipated audience led to the need for the project to expand its impact statements to incorporate this unanticipated group. As a result, by its final year, the Lost Ladybug Project identified three audiences it intended to impact: children between the ages of five and seven years old, children between the ages of eight and twelve years old and adult participants. The following impacts were specified for these audiences:

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[4] Outreach materials and resources can be found online at: http://www.lostladybug.org/pdf_resources.php.
[5] The flexible nature of the project and the single portal for data submission makes exact counts of group vs. individual/family participation difficult. Given complete data provided by participants, program staff are generally able to identify groups from the participant database. However, it is possible that some additional groups participated but were mistakenly captured within the self-directed participant count.
[6] The 2010 Newsletter is available on the project website: http://www.lostladybug.org/newsletter2010-975.php.

- Elementary children and adults will increase their knowledge and understanding of ladybug ecology.
- Elementary children and adults will feel confident that they have contributed to scientific research.
- Elementary children and adults will demonstrate scientific inquiry skills.
- Elementary children and adults will be interested in doing more citizen science projects.
- Families will participate in future outdoor, science, or citizen science activities.

Evaluation Questions

In the project's final year, summative evaluation of these impacts was conducted, collecting data from participants through both distribution mechanisms (i.e., self-directed and group-facilitated) and from individuals representing the adult and the youth populations. Summative evaluation was guided by the following overarching questions:

1) To what extent has the program achieved its intended science learning impacts (listed above)?
2) How are learning outcomes different for different types of participants?
    - For lone adult participants?
    - For children 5 – 7 years old?
    - For children 8 – 12 years old?
3) How does participation over multiple years relate to outcomes, attitudes, and motivations?
4) What strategies might support or motivate sustained participation over multiple years?

Methods

Adult Participants

In the final ladybug season (2011), 993 adult participants (participating either as individuals or within a family group) were identified as having submitted data to the Lost Ladybug Project under a unique email address.[7] Evaluation used a quasi-experimental design, using a one-shot, pre-test / post-test approach with non-paired samples, as well as quantitative post-only measures for other outcomes (as appropriate).

To gather baseline, pre-participation data, ILI recruited study participants using a pop-up message on the LLP website. This mechanism was used to gather a sample that was as equivalent as possible to the ultimate LLP participants in terms of incoming knowledge and experiences, on the assumption that a first step in participation is coming to the project website. This recruitment approach screened respondents to ensure study participants were adults who have not previously participated in the program. Those who agreed to participate were routed to an online questionnaire which collected baseline data about ladybug biology and environmental knowledge, motivation for participation, prior experience with scientific projects or citizen science, and demographic information (see Appendix A for instrument). Participants in this survey received a small incentive to encourage participation (a $10 gift card to Amazon.com).

Post-test data was collected at the completion of the 2011 program season, with respondents recruited via email from the database of those who submitted ladybug data to the project during 2011. Respondents completed an online questionnaire that included parallel items to the baseline instrument, as well as additional items to measure satisfaction, attitudes, and feedback on participation (see Appendix B for instrument). The use of web-based surveys was deemed appropriate for this audience, considering that their mode of participation was designed to be entirely web-based, participants were widely distributed around the country, and email was the only form of contact experienced between program staff and participants.

An additional indicator developed for the project was participants' success rate of making correct ladybug identification during the submission process (indicating their ability to analyze a specimen and identification resources to determine the species type). Data from the participant submissions and scientist verification were assessed for this measure.

All data from online questionnaires were analyzed using descriptive and inferential statistics. Data from open-ended questions were coded and quantified using on coding rubrics that were developed using an inductive process and refined with qualitative data in previous rounds of formative evaluation. Descriptive analysis is used to present trends and attributes of participant response to the project; non-parametric statistical analysis[8] was conducted to compare pre- and post-test data for evidence of significant changes in knowledge or attitudes.

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[7] Because LLP does not require registration, individuals may be captured multiple times in the participant database if they submit under multiple email addresses (the sole determinant of identity). As a result, the estimate of 993 participants is known to be an overestimate of participation, although it is not possible to determine by how much.

[8] Non-parametric analysis was selected as a conservative analysis approach due to potential non-normal distributions of the sample and substantial difference between pre and post sample sizes.

Recruitment and Participants: Adults

For the baseline questionnaire, the pop-up recruitment message was open on the LLP website from May 25 to May 31, 2011 and resulted in 75 clicks by viewers interested in participating. After the screening questions, 49 adults completed this questionnaire.

For the post-test data, in October 2011, an invitation to participate in an online survey was sent out by email to all 993 unique addresses from the Lost Ladybug Project database of those who had submitted data within the 2011 collecting season (between February and October). A reminder email was sent one week following the initial invitation to those who had not yet responded, and a final reminder was sent a week later. In total, 387 participants clicked through to view the survey online (a 39% participation rate), and ultimately 91% of those individuals, 353 participants, completed the survey. This resulted in an overall response rate of 36%.[9]

Table 1 shows the demographic characteristics of these two samples of adults, of which nearly two-thirds of the participants were female, and about three-quarters were between the ages of 35 and 64. In terms of education level, the sample was split rather evenly between those with less than a Bachelor's degree, a Bachelor's degree, and an advanced degree, although it was more heavily weighted to the latter two categories. Overall, the majority lived in either suburban or rural areas. Respondents to the post-survey, like program participants, came from many states in the U.S., as well as some from Canada. In total, respondents reported being from 46 different states, with the most common states (reported by 13 or more respondents) being: California, New York, Florida, Rhode Island, Texas, and Colorado (Table 2).

In general this demographic profile of survey respondents indicates that they are similar to the population. Geographically, the distribution of respondents is similar to the overall population, with New York, California, and Florida having the largest percentage of contributors. The sample seemed to have slight underrepresentation of international participants (from Canada or Mexico). In terms of participant ages, contributors are requested to report their ages (but not required). Comparing the sample to the distribution of adult ages reported by participants (55% of contributors), the sample is similar, but skewed slightly older.

[9] Some decrease of response rate is attributed to potential "survey fatigue" of multi-year participants in the program who may have encountered similar requests during formative evaluation phases and chose not to participate again.

Table 1: Demographic profile of adult survey respondents (pre and post combined)

	Percentage	Count
Sex (n=386)		
Female	62%	239
Male	38%	147
Education (n=375)		
Some high school	3%	10
High school diploma	14%	54
Associate's degree	13%	48
Bachelor's degree	34%	129
Master's degree	27%	101
Doctoral degree	9%	33
Region (n=387)		
Suburban	48%	193
Rural	29%	118
Urban	18%	72
Tribal lands	1%	4
Age (n=385)		
Under 18	3%	13
18 – 24	3%	11
25 – 34	11%	46
35 – 44	24%	98
45 – 54	26%	104
55 – 64	20%	79
65 – 74	8%	33
75+	0%	1

Table 2: States of survey respondents, post-only (n=301)

	Percentage	Count
California	11%	34
New York	9%	26
Florida	6%	17
Rhode Island	5%	15
Colorado	4%	13
Texas	4%	13
Other U.S. States	52%	158
International	8%	25

The data about respondents' patterns of participation (post-only) are presented in Table 3. As noted, this program has had an unexpected reach to adults who participate on their own, without a child or group; nearly two-thirds of respondents (64%, n=219) participated in this way. This was in stark contrast to the original design that anticipated families would be the primary Self-Directed participants. The next most common way of participating was with children (33%, n=113), followed by few respondents who

participated in a group of adults. There were no significant differences between the distribution of this sample and the population in terms of participation.

Over half of the participants (61%, n=209) reported submitting between 2-9 photos, and nearly a quarter (21%, n=72) reported submitting only one photo. Additionally, the two-thirds of participants surveyed (65%, n=219) participated for only one of the past five years, and 19% (n=64) participated for two of the past four years. Only two people reported participating all five years of the program (2007-2011).

Table 3: Participation profile of survey respondents

	Percentage	Count
Participation* (n=343)		
Just Myself	64%	219
Myself with Children	33%	113
Myself with a Group of Adults	8%	28
Photos Submitted (n=341)		
0	1%	5
1	21%	72
2-9	61%	209
10-19	11%	36
20-29	1%	2
30+	5%	17
Number of Years Participated (n=339)		
1	65%	219
2	19%	64
3	14%	48
4	2%	6
5	1%	2

*Respondents could select more than one answer, so percents do not equal 100%.

Child Participants

Data on the outcomes and experiences of children within the program were collected using several methods and approaches. In the original study design, the primary component of summative evaluation intended to use a quasi-experimental design, using a one-shot, pre-test / post-test approach with paired samples. For this portion of the study child participants were recruited through group leaders and teachers who intended to participate with their groups of children (ages 5 through 12) during the 2011 ladybug season (which included late Spring, Summer, and early Fall 2011). Teachers and group leaders facilitated collection of data, following protocols provided by ILI.

Pre-participation data of children's knowledge of ladybug biology and ecology was collected using a concept mapping activity, in which children were asked to complete a concept map with the word "Ladybugs" at the center. This method was selected to allow children to construct their knowledge and understanding in their own way using a combination of words and pictures. However, upon receipt of the data and follow-up interviews with teachers, it became clear that data collection was not able to

occur as intended. Due to logistics of the classroom, teachers often provided the initial concept mapping activity after a cursory overview of the project and what they would be doing. As a result, students wrote terms and concepts mentioned by the teacher in the introduction. Upon this assessment, evaluators determined that these data were not valid measures of students' baseline knowledge, and the study design was modified to be a quantitative case study using post-only data from students and data from teachers and parents.

Post-participation data were collected about children's knowledge of ladybug biology and related biological and environmental concepts, enjoyment, attitudes, and interest. Data were collected through two instruments completed by children: post-participation concept map (all children) and child questionnaire (children 8-12 years old) (see Appendices C & D). In addition, data were collected from adult facilitators, reporting on their perceptions of youth learning, via a questionnaire for group leaders/teachers (see Appendix E) and via the online questionnaire (described above) for adult participants who identified that they participated with children.

Concept map data were coded and quantified using a rubric that measured extent and breadth of factual and conceptual knowledge and attitudes, developed based on analysis techniques used with the Personal Meaning Mapping method (see Falk, 2003). Extent measures knowledge of relevant vocabulary and terminology of the subject, while breadth examines understanding at a conceptual level, the themes and concepts that learners articulated after their experience. Separate rubrics were developed for scoring written responses and student drawings. For measures of extent (vocabulary), two researchers separately coded the data using the rubrics, reviewed and corrected any discrepancies based upon the vocabulary rubric. For measures of breadth, inter-rater reliability was assessed with two researchers separately using the rubrics to code a random sample of the data (30 maps) and then comparing the two samples. The threshold for inter-coder agreement was 90%, which was achieved in the first round for coding of drawings. In instances where the first round of comparison did not reach this threshold (breadth of text), the rubrics were clarified and the process repeated with a new random sample; the goal of 90% agreement was reached on the second round. Resulting data were analyzed using descriptive statistics of extent and breadth of student knowledge; inferential analysis was used to examine differences in results between the two target age groups (5-7 and 8-12).

Data from student questionnaires were analyzed similarly, using descriptive and inferential statistics, as appropriate. Data from open-ended questions were coded using rubrics that were developed through a process that included both deductive and inductive elements (see Appendix F for all codebooks). Coding categories began from a framework that paralleled the framework developed in the adult studies (described above), with descriptions adapted using an inductive process to accurately reflect the nature of ideas that encompassed that code for the younger audience group. Results are presented descriptively in this report to document students' reports of learning, attitudes, and enjoyment. Data from teachers' and parents' observational reports of youth achievement were also analyzed descriptively, and these findings were triangulated with the student-generated data to provide additional context and interpretation of youth achievement of learning goals.

Recruitment and Participants: Children, Group Leaders, and Families

Recruitment for the youth study focused on drawing from the LLP program staff's contact-points with prospective or current youth group leaders, which included lists of schools/groups who had requested or received curriculum materials from the program and the database of registered participants from years past. Educators were contacted via email and/or phone beginning in May of 2011, with additional groups contacted as program staff became aware of them throughout the summer. In total 9

participating classrooms or groups, consisting of 171 children and 9 educators, were recruited to participate in the evaluation. Adults from family groups were recruited using the approach described in the previous section.

For data collected directly from children, participating via youth or school groups, data collection and analysis focused on the target audience of 5-12 year olds. A few groups did include children outside of the target age range, and these data were excluded from analysis. The majority of children who participated in the study were between ages 8-12 (79%, n=112).

Table 4: Ages of children represented in the questionnaires / concept maps (n=141)

	Percentage	Count
Age 5-7	21%	29
Age 8-12	79%	112

The data from the self-directed survey revealed that the children with whom adults participated tended to be between five and twelve years old, the project's target audience.

Table 5: Ages of children represented by the online survey* (n=110 groups)

	Percentage	Count
0-4 years	26%	29
5-7 years	62%	68
8-12 years	54%	60
13-17 years	19%	21

*Respondents could select more than one answer, so percents do not equal 100%.

Potential Bias in Samples

These approaches used non-random, convenience sampling, due to limitations of the distributed population and participant responses to requests for participation. It is worth noting potential sources of bias inherent in this method. For adult participants, web-based surveys, by their nature result in a self-selected sample of those who choose to click the link and complete the survey. The overall response rate of 35% suggests that the results may have a sample bias toward those participants who felt strongly or had a greater sense of investment in the project. Among youth, we received data from 26% of the participating youth groups that were identified as having participated during 2011. While every effort was made to obtain participation from as many groups as possible, the sample that responded was ultimately self-selected. In addition, while the recruitment approach sought to have LLP program staff identify first-time LLP educators through their network, it is likely that the sample more heavily favored teachers who had previously used LLP in their teaching environments.

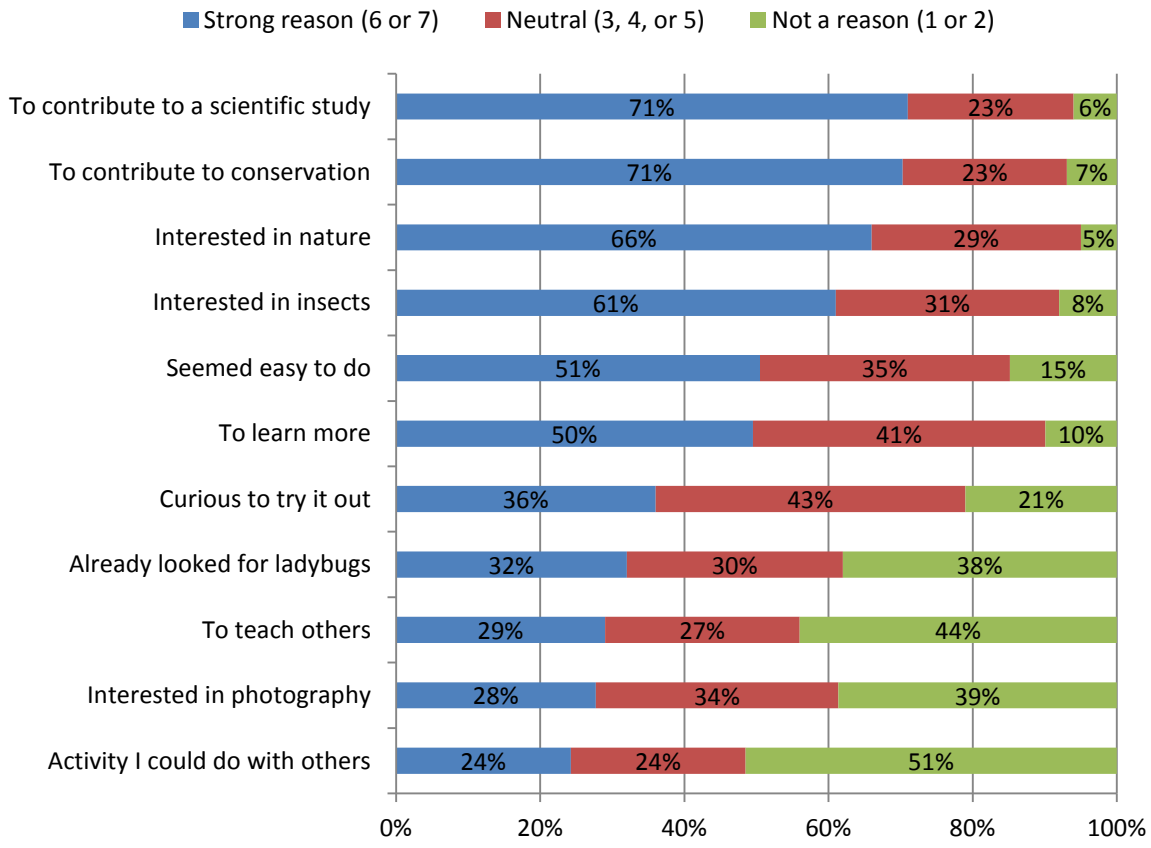
With both samples, evaluators compared demographic characteristics of the sample with those that were known overall population of participants (i.e., geographic distribution, lone/group participation, age of children in groups, etc.) and found that the sample was equivalent to the population in each area. However, we advise a conservative interpretation of the results be taken, considering these findings to present a "best case" of the impact achieved by the program.

Findings: Adults

Motivations and Enjoyment of Program

Overall, the most powerful motivation for participation was the desire to contribute to a scientific study or to contribute to conservation, with 71% of respondents indicating strong agreement (a rating of 6 or 7) with these statements (Figure 1). The next most common motivations were pre-existing interest, in nature-related topics or insects/ladybugs, (rated 6 or 7 by 66% and 61%, respectively). Interest in learning more about ladybugs and that the project seemed easy to do were also moderately strong motivators, with around half of participants rating it a strong motivator.

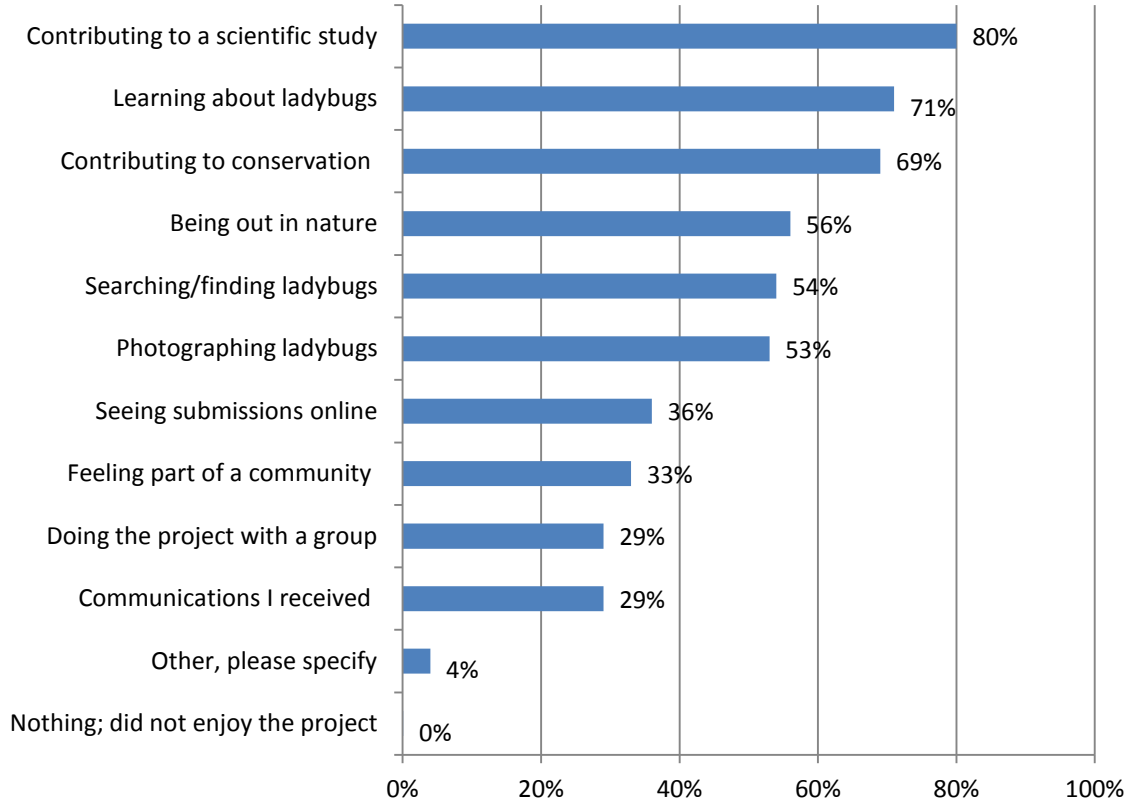
Figure 1: Motivations for participation (post-only)



Similarly, participants reported what they most enjoyed about participating was contributing to a scientific study (selected by 80%, n=281), followed by learning about ladybugs (71%, n=252), and contributing to conservation (69%, n=245) (Figure 2). Only two people reported not enjoying anything about the project. Those who selected "other" responses (4%) gave a variety of reasons including, "*We need ladybugs,*" and "*If one looks with an open mind, there is no telling what might be found*."

Half of the respondents (51%, n=175) said that they would definitely participate again, and 45% (n=154) of respondents said that they probably would participate again. Only a handful indicated they probably would not participate again (4%, n=16).

Figure 2: Frequency of selection of attributes of LLP most enjoyed by participants.



Use of LLP Educational Resources

Nearly all respondents (94%, n=324) reported reading information and resources about ladybugs on the Lost Ladybug website. In addition, participants were asked which of the "data-out" features they had used to explore the data being contributed by program participants; 79% reported they had explored these features. Two-thirds reported using the interactive maps, and over half reported using the summary tables of species and locations and the list of contributors (Table 6). Very few reported using the graphing feature (create your own pie chart) to more deeply explore data

Table 6: Use of "data-out" features by participants (n=350)

	Percentage	Count
Interactive map	63%	220
Summary tables of species and locations	54%	190
List of contributors	54%	189
Create own pie chart	5%	17
None of the above	12%	43
Don't Remember	9%	31

Participants were also asked what other features they would like to have available on the website. The most frequent request focused on wanting more information, usually information specific to a geographic location. For example, *"I would like to know what species of ladybug in my area is most popular"* and *"Local species that I can be expected to find during research, both common and*

uncommon. Also, what I can quantitatively expect to find during the season assigned (didn't find a single ladybug during 2011!).” Other features requested included better tools to identify ladybugs. One person asked for, *“Something that makes it a little easier to identify the kind of ladybug I saw”* and another asked for *“More on identification and ranges.”* Some people requested different that existing resources be provided in alternative formats, such as apps for their Smartphones, or the ability to download the interactive map into a printable format. A couple of people mentioned that they would like to see games as a part of the site.

Knowledge and Attitudinal Outcomes

In the online survey, self-directed participants were asked to report (via an open-ended question) what they felt they learned through the program; 242 (69% of sample) answered this question. Responses were coded into seven main categories with additional categories for other responses as well as unrelated comments (those who responded, but did not specify what, if anything, they learned). Over half of respondents reported learning something about ladybug species dynamics (60%, n=144), which included the number and variety of species and issues related to native and non-native species (Table 7). Comments included, *“I became more aware of the different species of Ladybugs,”* and *“I learned about the differences between rare native, native and invasive ladybug species*.”

The next most common concepts adults reported learning included nearly a quarter mentioning mentioned that they learned about how ladybugs are endangered (24%, n=59) with one participant stating, *“I did not know that the ladybug population was at risk.”* Next most common was learning about science skills or processes related to searching for or identifying ladybugs (21%, n=51) and basic concepts of ladybug biology (17%, n=42). Interestingly, a new concept emerged in summative evaluation results, which was not seen in previous formative evaluation results. 14% of respondents were coded as “citizen science,” which included responses focused on learning about their opportunity to contribute to science in a meaningful way through this program. Examples of this code include, *“I became more aware of the collaborative effort that can exist because of the ease of internet communication”* and *“How the web can be used to learn more about species that may be imperiled.”*

Table 7: Adults’ self-reported learning due to participation (n=242)

	Percent	Frequency
Species Dynamics	60%	144
Endangered Species	24%	59
Science Skills	21%	51
Ladybug Biology	17%	42
Citizen Science	14%	30
Affective Appreciation	8%	19
Other	5%	11
Ladybugs are Important / Beneficial	2%	4
Unrelated comments	6%	15

Knowledge about Ladybugs and Biological Concepts

To assess the program’s impact on biological concepts at the heart of LLP, adult participants from the pre and post samples answered a series of 10 forced-choice knowledge questions. Participants who answered at least 9 out of the 10 knowledge questions received one point for each correct

answer. Points were summed to arrive at a total knowledge score; the highest score a participant could receive was a 10. Answers were scored as incorrect if the participant selected the wrong answer, selected "I don't know," or skipped the question (<2%). Participants who skipped 2 or more items were excluded from analysis of knowledge items to prevent non-response from artificially lowering knowledge scores.

In comparing the pre and post samples, a higher percentage of the post-participation group had correct answers for all but one of the 10 knowledge questions (Table 8). In the post-test, 8 of the 10 items were answered correctly by over 80% of the sample. Pre-participation showed strong incoming knowledge about basic concepts (including that there are multiple species, the importance of biodiversity, and that ladybugs are beneficial); however, knowledge was far weaker in areas of species dynamics and populations in North America. Overall, the pre-participation sample received a mean knowledge score of 6.65 (median=7) and the post-participation sample received a mean knowledge score of 7.99 (median=8). Comparison of knowledge scores using a Mann-Whitney U test showed significantly higher knowledge score in the post-test condition ($U = 5170$, $z = -6.685$, $p<.001$); post-test scores had an average rank of 196.68 and pre-test scores had an average rank of 88.15.

Table 8: Comparison of pre- and post-test results on ladybug biology knowledge questions.

	% of Sample Answered Correctly	
	Pre	Post
There are scientists concerned about ladybugs	92%	99%
There is more than one species of ladybug	90%	97%
Need for biodiversity	92%	94%
How ladybugs are beneficial	94%	92%
Some native U.S. species are rare	57%	89%
Not all species in North America are native	57%	85%
Regional differences in where ladybugs are found	54%	81%
Number of species native to North America	27%	39%
Number of species in the world	29%	38%
Mean Knowledge Score	6.65	7.99
Median Knowledge Score	7	8

Science Skills

When submitting data to the project, participants were asked to attempt to identify the species found, although participants could choose to submit without an identification attempt. Science staff on the project then verify the identity of each submission before adding to the final data set. Frequently, program participants are notified if their identification was incorrect and given the correct species name for the sample collected.

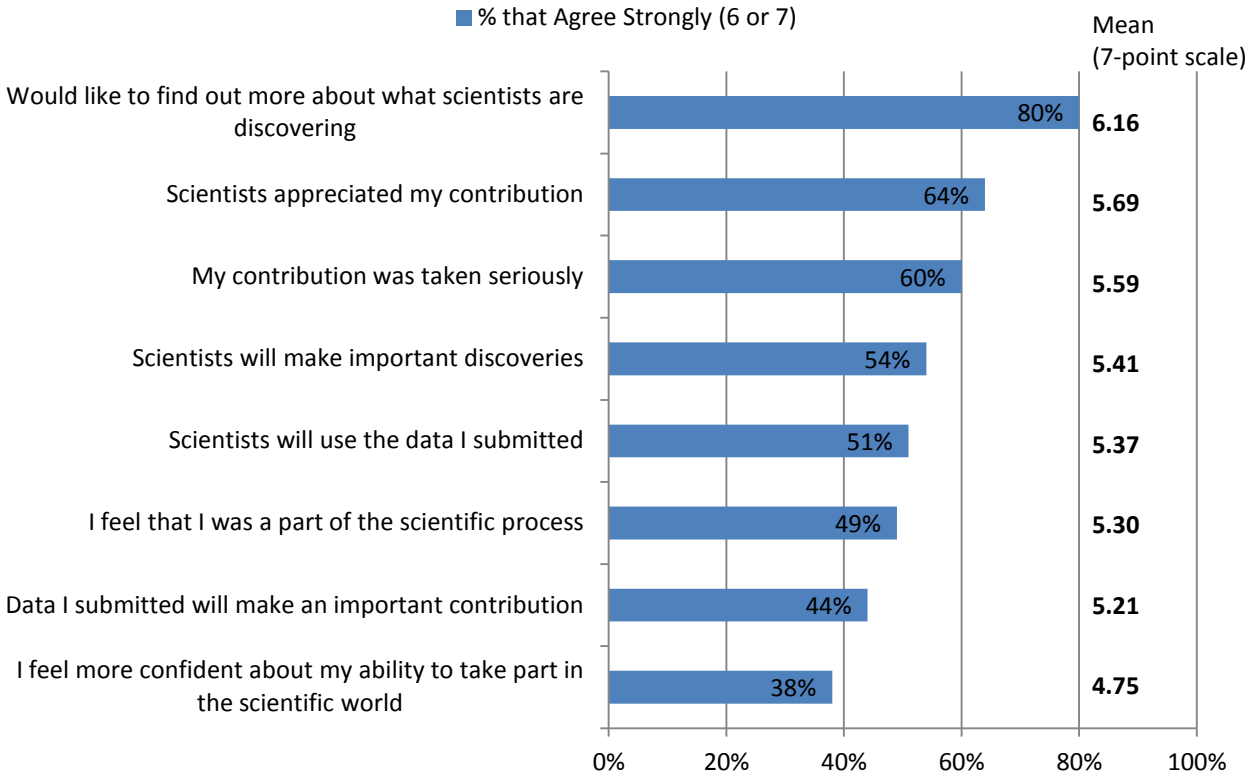
From these data, participants demonstrated their skills at correctly assessing and identifying a ladybug species using observation and species identification keys provided on the project website. Over the life of the project (2008-2011), 57% (7,807) of all specimens were submitted with an attempted identification. Of these attempted IDs, 93% (7,262) were correctly identified by participants. Over the life of the project, team members came to be aware that some participants are professional

entomologists, thus increasing their likelihood of attempting and being correct at a species identification. Anecdotally, the team thinks that participation from professionals and aficionado participants increasingly dominated submissions (and guesses) in later years of the project; however, this unexpected confounding variable was not systematically collected through submissions and its effect on identifications cannot be accurately determined.

Attitudes about Contribution to the Lost Ladybug Project

Adult participants showed a strong, positive attitude that their participation in the Lost Ladybug Project had a meaningful impact on science. In rating their agreement with a range of attitude items, participants had strong agreement overall (Figure 3), with all but one statement receiving mean ratings above 5 (on a 7-point scale). Strongest among these was desire to *find out more about what scientists are discovering* (mean=6.16, SD=1.24). High levels of agreement (a majority strongly agreeing, rating a 6 or 7) were also found for *scientists appreciated my contribution, my contribution was taken seriously, scientists will make important discoveries from my data,* and *scientists will use the data I submitted.*

Figure 3: Adult participants' attitudes about their contribution to the project

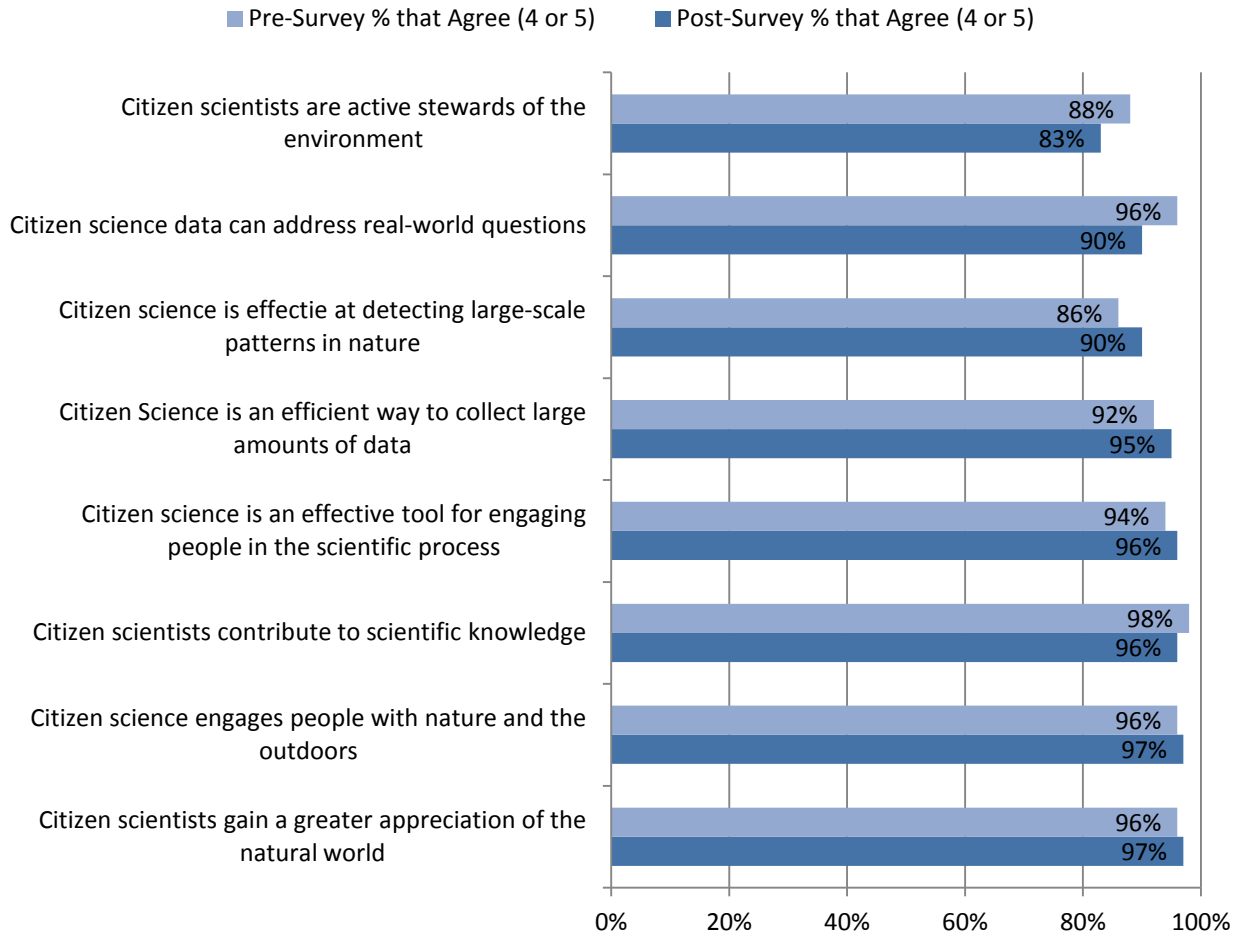


Attitudes toward Citizen Science

To measure attitudes toward citizen science (and change in attitudes due to participation), participants were asked to respond to an eight-item attitudinal scale that is currently under development by staff in the Cornell Lab of Ornithology (Phillips, personal communication). Due to the early stage of development for the scale, analysis was conducted at the item-level. LLP participants had strong agreement with all eight attitude items, with over 80% of respondents agreeing with each (rating of 4 or 5 out of 5) and each receiving a mean agreement rating of 4.27 or higher (Figure 4).

However, there was no evidence that the LLP program alone contributed to a change in these attitudes toward citizen science. There were no significant differences in the median ratings between pre and post tests, with ratings being very high in each condition.

Figure 4: Pre- and post-test ratings of agreement to items of attitudes toward citizen science.



Differences in Outcomes for Individual Adult Participants

Due to the unanticipated emergence of "lone adult" participants – those adults who participated without children – as a significant audience for this program, summative evaluation sought to investigate the degree to which outcome achievement was different for this audience. Of those who identified with whom they participated, 62% (n=211) participated alone and 39% (n=131) participated as part of a social group (with children and/or adults).

There were no significant differences for individual adult participants in the content learning outcomes – whether in knowledge measures or self-reported concepts learned. Similarly, there were no differences in individual adults' reported attitudes toward citizen science. Attitudinally, there were some slight differences in individual adults' responses to items about the value of their contribution to the Lost Ladybug Project specifically, with individual adults having slightly lower attitude ratings:

- Group participants were more likely to feel that scientists appreciated their contribution (U=11295.5, z = -2.035, p=.042).

- Group participants were more likely to feel more confident about their ability to take part in the scientific process (U=11322.5, z = -2.256, p=.024).

More striking were differences in this group's motivations to participate and factors of enjoyment. Not surprisingly, social factors (i.e., teaching others or participating with others) were rated much lower or selected far less frequently by individual adults:

- Individual adults rated lower the motivation of teaching others (U = 6056, z = -8.439, p<.001)
- Individual adults rated lower the motivation of participating with others (U = 4190, z = -10.843, p<.001).
- Individual adults were less likely to enjoy doing the project with a group (χ^2 = 199.07, df = 1, p<.001).

These were not the only differences, however. Individual adults were also slightly more likely to be motivated by their interest in photography. They were also more likely to report enjoying the photographing ladybugs and less likely to enjoy the process of data collection.

- Individual adults rated higher the motivation of interest in photography (U = 9781, z = -4.139, p<.001).
- Individual adults were more likely to enjoy photographing the ladybugs (χ^2 = 10.76, df = 1, p=.001).
- Individual adults were less likely to enjoy searching for or finding ladybugs (χ^2 = 4.64, df = 1, p=.031).

Influence of Multi-Year Participation

Another summative evaluation question was to explore the potential impact of repeat (i.e., multi-year) participation on outcomes and motivation. Of those who responded, two-thirds (n=219) indicated that they had participated in the program for one year, and 35% (n=120) indicated that they had participated in the program for multiple years.

Data showed that multi-year participants did demonstrate stronger outcomes in several areas. Comparison of content knowledge scores, using a Mann-Whitney U test, showed that multi-year participants' knowledge scores (mean: 8.48) were significantly higher than one-year participants' scores (mean: 7.73) (U=9433, z = -3.888, p<.001); multi-year participant scores had an average rank of 193.38 and one-year participant scores had an average rank of 151.87. No significant differences were found in the concepts mentioned in response to the open-ended item.

Multi-year participants also demonstrated attitudes that were significantly more positive regarding their contribution to the Lost Ladybug Project on six of the attitude items. Multi-year participants were more likely to rate the following items higher than one-year participants:

- Scientists will use the data I submitted (U=10054, z = -3.215, p=.001)
- Data I submitted will make an important contribution (U=9826, z = -3.421, p=.001)
- Scientists will make important discoveries (U=10897, z - -2.175, p=.03)
- My contribution was taken seriously (U=9899.5, z = -3.359, p=.001)
- Scientists appreciated my contribution (U=9761.5, z = -3.368, p=.001)
- I feel that I was a part of the scientific process (U=10167, z = -3.180, p=.001)

There were no differences in attitudes about the citizen science items.

Findings: Children and Families

Use of LLP Educational Resources

Within the LLP curriculum resources provided on the website, teachers generally selected just a few of the suggested lessons. Specifically, their activities focused on those that were about collecting and submitting the data. Lessons on the science or ecological concepts were used far less frequently (if at all). Three or more teachers reported using the data collection lessons: *Collecting Ladybugs Habitat I*, *Collecting Ladybugs in Habitat II*, and *Submitting Data to Lost Ladybug Project*. Just one teacher each reported using any other lessons: *Ladybug Life Cycle* (from K-2 curriculum); *Getting Ready to Collect*. No teachers reported using the following lessons: *Ladybug Bingo* (K-2); *Food Web / Biodiversity* (3-5); *Sampling Bead Game* (3-5); *Felt World Game* (3-5).

In addition to the formal curriculum from the Lost Ladybugs website, a handful of teachers reported reading general information on the Lost Ladybugs website and using the identification tools. Some educators supplemented their teaching with materials they drew upon from outside of the Lost Ladybug program – one teacher reported that she read the picture book, *The Grouchy Ladybug* (Carle, 1996), and another reported watching an informational video about ladybugs.

Youth Engagement with Program

Children who participated in the Lost Ladybug Project overwhelmingly enjoyed the project. Two-thirds (67) of children overall rated the program at the highest level of fun on a four-point scale (see Figure 5), with younger children (5-7) reporting slightly higher enjoyment than older children (8-12) (Figure 6). Only 16 children (11%) rated the project as "Just OK" or "Boring!" Similarly, on an agreement scale from 1 to 7 educators reported that students had fun doing the project (mean=6, SD=1.414) and were excited about the project (mean=6.71, SD=.488).

In reporting what they liked and did not like about the program, children of all ages liked the process of data collection the best (75% overall), which included searching for, finding, handling, taking photos, and closely examining ladybugs with examples of student responses including, "*Finding the ladybugs," "Taking pictures of them,"* and *"I found two of them."* The next most common aspect mentioned was the project's context of being outdoors and/or in nature; youth, especially 8-12 year-olds (11%), mentioned liking the opportunity to be outdoors and explore during the project. Other concepts were mentioned by 6 or fewer children (Table 9).

Table 9: What youth liked most about the Lost Ladybug Project

	Ages 5-7 (n=29)		Ages 8-12 (n=111)	
	Percentage	Count	Percentage	Count
Data collection process	76%	22	74%	83
Being outside / contextual factors	7%	2	11%	12
Everything (generic statement)	10%	3	6%	7
Learning about ladybugs	3%	1	5%	6
Already interested in ladybugs/insects	--	--	4%	4
Don't know	--	--	1%	1
Other	7%	2	5%	6

Figure 5: Image of rating item for youth enjoyment of LLP.

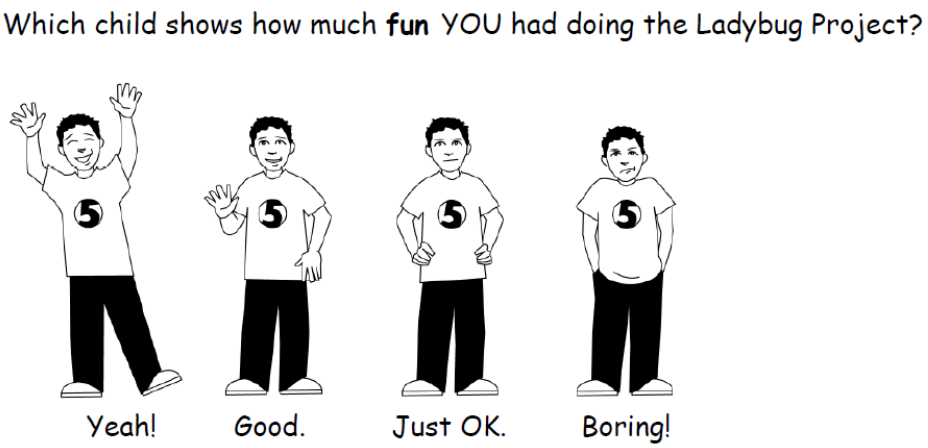
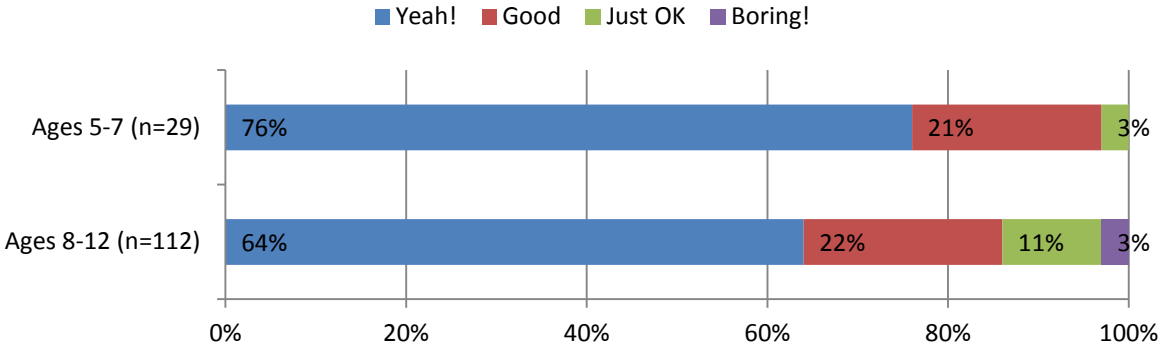


Figure 6: How much fun students had doing the Lost Ladybug Project



Comments about what students did not like support the findings of high enjoyment, with 40% of children indicating they couldn't think of anything they didn't like about it. Three concepts stood out as aspects of the program children liked least (Table 10): aspects of the data collection process such as *"Putting them in the freezer," and "Some of them escaped."* (16%), not finding any ladybugs (16%), and contextual factors of being outdoors (primarily weather-related) (9%). Other dislikes included the feeling that looking for ladybugs was a difficult task and completing the evaluation requirements (especially writing).

Table 10: What youth liked least about the Lost Ladybug Project

	Ages 5-7 (n=29)		Ages 8-12 (n=111)	
	Percentage	Count	Percentage	Count
Nothing / Don't know	48%	14	38%	42
Data collection process	17%	5	16%	18
Not finding any ladybugs	10%	3	17%	19
Being outside / contextual factors	3%	1	11%	12
Looking for ladybugs is hard work	3%	1	6%	7
Evaluation	3%	1	2%	2
Other	14%	4	11%	12

Knowledge and Skills Outcomes

When asked to recall one new thing they learned in the project, nearly half of students wrote a concept about ladybug biology (46%, n=63), including ladybug characteristics, features, behaviors, and/or life cycle (Table 11). Next most common were responses about species diversity and dynamics (24%, n=33), which focused on the diversity of ladybug species and the existence of non-native species. Teachers primarily reported that students learned science skills, and about the diversity of species. One teacher mentioned that students learned about the importance of ladybugs, that they are endangered, and about ladybug biology.

Table 11: Student report of "One new thing I learned"

	Ages 5-7 (n=25)		Ages 8-12 (n=111)	
	Percentage	Count	Percentage	Count
Ladybug Biology	69%	20	39%	43
Species Diversity / Types	14%	4	26%	29
Endangered Species	3%	1	17%	19
Science Skills	--	--	6%	7
Affective Appreciation	3%	1	--	--
Ladybugs are Important / Beneficial	--	--	--	--
Citizen Science	--	--	--	--
Incorrect fact/statement	3%	1	10%	11
Other/Illegible	7%	2	4%	4

Table 12: Parent report of what children learned (n=76)

	Percent	Frequency
Science Skills	46%	35
Species Diversity / Types	38%	29
Ladybug Biology	28%	21
Affective Appreciation	18%	14
Citizen Science	17%	13
Ladybugs are Important / Beneficial	15%	11
Endangered Species	13%	10
Other	1%	1
Unrelated statement	11%	8

Content Learning

Concept maps were used to determine the extent and breadth of student learning about relevant content related to ladybugs. In total, 128 maps were received, 27 from 5-7 year-old students and 101 from 8-12 year-old students. 127 of the maps included words and/or sentences, and 15 of the maps included student drawings (with or without words).

To measure extent of learning, each relevant vocabulary word/phrase (see Appendix F for vocabulary codes) was counted from maps that included words (n=127) to give each map a score of extent of learning. Extent scores ranged from 0 to 14 for 5-7 year-olds and 0 to 15 for 8-12 year-olds. The mean extent score for 5-7 year-olds was 4.67 unique vocabulary words (median = 3), and the mean extent

score for 8-12 year-olds was 6.45 unique vocabulary words (median = 6). Comparison of extent scores, using a Mann-Whitney U test, showed that 8-12 year-olds extent scores were significantly higher than 5-7 year olds (U=921, z = -2.54, p=.01).

Figure 7: Extent scores for 8-12 year olds (n=100)

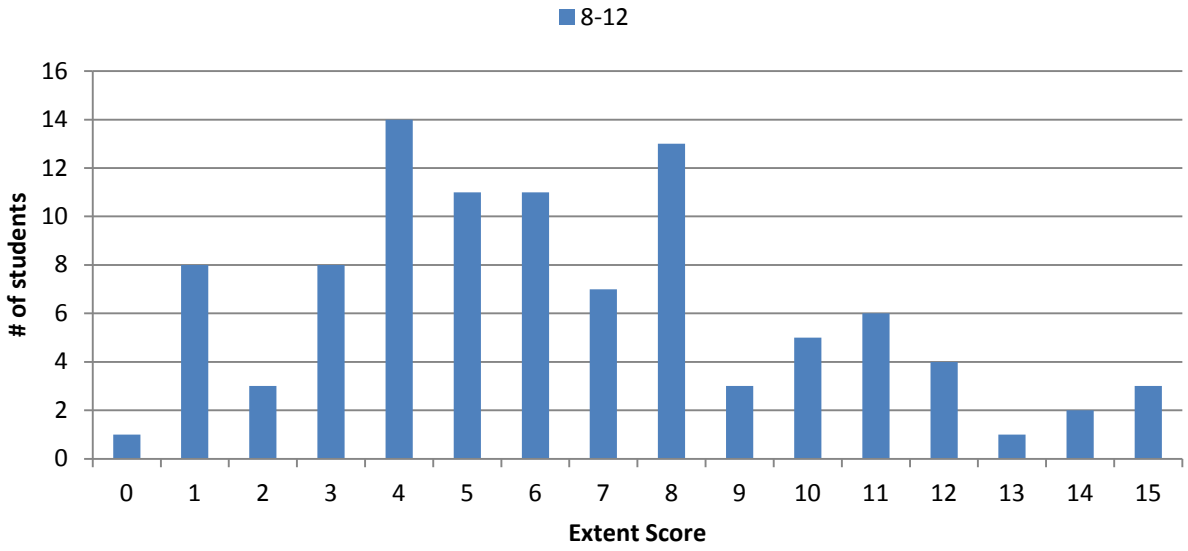
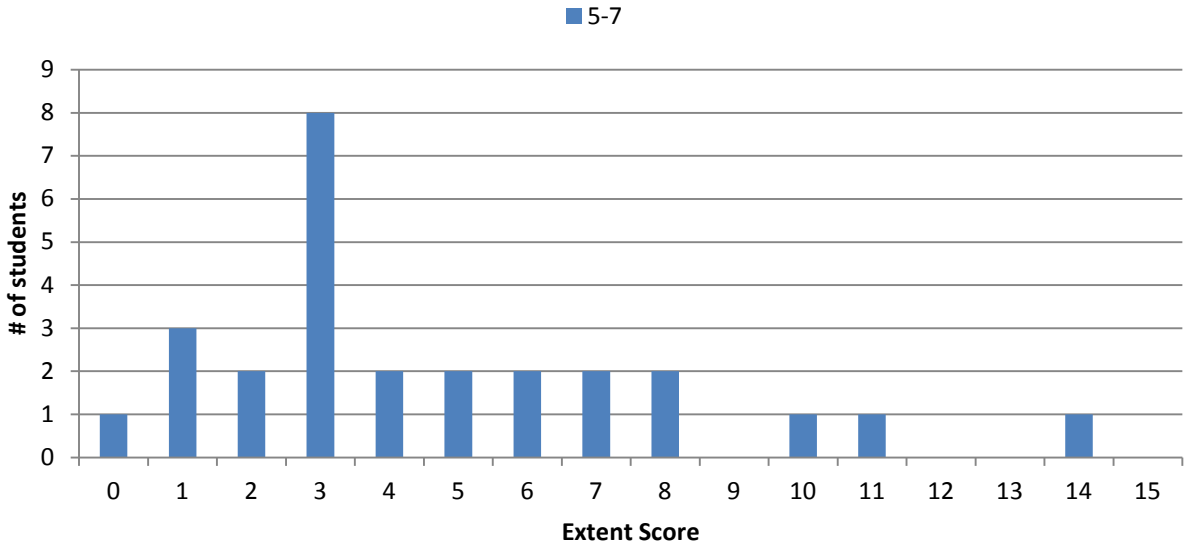


Figure 8: Extent scores for 5-7 year olds (n=27)



To measure breadth of learning, students' writing and drawings were coded to reflect the different types of concepts reflected in student maps, and the total number of unique concepts mentioned was summed to get the overall score for breadth. Seven different concepts were scored, using the same framework as above: Ladybug Biology; Species Diversity/Types; Endangered Species; Science Skills; Affective Appreciation; Ladybugs are Important/Beneficial; and Citizen Science.

For all age groups, concepts of ladybug biology were learned by almost every student in the evaluation (96% of 5-7; 94% of 8-12) (Table 13). Although scored as one concept in the coding framework,

students' maps generally reflected a wide range of specific facts and information about ladybug biology, including life cycle, behavior, food chain, and physical characteristics. (See example concept maps in Appendix G).

Beyond biological facts, students showed knowledge of concepts around species diversity (such as the number of different kinds of species and variation in their appearances), represented by 50% of 8-12 year-olds' maps and 19% of 5-7 year-olds' maps. That ladybugs are beneficial was also represented widely, by 35% of 8-12 year-olds and 37% of 5-7 year olds, which almost exclusively was knowledge that ladybugs eat aphids.

In total, just ten students' maps (8%) contained any facts or information that were incorrect or showed misunderstanding of core concepts. In most cases, incorrect statements reflected persistent myths, such as *"the number of spots on a ladybug tells you how old it is."*

On average, students represented about two of the seven possible concepts, with 8-12 year olds' maps containing an average of 2.11 concepts and 5-7 year olds' maps containing 1.93 concepts. The difference in these scores were not significantly different between the two age groups (U=1202, z = -0.913, p=.361). In comparison with the extent scores, the breadth scores showed far more modest achievement. This is likely due to the comprehensiveness of what was included within conceptual understanding of the "ladybug biology" code. Students' responses within this concept generally contained several different sub-concepts of biological understanding, which were not captured at the higher level of coding.

Table 13: Concept Maps, breadth measurement: frequency of concepts mentioned

	Ages 5-7 (n=27)		Ages 8-12 (n=101)	
	Percentage	Count	Percentage	Count
Biology	100%	27	94%	95
Species	19%	5	50%	50
Beneficial	37%	10	35%	35
Endangered	7%	2	20%	20
Skills	4%	1	4%	4
Affective	11%	3	2%	2
Citizen Science	--	--	--	--
Other	15%	4	8%	8
Incorrect	7%	2	8%	8

Science Inquiry Skills

Teachers were asked to report (on a scale from 1 to 7) their students' use of science inquiry skills through the Lost Ladybug Project. Out of all the items, teachers indicated that use of scientific tools, understanding the study purpose were the skills most demonstrated by students; teachers rated *Children were able to use the tools of data collection and recording* and *Children understood the purpose of the investigation* (both means = 5.86) the highest. Collection and recording of data and asking questions about what they found were agreed with moderately.

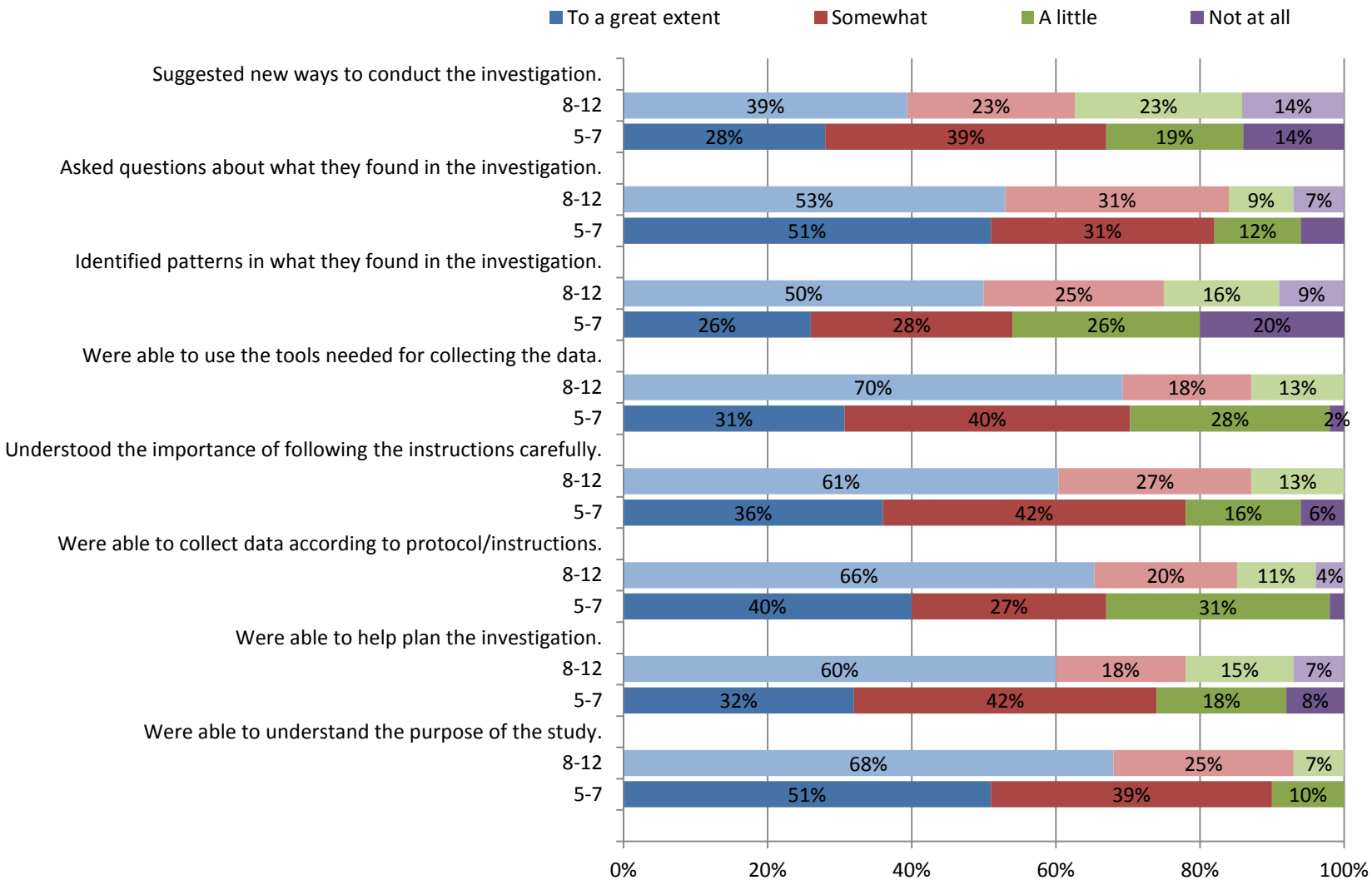
However, the skills of analysis and inference were generally not demonstrated, in teachers' assessments – *Children identified patterns in what they saw or collected in the project* the lowest at a mean rating of 3, indicating slight disagreement. Similarly, *Children helped plan the investigation* was rated neutrally, indicating that this part of the inquiry process was also not a strong skill demonstrated by youth.

Table 14: Teacher report on student science inquiry skills (n=9)

	Mean	SD	Median
Children were able to use the tools of data collection and recording (e.g., nets, charts, etc.).	5.86	1.57	7
Children understood the purpose of the investigation.	5.86	0.378	6
Children collected and recorded ladybug data according to the project's instructions.	5.71	1.11	6
Children asked questions about what they found.	5.71	1.25	6
Children helped plan the investigation.	4.14	1.57	5
Children identified patterns in what they saw or collected in the project.	3	1.87	4

Parents were also asked to report on the science inquiry skills they observed their children using during the project. On each item, parents rated the skills achieved by 8 to 12 year olds higher than the 5 to 7 year olds (see Figure 9). Skills reported strongly for both age groups were understanding the purpose of the study and asking questions about what was found in the investigation (more than 50% of parents reporting "to a great extent" for each age group). In other skills, however, differences between the age groups were more dramatic. 60% or more of parents of 8-12 year olds reported that their children were very well able to use the tools of data collection, collect data according to the protocol, understood the need to follow instructions carefully, and helped plan the investigation; parents of 5-7 year olds, in contrast, were more likely to indicate their children only somewhat demonstrated these skills in the program. For both age groups, the science skill that was one of the least demonstrated was "suggesting new ways to conduct the investigation," as was identifying patterns in what they found for 5-7 year olds (with nearly half indicating this was demonstrated only a little, or not at all).

Figure 9: Parents' reports of children's demonstration of science inquiry skills



Attitudes about Contribution to the Lost Ladybug Project

Participating youth were aware of the primary, scientific purpose of their contribution to the project, with over two-thirds of each age group recognizing that the photos they took were to be used by scientists for a study. Over a third indicated that they felt their submission would be available on a website for others to see, and only a handful of the students felt that nothing would come of their contribution.

Table 15: Student perception of purpose of contribution

	Ages 5-7 (n=29)		Ages 8-12 (n=112)	
	Percentage	Count	Percentage	Count
Scientists will use them to learn more about ladybugs	69%	20	67%	75
They will be on a website for other people to see	34%	10	46%	52
I can share them with my family	17%	5	17%	19
Nothing	--	--	6%	7

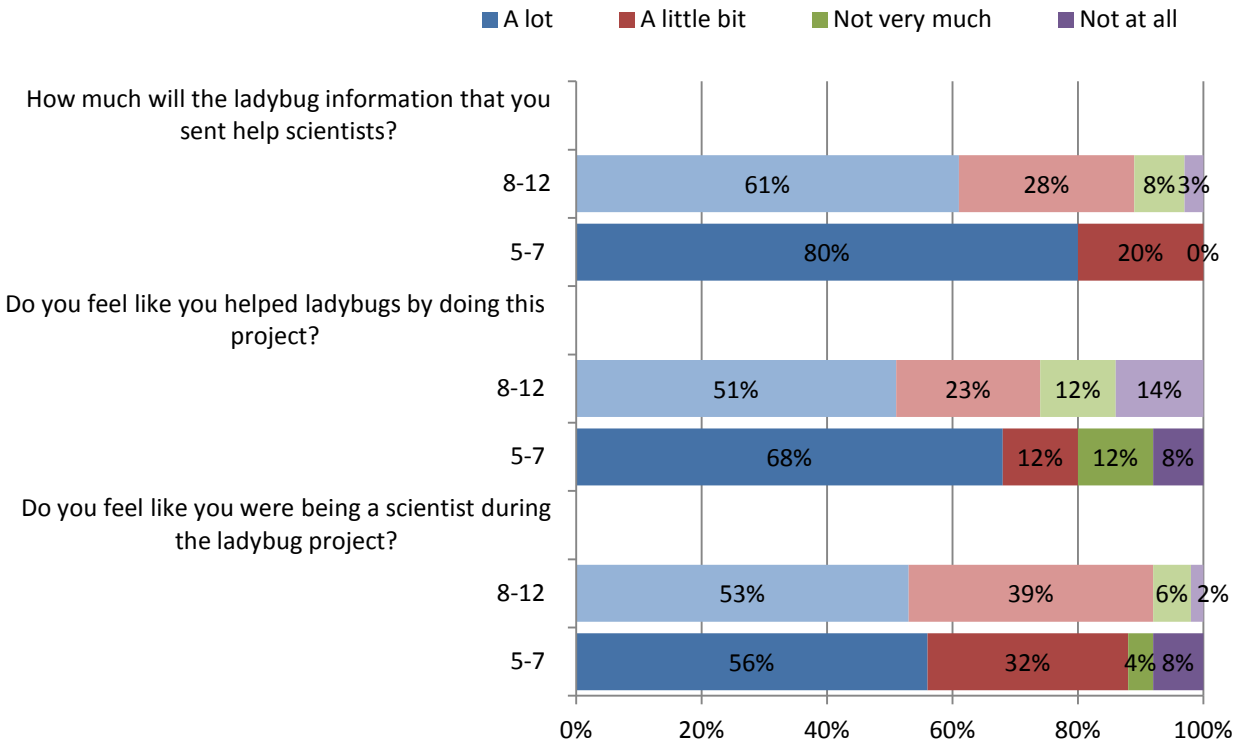
In a series of questions aimed at understanding student attitudes about their contribution, students indicated a very positive attitude in these areas, with nearly all students responding with "a lot" or "a little" on all three attitude items (see Figure 10). Most notably, youth felt very confident that the data they collected would help scientists (80% of 5-7 year olds and 61% of 8-12 year olds said "a lot"), as well as that it would help ladybugs (68% and 51% reporting "a lot", respectively). For both of these items, 5-7 year olds responded with slightly higher confidence in their contributions. A little more than half of the students in both age groups felt strongly that they were being scientists during the ladybug project.

Teachers also reported their perceptions of student attitudes towards their contribution on the same three attributes. On a scale from 1 to 7, teachers rated all three items above a mean of 5.43, showing strong sense that students had positive perceptions about the value of their contribution through the project.

Table 16: Teacher perception of student contribution (n=9)

	Mean	SD	Median
Children believed they were helping ladybugs with this project	6.29	0.756	6
Children believed they were being scientists in the project	6.29	0.756	6
Children believed they were helping with the nature and the environment with this project.	5.43	1.134	6

Figure 10: Student attitudes about contribution; (5-7 year olds n=29, 8-12 year olds n=112)



Citizen Science Interest

The vast majority of children indicated that they would be very interested in doing a citizen science project like Lost Ladybugs again in the future; 79% of 5-7 year olds and 69% of 8-12 year olds (see Table 17). Only a few children (17 overall, 12%) indicated that they would not be interested in participating again ("not really" or "no way"). Similarly, teachers reported that they would be interested in participating in future citizen science projects with their classes (mean=6, SD=1.414).

Table 17: Would you like to do a project that is like the Lost Ladybug Project again?

	Ages 5-7 (n=29)		Ages 8-12 (n=112)	
	Percentage	Count	Percentage	Count
Yes!	79%	23	69%	77
Maybe	7%	2	20%	22
Not really	7%	2	6%	7
No way!	7%	2	5%	6

Among family groups who participated, the pre-participation survey showed that families interested in the Lost Ladybug Project already participated in outdoor activities, citizen science projects, as well as general science projects prior to participation. All respondents indicated that they engage in outdoor and science activities somewhat or very much (Table 18); 81% indicated that they have had some participation in citizen science projects, but only one participant indicated a lot of experience in this type of activity.

In line with these findings, when family groups were surveyed after participation, a substantial number indicated that the Lost Ladybug Program had not affected their likelihood of participating in science or outdoor activities, primarily because they indicated they would have participated in these activities regardless of the program (63% regarding outdoor activities, 46% regarding science activities; see Table 19). In terms of citizen science projects, however, a larger number (47% of family groups) indicated that the project had made them very likely to participate in citizen science projects in the future (only 36% said it had no influence on their likelihood of participation).

Table 18: Pre-Participation in the following activities (n=31)

	Not at all		Somewhat		Very much	
	Percent	Count	Percent	Count	Percent	Count
Outdoor Activities	--	--	55%	14	45%	17
Science Activities	--	--	84%	26	16%	5
Citizen Science projects	19%	12	77%	24	3%	1

Table 19: Likelihood of participating in the following activities due to participation in LLP (n=107)

	Not at all / I would Participate Regardless		Somewhat Likely		Very Likely	
	Percent	Count	Percent	Count	Percent	Count
Outdoor Activities	63%	67	6%	6	32%	34
Science Activities	46%	49	11%	12	43%	46
Citizen Science projects	36%	38	18%	19	47%	50

Discussion

Overall, the Lost Ladybug Project showed achievement for each of its identified science learning impacts, with data showing specific aspects of the program's strength and other areas somewhat weaker. Some of these findings may relate to data demonstrating which of the LLP resources participants tended to use (and those they did not use as frequently). For instance, among adult participants, nearly all reported reading some of the online resources and guides, and three-fourths reported looking at one or more of the "data-out" features, including the map, existing data tables, and list of contributors. Participants did not, however, make use of the more interactive features, such as the "make your own pie chart" option. It is not clear whether participants were less interested in self-directed data exploration in the one interactive application or less aware of its availability.

Among youth and school group participants, educators reported not using the entire set of curriculum materials provided on the LLP website. Instead, teachers selected specific activities and expanded with their own lessons and materials. In particular, teachers gravitated toward the lessons that were specific to the data collection and submission steps of the project. Only one content-based lesson from the curriculum was used, which was "Ladybug Life Cycle;" this may help interpret data from children's concept map data, which frequently showed detailed understanding of the life stages of ladybugs.

Knowledge of Ladybug Biology and Related Concepts

The Lost Ladybug Program showed significant impact on adults' knowledge of ladybugs, with data showing significant pre- to post- increases in scores on a series of questions about ladybug biology and species diversity. Adults also self-reported learning specific concepts in this area, with the strongest relating to species diversity concepts (60% of adults) and the endangerment of certain species (24% of adults).

Children of all ages (5-12) showed strong knowledge of ladybug biology concepts after the program, including demonstrating strong scores in measures of extent of knowledge (relevant vocabulary) and breadth of knowledge. In this area of conceptual knowledge, students demonstrated particularly strong conceptual knowledge in the area of ladybug biology; in fact, low extent scores overall masked the fact that many students' demonstrated biology knowledge included multiple sub-concepts of ladybug biology, including life cycle, behaviors, food chain relationships, etc. In contrast, however, far fewer students demonstrated and reported knowledge of project concepts related to species diversity or issues of endangerment.

Attitudes about Contribution to Science Research

Adult data showed that the desire to contribute to scientific research and to conservation were two of the most powerful motivating factors and two of the strongest factors of enjoyment for those who participated in the program. This was a critical aspect of the program that needed to be emphasized and supported. Following participation, both adults and children in the program rated very high levels of confidence about the usefulness of their contribution and its importance to scientists. Among adults, strongest agreement was the feeling that their contributions mattered to and were taken seriously by scientists, as well as interest in learning more about what discoveries were made based upon their data. Among children, there was clear understanding of the purpose of their role in the science process and a strong feeling that their contribution would help scientists and, to a lesser extent, ladybugs.

Science Skills

As in any citizen science project, individuals' participation in the endeavor inherently demonstrate some abilities and skills in particular steps of the scientific process; in this case, data collection. For adults in this project, there was relatively weaker self-reported learning in this area for themselves (21% identified this as an aspect of their learning). However, data from project submissions show that adults demonstrated very strong skills in identification of species with a 93% success rate among those who tried to identify their specimen (57% of submissions). This skill requires use of scientific resources and keys (whether provided by the LLP or other accessing other resources) in order to be successful.

Among children, there was little self-reported learning in the area of science skills; however, the adults who worked with them reported this as a strong area of learning and gain among children of both age groups. These adult assessments showed great differences among the abilities of the two age groups, as expected, with 8-12 year olds reportedly demonstrating a stronger abilities in a wider range of the targeted inquiry skills. In general, among both age groups, the skills most emphasized by LLP relate to data collection and understanding the purpose of the study. Skills around data analysis and drawing inferences were generally weakest overall, even among groups facilitated by a teacher. It is likely that for all ages, the nature of LLP as a contributory citizen science project causes a focus on the required

science skills (data collection) and educators are not extending the lesson to use this project to teach about later steps of the scientific process (analysis).

Interest and Attitudes toward Citizen Science

Among adults, there was demonstrated interest in participating in future citizen projects as a result of their participation. In addition, adults showed very strong, positive attitudes about citizen science generally. However, these attitudes did not seem to be particularly influenced by participation in this project; no significant differences were found in ratings of these items between pre and post samples. This was partially due to a ceiling effect; ratings were already very positive in the pre condition, there was little room for them to increase in a post condition.

Among children, satisfaction with the program was high overall, with students most enjoying the parts of the project that involved the tasks of citizen science – searching for, finding, examining, and handling the ladybugs. When thinking about this type of project, youth were very positive about the idea of doing something similar again in the future.

Family Participation in Future Activities

The program showed relatively little impact on family groups' likelihood of participating in outdoor or science activities. Pre-participation data showed that those who are likely to participate in LLP already demonstrate high levels of engagement in these types of activities, leaving less opportunity for the project to influence their participation. This was also somewhat true for citizen science activities, with a substantial portion of the pre sample indicating that they had some previous engagement with citizen science activities. However, of the three types of activities, likelihood of citizen science participation was reported to be positively influenced by LLP participation, with almost half of family respondents indicating this. There may be some limitations to this potential impact, but the LLP does show a positive influence on whether participants to take part in citizen science projects in the future, although this is not particularly true for outdoor or general science activities.

Differences between Sub-Groups

Although the individual adult, someone who participated without a group or with children, emerged as a unique audience, the results showed that there were very few differences in outcomes for this audience. They showed equivalent knowledge and attitudes as other adults in nearly all areas.

More striking differences were seen, as expected between the two age groups of children that participated. In general, 8-12 year olds showed higher levels of scientific inquiry – with adults reporting that these children showed stronger levels of more steps of the inquiry process than younger children. In terms of knowledge, their concept maps showed greater extent of knowledge (more vocabulary words) and although breadth scores were similar, their maps showed a greater focus on concepts of species diversity; where younger students' maps focused more on biology concepts. Both of these differences align with expectations that the older ages would be able to delve deeper into the core concepts of the project. Interestingly, however, 5-7 year old children responded slightly more positively about their contribution, both its value and their enjoyment of it.

Another striking relationship was that participation over multiple years appeared to have a relationship with knowledge and attitudinal outcomes among adults, with those who participated for multiple years

demonstrating higher knowledge scores and having more positive attitudes about the value and utility of their contribution than one-time participants. The strong relationship between repeat participation and the attitudinal differences is worth noting; there is likely a reciprocal relationship between these two factors. Because adults are motivated by the opportunity to contribute to scientific research, it is important that the program feedback to support participants' feeling that their contribution was taken seriously. It is likely that increases in the sense of the value of one's contribution will influence their ongoing participation and that ongoing participation will continue to increase the attitude that their citizen science contribution is significant to the research.

Conclusions & Recommendations

Despite changes to focus and approach to participant recruitment over the life of the project, the evaluation generally shows that it was successful at achieving outcomes in knowledge, attitudes, and skills with its participants – an audience that expanded to include both adults and children. As the program moves forward, the findings point to a couple of key considerations and recommendations to support and enhance its support of participant learning.

Adult Participants

Adult audiences, very often participating without children, continue to be a large portion of the audience for the Lost Ladybug Project. It is important that the project find new ways to engage and support and expand the experience by this unique audience, who show significant motivation despite the program and website's strong emphasis on children and families. Some specific recommendations include:

- Adult participation and motivation will benefit from **sustained, ongoing communication about researchers' findings and hypotheses that are being generated from their contributed data.** One of the strongest sentiments expressed by adults was a desire to find out more about what scientists were discovering from these contributions.
- Compared to formative phases, there appeared to be an increase in comments about the importance of citizen science and of community around citizen science projects. As such projects proliferate worldwide, **this project may be contributing (with these other efforts) to a growing, broader understanding of the importance and role of citizen scientists.**
- **Consider and define the goals and desired use of various data-out features on the website.** Over 75% of adults reported using one of the data-out features, but primarily looking at pre-existing maps, tables, and images. Very few reported using the interactive feature to manipulate data independently. If a goal is to engage adults in such activities, the benefit and motivation for this audience may need to be made clear.
- **Consider adding new features and resources that can reflect geographically localized information.** Participants tend to be most interested in narrowing down information to understand what is happening in their location – perhaps to help them do better at identifying species they find. Other requested resources include more tools for helping to identify species found.

Children and Family Participants

Children who participated in the program also showed achievement in targeted impact areas, including demonstrating relevant content knowledge, attitudes, and generally enjoying the chance to participate in the program. The shift in the program's emphasis toward self-directed use of online materials, and away from one-on-one training or train-the-trainer models, highlights some unique aspects of how educational content is employed in real settings. These findings result in some specific recommendations, including:

- **Teachers and educators who implement the Lost Ladybug Project with their groups and classrooms do not use the full set of curriculum materials provided on the website.** Educators' lessons focused heavily on the steps of data collection and submission. Few/no teachers reported using the LLP supporting pre-lessons about food webs, species diversity, or invasive species. A few reported used the life cycle lesson. Teachers also supplemented curriculum with other activities, videos, or books they found on their own. **If the Project wants teachers to engage students directly in understanding related science concepts of species diversity, food webs, etc., new strategies may be needed to understand what resources teachers are more likely to use and/or if there are barriers to use of existing materials.**
- Children very much enjoy participating in the project and feel that it is fun, particularly because of the data collection process, which combines searching, catching, and handling ladybugs to take the photo. As anticipated, **this hands-on and participatory process – at which children can be successful and take ownership – is a hallmark of this project and its motivational power.**
- One limitation to student satisfaction, interestingly, was when something did not go right in the data collection process — such as a ladybug escaping, or accidently stepping on a ladybug – or if they did not find any ladybugs. **The Project could consider mitigating these disappointing moments into teachable moments,** by highlighting these as real life parts of the scientific process. In particular, **this provides an opportunity to teach that a lack of data *is* data, a core factor in understanding the nature of science**.[10]
- Much of what the children reported learning was based on ladybug biology, followed by species diversity. On the other hand, parents and teachers felt that one of the main things the students were learning were science skills. This shows **the importance of triangulating data sources for this evidence, as children's meta-cognitive skills and/or interpretation of the word "learning" tended to focus on facts and concepts, rather than skill development**.
- Understanding some differences in capabilities and achievement of different age groups of children, as the project continues, **it may be possible to increasingly refine the tasks, lessons, or intended outcomes to be more specific to different age ranges of students. In particular, 5-7 year olds seem best suited to learning about taking care s in data collection; while 8-12 year olds are increasingly able to think about the purpose of a study, help plan a study, and identify patterns.**

End of Report: March 21, 2012

[10] For an example of how a project supports this kind of thinking, see the Vital Signs project website: http://vitalsignsme.org/when-not-found-good-really-good

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Appendices

[appendices attached in separate file]