garibaygroup

Driven to Discover
Summative Evaluation Report

University of Minnesota Extension

Summer 2015

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Overview

The University of Minnesota Extension (UME) contracted Garibay Group to conduct a summative evaluation of the *Driven to Discover* program (often referred to as D2D by youth participants and adult leaders) to assess how adult leaders in Informal Science Education (ISE) settings used the curriculum and citizen science projects as conduits to engage youth in authentic science inquiry.

The *Driven to Discover* project was inspired by the growing number of individuals engaged in citizen science. The team that developed *Driven to Discover* saw these citizen science programs as an opportunity to build the capacity of participants to expand their scientific knowledge and initiate their own scientific investigations that could also contribute to science.

The *Driven to Discover* project was designed to train adult leaders to engage middle-school youth (approximately 12–14 years old) in citizen science projects and inspire them to engage in their own authentic science inquiry projects in informal science education (ISE) settings. The ISE settings in which adults engaged youth in citizen science—identified early in the development process—included nature center groups, middle-school teachers working with youth during summer and after-school programs, and group leaders working with youth in club settings.

The project was implemented in two distinct phases. Phase 1 (2010–2012) focused on a formative, participatory action research process involving Minnesota Extension 4-H and Natural Resource Conservation programs and research teams that included Extension educators, youth participants, and their adult leaders. The goal of the research was to develop a program model and identify key attributes involved in successful authentic youth inquiry using citizen science and adult leaders in an ISE setting. Two citizen science programs were used in developing the model: the Monarch Larva Monitoring Project (MLMP) and eBird. The outcomes for this phase are addressed in the grounded research study results.

Phase 2 of the project (2013–2015) focused on disseminating and evaluating the project in order to assess how the program's impacts were met—namely how youth engaged in inquiry through citizen science with the help of their adult leaders. This summative evaluation report focuses on assessing youth and adult leader program outcomes.

Key Definitions

Citizen science refers to partnerships between volunteers and scientists that answer real-world questions. Volunteers typically make the observations using protocols defined by the scientists who then use the data to help answer their questions.

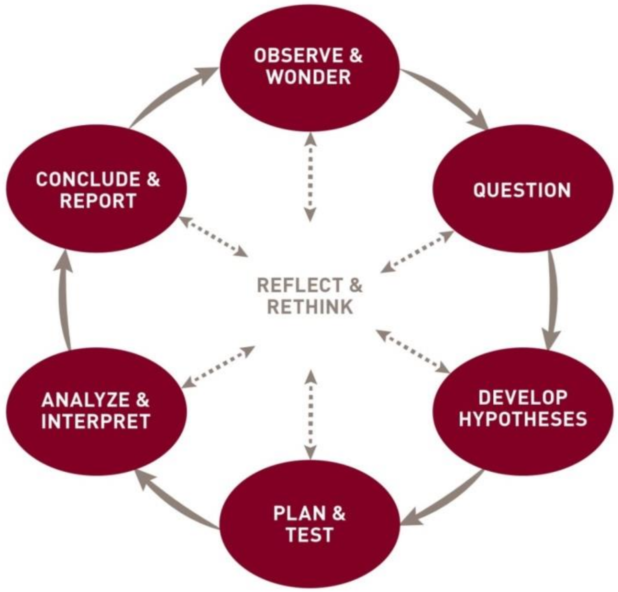
Science inquiry is a process for answering questions through investigation.

Authentic inquiry is involving youth in initiating and directing the scientific process through engagement with scientific phenomena, tools, and methods.

Overview, cont'd.

The *Driven to Discover* project team developed a model to describe the seven phases of science inquiry and their relationship to one another (Figure 1). We will refer to these phases throughout this report.

Figure 1. The Process of Science Inquiry
University of Minnesota Extension
Driven to Discover



Evaluation Overview
The summative evaluation focused on assessing outcomes for the two target audiences of the project: youth and adult leaders (see Appendix A).

The program aimed to increase adult leaders' knowledge about the specific organisms and ecological systems of their citizen science program, the process of science inquiry, best practices for inquiry-based instruction in an informal setting, and how, as research mentors, to engage youth.

At the same time, the program aimed to increase youth knowledge about the organisms and ecological systems of their citizen science program and the purpose of citizen science; to help youth become engaged in science via collecting data for the citizen science project and engaging in the whole science inquiry process through their own authentic science inquiry activities; and to support youth in developing stronger identities as scientists.

Data were collected from 2012 to 2014 to evaluate these goals. The core data were collected in 2013 (see the Methods section of this report).

Primary Evaluation Questions

- To what extent did the *Driven to Discover* program help adult leaders gain knowledge and skills for citizen science, science inquiry, and authentic science inquiry mentoring?
- To what extent did the *Driven to Discover* program support youth in gaining content knowledge, engage them in authentic science inquiry and support the development of their science inquiry skills, increase their understanding of citizen science, and help them develop positive attitudes about their role in science?

Overview, cont'd.

Number of Teams in the Program
In 2014, project efforts were focused on refining and disseminating curriculum rather than recruiting and training new leaders. Therefore, no new training was offered in 2014; all participating adult leaders had been trained previously. There were 20 teams in 2013 and 13 in 2014. The difference in number of teams is attributed to two circumstances: 1) some adults did not return to lead a team because of difficulty recruiting youth and 2) the project team decided to focus on disseminating the program rather than training new leaders. This decision by the project team allowed them to continue to observe trained club leaders' skills, confidence, and overall success in light of decreased support from the program.

Despite there being fewer *Driven to Discover* teams in 2014, the number of youth did not fall dramatically—from 136 participants to 110 (See Table 1). Teams that continued in 2014 maintained, or even increased, the number of youth they engaged. Likewise, the percentage of teams attending the science fair, 50% in 2013, increased to 62% in 2014. The number of science fair projects also remained high in 2014 (35) compared to 2013 (39).

Team Meetings
The duration and schedule of meetings varied greatly. The following are some examples:

- Summer camp sessions met for two weeks of camp activities that included the *Driven to Discover* activities.

Table 1. *Driven to Discover* Team Outputs by Year

Output	2010	2011	2012	2013	2014
Total # of teams	9	11	16	20	13
Total # of youth	68	117	157	136	110
Total # of adult leaders	12	14	23	28	16
Attendance forms returned	N/A*			13	9
# of teams attending the annual science fair	N/A*			10	8
% of teams attending the annual science fair	N/A*			50%	62%
# of youth attending the annual science fair	N/A*			72	73
% of youth attending the annual science fair	N/A*			53%	66%
# of science fair projects	N/A*			39	35

* These data were not reported as they were not part of the summative evaluation.

Overview, cont'd.

- Summer sessions met approximately five to ten times, weekly or bi-weekly, during the summer.
- Summer and fall sessions met for five to ten weeks in the summer to observe, design the survey, and collect data, reconvening in the fall to analyze and report on the data before the science fair.
- Summer and fall sessions met for a two-week intensive period in the summer, followed by individual youth projects that continued—with mentor support—through the fall.

The variety of meeting schedules demonstrated the flexibility of the *Driven to Discover* program, a flexibility which allowed it to fit into different programming scenarios.

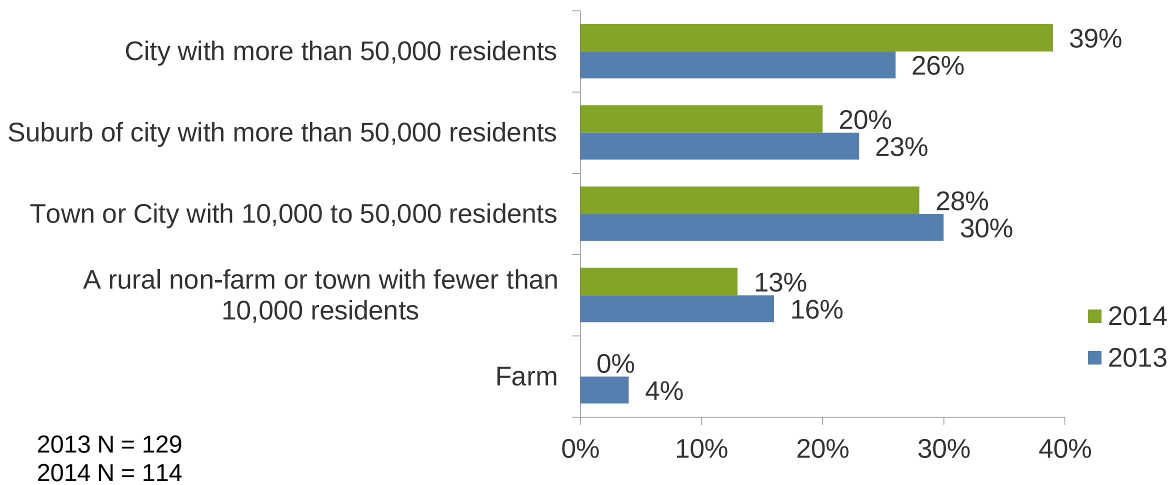
Geographical Locations of Teams
The *Driven to Discover* teams were located in four states: Minnesota, Wisconsin, Virginia, and Ohio. The number of teams remained the highest in Minnesota in 2013 and 2014 (Table 2). The programs that established core sustainability continued into 2014.

Teams met in locales ranging from farming areas, small towns (less than 10,000), suburbs, and urban settings. (See Figure 2.)

Table 2. Teams by State by Year

State	# of Teams 2010	# of Teams 2011	# of Teams 2012	# of Teams 2013	# of Teams 2014
Minnesota	9	11	11	11	7
Wisconsin	0	0	3	6	4
Virginia	0	0	1	2	1
Ohio	0	0	1	1	1

Figure 2. Percent of Youth Participants by City Size by Year



Overview, cont'd.

Number of Adult Leaders in the Program
In total, 33 adult leaders were involved in the Driven to Discover project. Of those, 27 were involved during the project's summative phase. The majority of leaders involved in the summative project were involved for 2 (12 adult leaders) or three years (8 adult leaders) of the project. In addition, 4 leaders had been involved for 4 years of the project. During the summative evaluation period, 3 leaders had been involved in the program for only a year (Table 3). Those leaders who had been with the project for 3–4 years had participated in the formative-research phase activities. These leaders had far deeper interactions with teams and scientists than the leaders who entered *Driven to Discover* later.

Adult leaders involved in the program had varied backgrounds, among them formal educators (11), naturalist educators (9), youth leaders (10), and those (3) with no specialty area for education or youth development. This spread demonstrates that the recruitment was well stratified across the adult leader categories the program aimed to serve for ISE settings. On the other hand, adult leaders were predominantly female (only 4 of the 33 were male).

Table 3. Number of Years Adult Leaders were Involved in the Program (N = 33)

# of Years Involved	# of Adult Leaders	# of Adult Leaders During Summative Evaluation (2013–2014)
4	5	4
3	8	8
2	13	12
1	7	3
Total	*33*	*27*

Overview, cont'd.

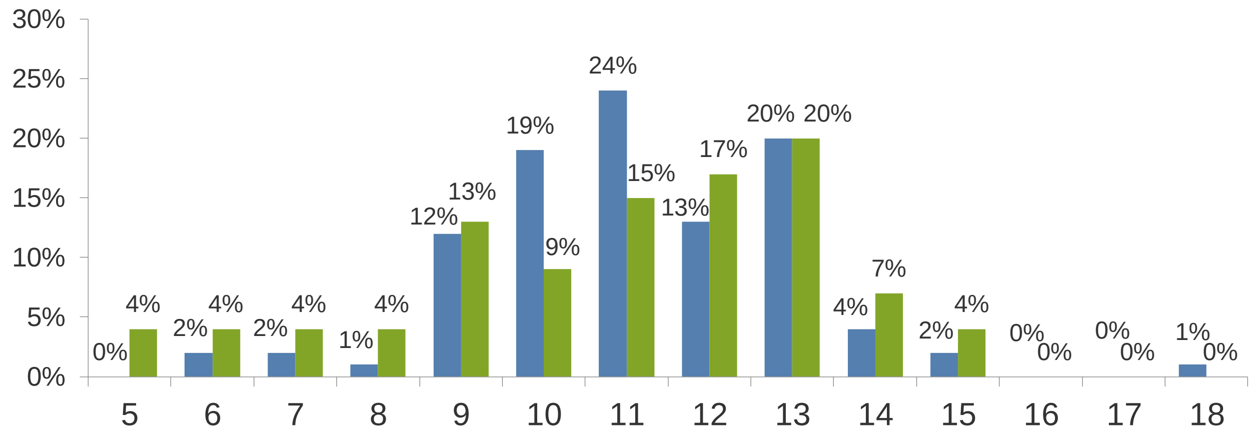
Youth Demographics
Below we report the output for youth participants during the summative phase (2013 and 2014).

Gender
More girls than boys participated in *Driven to Discover* in both 2013 (60% female, 40% male) and 2014 (67% female, 33% male).

Age Range
Youth participants spanned ages 5–18 (see Figure 3). The largest proportion of youth were between 9–13, slightly younger than the project's target age range of 12–14. The wide age range of participants reflects the reality that younger siblings often attend ISE programs with their older siblings.

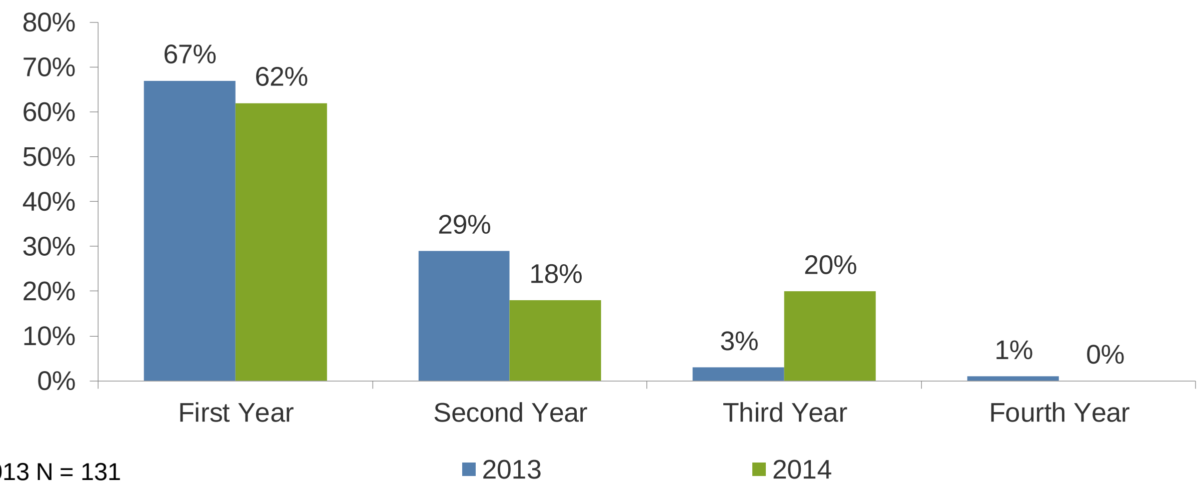
Youth Return Rates
Approximately two-thirds of the youth were "new" each year. Just a bit more than a third of youth (38%) returned in 2014, however, which may indicate a trend of more students returning as the program continues (Figure 4).

Figure 3. Youth Age Distribution by Year



2013 N = 133
2014 N = 114

Figure 4. Percent of Youth by Years in Program by Year



2013 N = 131
2014 N = 114

Overview, cont'd.

Race/Ethnicity
The majority of youth who participated in *Driven to Discover* were White, but some teams were more diverse, including youth with other racial or ethnic backgrounds. (See Table 4.)

Table 4. Youth Race/Ethnicity Distributions by Year
(could choose more than one)

Race/Ethnicity	% of Youth 2013 (N = 130)	% of Youth 2014 (N = 113)
African American/Black	23%	12%
American Indian/Alaskan Native	8%	0%
Asian	8%	7%
Hispanic/Latino	2%	3%
Pacific Islander	1%	0%
White	73%	75%
Other*	2%	4%

* 2013: Chinese, Vietnamese, Russian, Filipino
2014: Ethiopian, Virgin Islander, Indian

Methods

This study used a mixed-method design (Greene & Caracelli, 2003) which combined quantitative and qualitative data collection.

Collecting key information about the same constructs in different ways allowed us to seek convergence or corroboration of information to confirm and explain the outcomes in greater depth (Graham, 1989). For instance, when assessing youth participants' engagement and increases in knowledge and science inquiry skills, we collected data from multiple sources including adult leader attendance and reporting records, youth pre- and post-program surveys, adult leader post-program surveys, adult leader focus groups, and youth science project interviews conducted by scientists at the annual science fair. Results from all sources were used to more thoroughly assess and explain outcomes.

Additionally, using a variety of quantitative and qualitative measurements allowed us to include both the rigor of statistical analysis and the depth and breadth of qualitative data.

Youth Audience

Youth Pre-/Post-Program Surveys

Surveys were administered in person to participating youth at the beginning of the program and at the end of the program (i.e., a pre-/post-design). The focus was to assess how the citizen science and science inquiry activities affected youth participants' knowledge, attitudes, and science inquiry skills. Participants completed both pre- and post-program surveys during club meetings. Participants did the pre-program survey prior to *Driven to Discover* activities and completed the post-program survey after finishing their science projects.

We piloted youth evaluation questions during the project's formative period (2012). Based on results of the pilot, the evaluation used a short preliminary survey to assess baseline experience, knowledge, and attitudes, then a longer, post-program survey with the same questions and additional retrospective questions to measure pre- to post-program changes.

We explored using validated youth science attitude instruments to assess shifts in the participants' attitudes towards science. The validated science attitudinal scale that matched our audience the best was the Modified Attitudes Towards Science Inventory (mATSI), which was developed for fifth-graders. It used a five-point agreement scale (strongly agree, agree, neutral, disagree, strongly disagree) and a set of 25 statements to rate. We also developed a shorter set of nine statements to assess citizen science attitudes.

The youth pre- and post-program surveys were collected in 2013 as part of summative data. The program and evaluation team decided to not collect additional youth survey data in 2014 because: 1) some adult leaders reported that the pre-program surveys were adversely affecting youth recruitment at the initial team meetings, and we wanted to observe the programs working with less interference from evaluation activities; 2) some youth continued to participate after the first year, making the interpretation of the outcomes more complex; and 3) we were approaching data saturation (i.e., not finding anything new).

Response rates for both individuals and teams were reasonable for this type of program:

- 100 of 139 youth returned both pre- and post-program surveys, a 72% response rate.
- 14 of 19 teams returned both pre- and post-program youth surveys for a 74% response rate at the team level.

Methods, cont'd.

Youth Outputs: Attendance, Meeting Activities, Demographics, Youth Science Project Outputs
Adult leaders kept record of various "output" related to youth participants. After each meeting, youth attendance and meeting activities were recorded. These records allowed us to track which phases of inquiry the teams engaged in over the duration of their meetings. In 2013, 13 of 19 (68%) of the teams returned attendance forms. In 2014, 9 of 10 (90%) of the teams returned attendance forms.

Leaders also recorded youth demographic information for us in 2014; we had not collected it from youth surveys that year. In 2013, we obtained 96% of the youths' demographic information from their pre-program survey. In 2014, all 10 teams submitted the demographic information for their youth participants.

Finally, leaders documented several outputs from the youth science projects in 2013 to inform us about the science content in which the youth engaged. All 39 project outputs were documented.

Youth Team Interviews
Scientists conducted youth team interviews during pre-conference activities. They posed two questions to the teams to help us assess their understanding of citizen science at the end of their program. The questions were:

1. Tell us how you would describe what citizen science is to someone who does not know.
2. How is the scientific information you collected as a citizen scientist this summer helpful to the field of science or conservation?

Scientists took notes as participants answered these questions. The replies were then summarized and submitted for evaluation purposes.

Youth Project Interviews
During the science fair, scientists interviewed youth about their projects. The interviews assessed the extent to which youth met four goals for their project, including how topics were addressed and how methods, results, and discussion areas were fulfilled. The scientists scored questions about each of these areas on a 3-point scale: 1 = not fulfilled; 2 = partially fulfilled; and 3 = completely fulfilled. Scientists also made general comments about the projects. The data on these interview forms were only submitted for evaluation; less specific, positive feedback was given to youth participants to support their science development process.

Adult Audience
We used several methods to gather information about the impact on the program's adult leaders. Both the adult leader training and the post-program surveys were used to quantitatively assess the impacts on adult leaders from their perspectives. Data from focus groups and observations deepened our understanding of selected impacts, in order to better assess how youth and adult leaders engaged with citizen science and science inquiry.

Adult Leader Post-Training Survey
Retrospective adult leader surveys provided a deeper understanding of 1) their increased knowledge due to training and 2) adult leaders' confidence as they began working with their teams. Evaluation staff administered hard copy on-site surveys following the three-day adult leader training session. The only training for the summative phase was held in 2013. We collected 13 surveys representing 93% of the leaders attending this training session.

Adult Leader Post-Program Survey
Retrospective adult leader post-program surveys provided a deeper understanding of:1) the adult leader experiences with their team and 2) the impact of the *Driven to Discover* activities on adult leader knowledge, attitudes, and youth science inquiry facilitation skills.

Methods, cont'd.

Following the completion of team activities, leaders received an online adult leader post-program survey. In 2013, 21 of 22 leaders completed surveys, which accounted for 95% of the teams. In 2014, 8 of 14 leaders completed surveys, accounting for 70% of the teams.

When using responses to interpret youth or team impacts, we called exclusively on 2013 adult leader responses for consistency with the period of the youth data collection. We did, however, use the latest survey (either 2013 or 2014) from the leaders to interpret their accumulative knowledge, attitudes, and skill impacts.

We explored the Teaching Science as Inquiry (TSI) validated instrument to help assess adult leaders' self-efficacy in facilitating youth science inquiry. The original instrument was developed and validated to measure preservice teachers' self-efficacy with regard to teaching science as inquiry (Dira-Smolleck, 2004). We used 15 questions from the original 69 questions most closely related to the activities that *Driven to Discover* leaders needed to facilitate. The wording of the items remained identical with the exception of changing the verb tense from future to past.

Adult Leader Focus Groups
Focus groups were held at the University of Minnesota the Friday evening prior to the 2013 and 2014 science fairs.

In 2013, the leaders were divided into two groups according to their citizen science project (Monarchs or Birds and Water). In 2014, all leaders participated in the same focus group.

In 2013, the focus groups addressed the following:

- How adult leaders perceived their citizen science and inquiry research process with the team;
- What worked well and not so well for adult leaders in engaging youth in citizen science and science inquiry; and
- What support will adult leaders need in the future to engage youth in either citizen science or inquiry?

In 2014 the focus group goals were to:

- Elicit adult leaders' perceptions of themselves as citizen scientists and trainers of upcoming citizen scientists and why it was important for them to participate with their team;
- Deepen our understanding of how adult leaders navigated the balance between youth engagement (activities that were fun and stimulating) and authentic citizen science (activities that closely resembled real science);
- Deepen our understanding of how adult leaders helped their teams navigate areas where they had less experience or felt less skilled or knowledgeable; and
- Describe how the experiences of working in new/unknown areas tested and/or affected leaders' science/teaching practice.

Program Context and Audiences
Observations
We observed team meetings to understand how the program was implemented and how adult leaders and youth engaged with the program as well as to see the contexts of the various settings in which the program was implemented. We observed four teams in 2012 and two teams in 2013. We observed the teams two to three times each with the intention of observing them at different times to see how they engaged in the phases of science inquiry as defined by the *Driven to Discover* Process of Science Inquiry model (see Figure 1).

We used purposive sampling to select respondents for the observations (Babbie, 1998). In purposive sampling, we selected teams based on characteristics identified as most useful or appropriate for the study. In this case, the goal was to observe teams with leaders who had different professional backgrounds and who conducted their *Driven to Discover* programs in a variety of settings. This population included teachers, environmental/naturalist educators, youth leaders, and general citizens.

Methods, cont'd.

Data Analysis

Survey and Output Data

Quantitative data were analyzed using basic descriptive statistics which are summarized in tables or charts. (When data are presented in percentages, some percentages do not add to 100% due to rounding.)

We examined frequency and percentage distributions using statistical analysis tests to assess whether differences were statistically significant.

The main statistical tests used included:

- Pearson Chi-Square tests for differences in pre/post-program nominal variables and Exact tests for small samples.
- McNemar tests for pre/post program differences in binomial variables when we were testing for changes within subjects.
- Related or paired sample Wilcoxson signed-rank tests for ordinal variables assessing differences with pre/post-program answers.

For these analyses, we accepted any shifts as statistically significant at a 95% confidence interval or when the p-value was less than 0.05.

We analyzed open-ended survey questions using content analysis to develop response categories and descriptions.

Observations

Observation data consisted of written field notes, scale items, and debrief summaries. Data were coded using thematic analysis and disaggregated when appropriate for interpretation.

Focus Groups

Focus group sessions were recorded and the audio transcribed for analysis. All data were coded using inductive coding (Strauss & Corbin, 1990; Patton, 1990), which allowed researchers to identify emergent patterns and themes in the data without the limitations imposed by pre-determined categories. As patterns and themes were identified, researchers teased out the strength of these patterns and themes (Miles & Huberman, 1994).

Limitations

As in most informal learning programs, much of the data collection depended on adult leaders, who administered, recorded, and returned data to the evaluator. Steps were taken to reduce the leaders' work load and ensure the maximum return of the data, but even then, program activities at times took precedence over data collection.

The need to affect the teams' experiences as little as possible also limited evaluation approaches somewhat. For instance, interviewing individual youth was not possible, either due to inconsistent attendance by youth for on-site interviews or a desire not to interrupt them during their time at the science fair. To obtain a deeper understanding of youth impacts with these constraints, we settled for group youth interviews conducted by the scientist leaders at the science fairs.

Results: Youth Outcomes

Youth Outcome 1: Gain Knowledge About Science Content

This outcome was met. Youth participants engaged with science content relevant to their projects, such as wildlife behavior and life cycles. Moreover, pre/post surveys showed statistically significant increases in first-year youth understanding of the science inquiry concepts.

Outcome 1: Youth will gain knowledge about science content relevant to their citizen science and independent research projects.

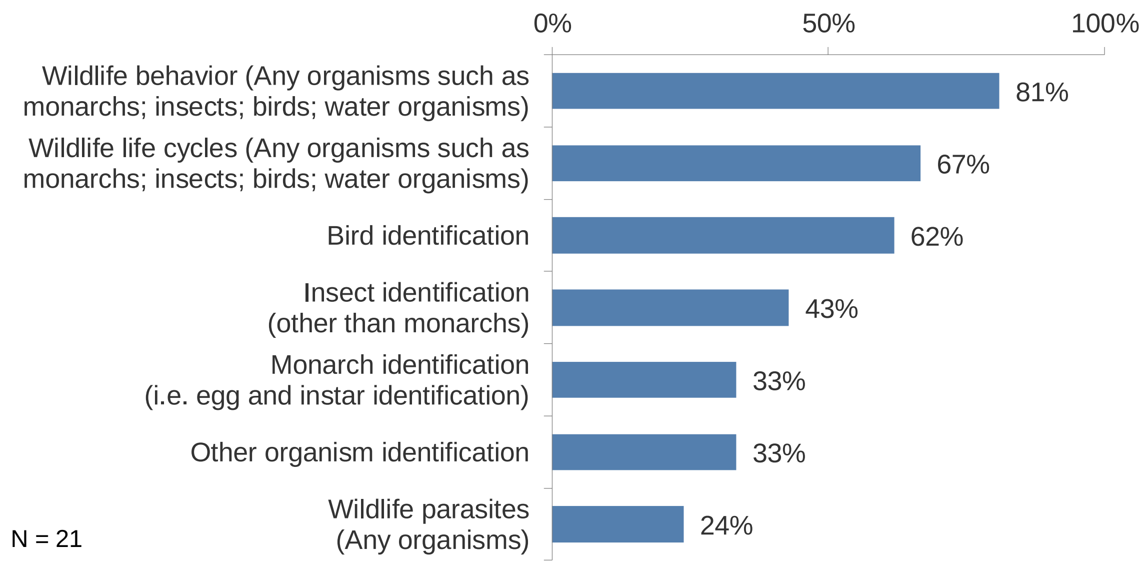
In order to assess Outcome 1, we needed to assess whether youth were engaging in the science content areas relevant to their projects. We assessed team projects and poster sessions to triangulate student learning. Observational data also indicated that youth engaged in the appropriate content areas and learned science skills. At a more minute level, we examined the youth participants' understanding of the scientific inquiry concepts of hypothesis and scientific process for pre/post knowledge gains. *Driven to Discover* clearly was engaging youth in these ideas and when the first-year youth data were examined, statistically significant increases in understanding of these concepts were found.

Science Content

Based on adult leader reports, youth engaged in a range of relevant science content learning. The areas with the highest percentage of groups involved learning about wildlife behavior, life cycles, and identification. (See Figure 5.)

Interestingly, in youth surveys, respondents also referred to science content they had learned. In fact, when asked what they found most interesting about their research club, 68

Figure 5. 2013 Teams: Science Content Areas in Which Youth Engaged (As Reported by Adult Leaders)



I learned so much about monarchs and about what plants they go on and what they eat and where they lay their eggs. I also learned many different kinds of plants and insects. I learned about instar stages of the monarch caterpillar.

How to tell a trumpeter swan from a tundra swan.

I learned about how to raise monarchs. I also learned how to handle caterpillars.

How the pigeons were scared off by the plastic owl.

I learned more about flowers and insects in the meadow, not just the monarchs and milkweed living there.

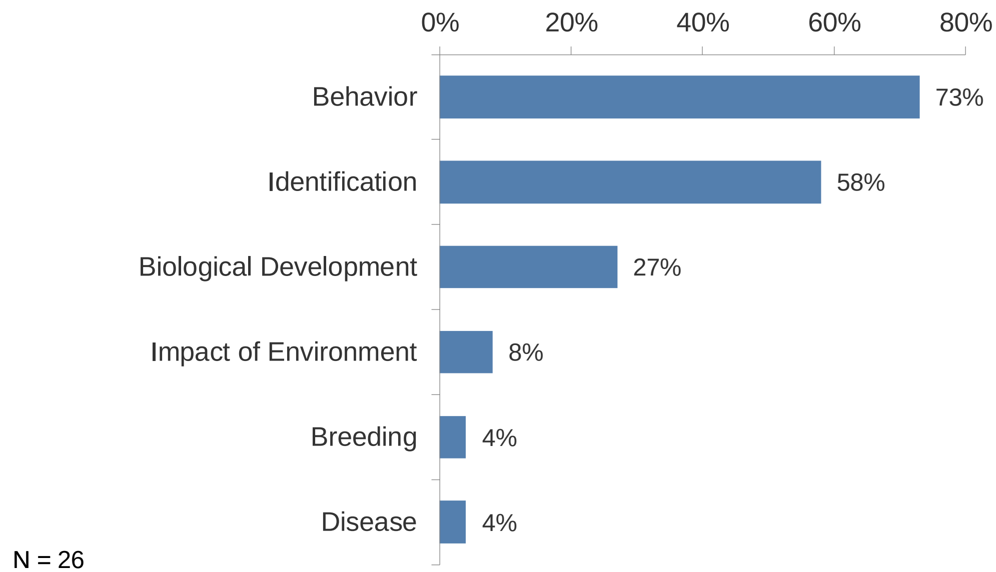
Youth Outcome 1, cont'd.

youth provided responses related to science content and another 22 reported learning about a scientific skill.

In addition to survey data, we also had evidence from poster presentations of youth learning about science content. About one-half—52%--of youth teams presented a poster at the 2013 science fair. All the posters (100%) indicated that youth studied a range of science content. The highest percentages involved behaviors (73%) and identification (58%). Smaller proportions of the projects explored biological development (27%), environmental impacts (8%), breeding (4%), and disease (4%). (See Figure 6)

Finally, observations of the teams provided qualitative data that youth were learning science content. The following examples come from field notes taken during three different observation sessions:

Figure 6. Percentages of 2013 Teams that Studied Each Science Content Area to Complete their Science Inquiry Project/Poster



Youth were learning what some of the orders of insects were. They had to find a peer who had an insect in the same order but a different species. Later, while monitoring, one youth referred to one of these orders while making the gesture of how its wings lay on its back (by putting her arms behind her and overlapping her hands). The leader had made this gesture earlier during the activity. The leader quizzed youth on how to properly look at the milkweed before they checked it, and they were able to answer all of her questions.

The youth have learned names of water organisms. The fourth group was trying to remember what they had found, and they mentioned daphnia, leech, water boatman, back swimmers, nematodes, and sea shrimp….The first group found a "giant worm" in the inlet, but they were unsure of what it was…the leader helped them think about how it might have gotten there (Where does water from the inlet come from?).

In the field, youth were able to identify organisms or ask peers to help them. One youth sees a bug that she wants a peer to help identify but the bug moves before she can see it. She tells the peer that it was orange and black and looked like a ladybug, and the peer believes she knows what it is and thinks it was a juvenile.

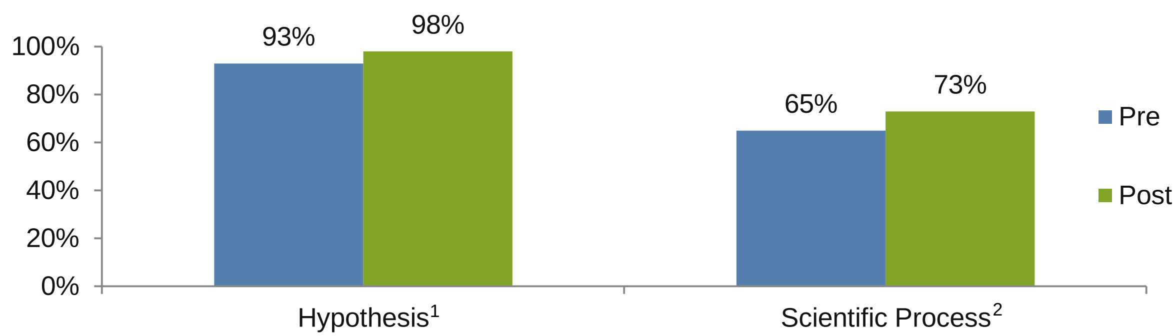
Youth Outcome 1, cont'd.

Scientific Inquiry Concepts
In addition to examining youths' engagement with science content to assess Outcome 1, we looked at their understanding of the science inquiry concepts of hypothesis and the scientific process. We asked participating youth whether they had heard the term *hypothesis* prior to and after their project. Results show 93% of all youth had heard the term *hypothesis* before they began the project, so the increase to 98% after the project was not statistically significant. When, however, we disaggregated the first-year youth participants, we saw fewer coming in knowing the term *hypothesis* (89%) and the same after program proportion (98%) documenting that they had heard the word. This change was statistically significant. (See Figure 7.)

We asked the same question about whether they had heard the term *scientific process* before. Fewer youth had heard of this term both prior to (65%) and after (73%) the program, and the change was not statistically significant for all youth. Again, when we disaggregated the youth to see whether first-year participants' totals differed, we saw a statistically significant change—from 53% who had heard about it prior to the program to 68% after the program. (See Figure 8.)

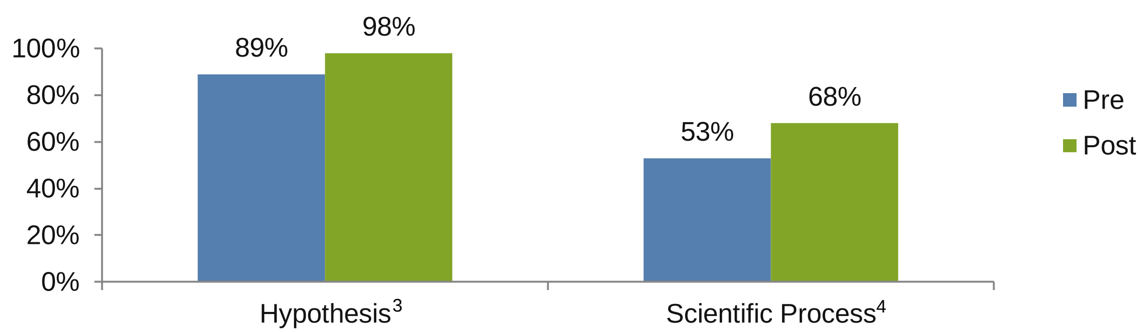
When we examined youths' pre- and post-program open-ended definitions of *hypothesis* we found that most of them answered, both prior to and after the program, with some version of "an educated guess." A small

Figure 7. All Youth Hearing About Hypothesis or the Scientific Process



Pre n = 100 Post n = 100
[1] Pre missing = 1; Post missing = 3; Related samples McNemar $p = 0.125$
[2] Pre missing = 4; Post missing = 3; Related samples McNemar $p = 0.143$

Figure 8. First-Year Youth Hearing About Hypothesis or the Scientific Process



Pre n = 66 Post n = 66
[3] Pre missing = 1; Post missing = 1; Related samples McNemar $p = 0.031$
[4] Pre missing = 4; Post missing = 3; Related samples McNemar $p = 0.039$

Youth Outcome 1, cont'd.

portion (9%) increased their understanding to see an hypothesis as a possible outcome to their question (a concept that the *Driven to Discover* attempted to encourage leaders to teach). This change was not statistically significant (Pearson Chi-Square p = 0.085).

When we examined youth pre- and post-program definitions of *scientific process* there was about a 15% shift towards a complete answer, a statistically significant change (Pearson Chi-Square p = 0.001).

Moreover, 12 respondents confirmed that they learned about the scientific process when describing the most interesting things they learned in their research club that year. In addition, about three-fourths of youth documented that they were engaged in the scientific process when they collected data to answer their own questions about monarchs, birds, or pond organisms. Given these outcomes, we conclude that there were larger gains in learning about the overall scientific process for the youth attending the program in 2013 than just learning about hypotheses.

While observations triangulated the conclusion that youth were learning about the scientific concepts of hypotheses, they also reveal the range of understanding present both within and between groups when it came to scientific concepts. For instance:

> *They [the youth] were moving toward getting the concepts and learning how to write the questions and hypotheses. For instance, one group wrote one word for each hypothesis, but learned that they needed to write complete sentences. Otherwise, all participants understood the difference between the question and the multiple outcomes or hypotheses that would be possible outcomes of the question. So, they were getting the concepts and applying them.*
>
> *It appeared that all but the youngest understood the difference between the scientific question and the hypothesis. They understood that they needed multiple hypotheses and knew how to write them out for the most part.*
>
> *While the leader was questioning the youth during the mini-inquiry, the youth were able to answer all of the questions, which points to the fact that they have learned the material. The youth were able to describe the formula for a question, knew what the null [hypothesis] was, and knew why there was more than one hypothesis.*
>
> *The first group listed all of their hypotheses (1. more organisms at the inlet, 2. more at the outlet, 3. the same number at both, Null: no organisms at either). When the leader joins the group, she asks what their hypotheses are and then tells them that their third hypothesis is actually the same as their null hypothesis; the youth seem to understand. She also asks the youth what they expected to find…This helps youth remember and articulate why they decided on a certain hypothesis and also puts it in terms that can be easily understood.*
>
> *The majority seemed to be getting the concepts a little, but struggling to apply them and not quite able to make the leap to devising their own questions to investigate, although getting close. One example of a student getting to the next stage was Corin, who observed that "dragonflies like dirty water." When asked by the leader if she could turn this observation into a hypothesis she came up with "hypothesis 1. (null) dragonflies prefer dirty water, hypothesis 2. dragonflies prefer clean water, hypothesis 3. dragonflies like both clean and dirty water."*

Youth Outcome 2: Increase Awareness of Citizen Science

This outcome was adequately met. The program introduced youth to the term and general concept of citizen science. It was less successful, however, in helping youth understand the nuances of how their data would be used.

Outcome 2: Youth would increase their awareness of what citizen science is and ways it can contribute to science.

The *Driven to Discover* program model used citizen science programs as a starting place and structure for the teams to engage with science content and to learn about data collection methods.

Adult leader surveys from 2013 confirmed that all youth participated in a citizen science program; 7 teams worked with the Monarchs Larva Monitoring Program and 11 teams with eBird.

We asked the youth, both prior to and after the 2013 program, about whether they had heard of citizen science in order to assess what they had learned during their meetings about citizen science. Looking at youth who returned both their pre- and post-program surveys, we found that 56% of youth had heard of citizen science prior to their team meeting that year and 82% had heard of the term after their meetings—a statistically significant change (see Figure 9). Those participating in *Driven to Discover* for the first time that year had slightly larger changes (also statistically significant): 39% had not heard the term prior to the program and 74% recognized the term at the program's end (see Figure 10).

Figure 9. All Youth Hearing about Citizen Science in 2013

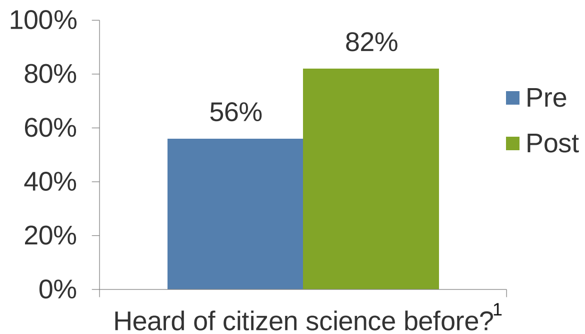
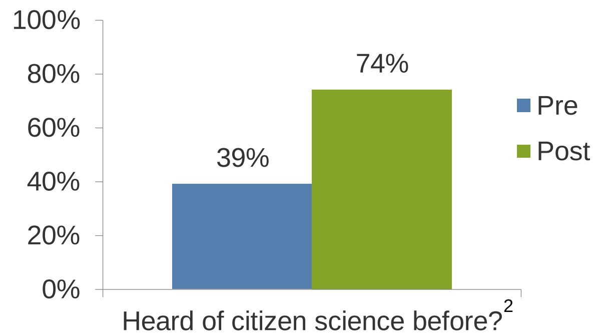


Figure 10. First-Year Youth Hearing about Citizen Science in 2013



All youth pre n = 100
All youth post n =100

First year pre n = 66
First year post n = 66

[1]All youth pre missing = 3; Post missing = 1; Related samples McNemar $p < 0.001$
[2]Pre missing = 2; Post missing = 1; Related samples McNemar $p < 0.001$

Youth Outcome 2, cont'd.

Of the youth post-program 2013 survey respondents (82%) who said they had heard of citizen science (both first-year and returning youth):

- 35% provided an answer that conveyed a good understanding of citizen science;
- 49% of the answers conveyed only a partial understanding of citizen science; and
- 16% of the answers failed to convey that they understood citizen science.

Responses that conveyed a good understanding of citizen science:

People who aren't necessarily "scientists," but they act as scientists in helping larger programs collect field data.

People that collect data and do experiments as scientists. The people aren't professional scientists.

Responses that conveyed a partial understanding of citizen science:

When you report what you see and it gets recorded.

Regular people who study science.

Responses that failed to convey an understanding of citizen science:

Citizen science is a science that helps citizens.

Young kids learning about science.

At the annual science fair, we asked the youth participants open-ended questions about citizen science to help us understand their perspectives about it. Scientists asked the youth the questions in a team setting and summarized their answers.

The first question asked was, "Tell us how you would describe what citizen science is to someone who does not know?" Teams varied slightly in their responses to this question. Nearly all teams, however (9 of 10) reported that it involved a person who was not a professional scientist, sometimes described as a person not getting paid to engage in science. Five teams reported that the individuals collected data, often mentioning that the data contributed to a central database at a science organization. After these two categories, other themes varied and included foci on:

- Citizens answering their own science questions (3);
- Studying nature (4);
- An engaging way to learn (3);
- Contributing to science (1);
- Answering a larger research question (2);
- Working with a team (2) or mentor (1); and
- Purpose is to make earth a better place (1).

A *Driven to Discover* team in the field observing birds. Youth directly engaged in ongoing citizen science programs such as eBird.

Youth Outcome 2, cont'd.

The second question asked by the scientists of the teams at the science fair was: "How is the scientific information you collected as a citizen scientist this summer helpful to the field of science or conservation?" All teams provided reflective answers about how the information they collected could help the field of science or conservation.

Several teams articulated how the data could help scientists identify shifts over time, calculate population levels, or understand migration patterns. Some teams offered other ways their data could help scientists, such as increasing database sizes to improve the accuracy of experiments, inspire new questions, identify new things (i.e. unidentified organisms or behaviors), mitigate the effects of humans destroying habitat needed for certain species, and even being an advocate for science.

How is the scientific information you collected as a citizen scientist this summer helpful to the field of science or conservation?

It tells what bird species live in different habitats, tells people what to look for if they wanted to do more detailed research, [and] *what species lives in park.*

It tells about migration routes, if populations are going extinct, if there's a new type of bird. It can [also] *tell you about plant life, what birds are eating or if that food is gone.*

So they know which birds are still alive, so they can look back and compare. They can see if a population is declining.

[Water] *Samples year by year help identify changes from year to year. That may tell us how the planet is changing and so on.*

We can study ice changes, when it freezes, but now freeze time is shorter, so this might tell us more about pollution in the water and how we can save the earth.

Let others use their data. If monarchs in the sun did best, someone else can use that data to help them do another project.

Compare data over time to see how the monarchs are doing.

It can be helpful because they can see what birds are in the area and how many are living there. When they know where the birds are, they can average what birds are there and what time of the year they're there.

Youth Outcome 2, cont'd.

Post-program survey questions showed that the majority of the youth participants either "agreed" or "strongly agreed" that they understood why and how they were to collect data for the citizen science project. Of respondents, 91% said they understood how to collect the data and why they were collecting it. These results indicated that even if the participants were not familiar with the term *citizen scientist*, they understood that they were collecting data for a project.

The level of progression of their understanding of what they were doing with citizen science shows that slightly fewer youth understood the nuances of how the citizen science data they collected would be used. (See Table 5.)

Table 5. Youth Agreement Ratings Regarding their Understanding of Working with Their Citizen Science Data (N = 108)

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Don't Know/ Not Sure	Missing
I understood how to collect data for the project.	1%	0%	6%	33%	**58%**	3%	1%
I understand the reasoning behind how I collected data for the project.	1%	1%	3%	**48%**	43%	4%	2%
I understand how the data will be used.	1%	0%	13%	**41%**	39%	6%	1%

Youth Outcome 3: Develop Positive Attitudes About Role

This outcome was met. Youth rated their enjoyment with the club activities highly and most agreed that what they were doing in the program was valuable. Though their motivation to continue the program had slightly lower agreement ratings, pre-/post-program agreement ratings for nearly all statements measuring attitudes about science show statistically significant shifts towards stronger agreement.

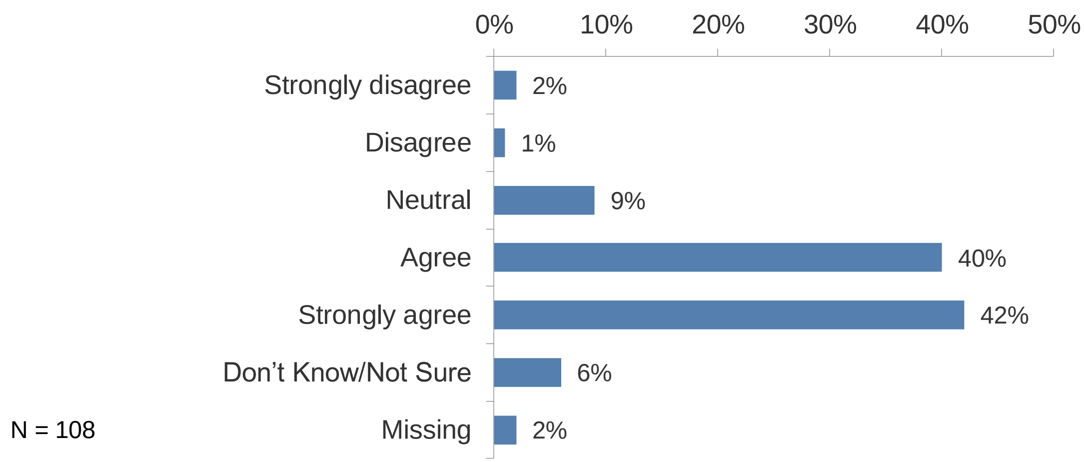
Outcome 3: Youth will develop positive attitudes about their role in science.

We assessed positive attitudes about youths' role in science by examining their ratings of their enjoyment of the program, the value of their science contributions, their motivation to continue to engage in their clubs, and whether they saw themselves as scientists.

Enjoyment

A heavy majority (95%) of youth claimed to have enjoyed the research club activities a "moderate" (25%) amount or "a lot" (70%). Only 5% of the youth said they enjoyed the activities "a little." No one reported enjoying them "not at all." Observations confirmed that most youth appeared to be enjoy the activities. Some youth conveyed less enthusiasm for activities than others. Lower enthusiasm tended to be expressed by youth who had not decided to attend the program on their own. (In these cases, a parent made the choice or a judge court-ordered the youth to attend the program.) As a result, these youth were likely less motivated to attend regularly and participate in the activities than those joining the program of their own volition.

Figure 11. Youth Agreement with the Statement: "The data that I collected for the citizen science project are valuable."



Value of Science Contributions

Overall, we found that youth believed they were contributing to science, which provided a sense of worth to their activities. We specifically asked the youth participants whether the data they collected for the citizen science project were valuable. A majority (82%) of the youth agreed with the statement that the data they collected were valuable. (See Figure 11.)

Motivation to Continue

Of the youth returning post-program surveys in 2013 (N = 105), 78% said they would like to continue with their club, 17% were not sure if they wanted to continue, and 5% did not want to continue. Likewise, we saw that about one-third of the youth returned from year to year. Out of the five youth who did not want to continue, two said they wanted to do other things, one did not enjoy the activities (this

Youth Outcome 3, cont'd.

person did not attend the program by choice), one was tired of the activities, and one wanted the freedom to expand his/her research on birds to other locations.

The biggest reasons why youth were motivated to continue with their clubs: it was fun (59 citations); they learned a lot (23 citations); they had the opportunity to do science such as data collection, experiments, and generally contributing to science (14 citations); they had the opportunity to do things outdoors (5 citations); and they could work with others such as friends, teachers, and other interesting people (8 citations). Other reasons given included that it was interesting, that they were able to attend the science fair, that they could learn about science content, and that they could go on field trips.

Youth who were not sure if they would be back the following year reported various reasons they might not return, including that they had competing activities, wanted to study something different, had no interest in the topic, had low confidence, or were moving to a new school.

I would like to return to Driven to Discover because…
I liked this club because we get to come up with our own experiments and we got to make a cool poster board.

It was fun and I felt like I was contributing to science.

I thought it was very interesting to see all the wildlife, and I learned so much about monarchs and other insects.

I would because I could teach my mom and friends.

I would like to participate in the research club next year because it was a good way to do fun science activities over the summer.

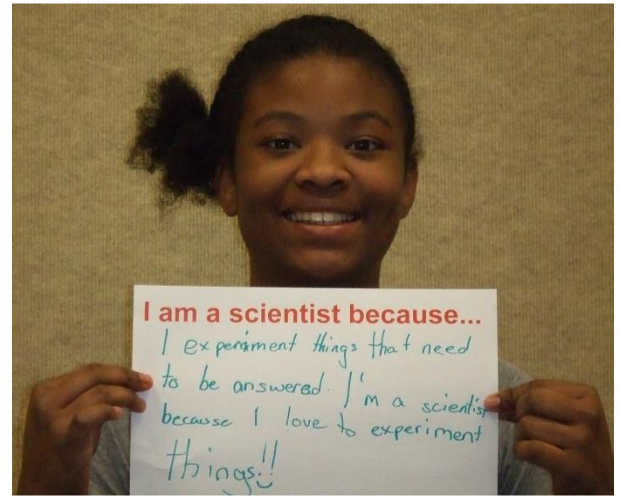
I would like to participate in this research club again because it was fun and I feel like I am making a difference in the world of birding.

I'm not sure about returning next year…
Because you have to wake up early.

I think I wasn't really prepared for this project

It is sometimes a little boring by doing the same thing every time, but interesting.

I really love this program and what it offers, but the only reason I wouldn't want to do it next year is because I'm getting a very tight schedule, otherwise I would do it again.



Two youth participants in the *Driven to Discover* program show their responses to the "I'm a scientist because…" prompt. Responses such as these suggest that youth participants were understanding some of the characteristics of scientists and identifying with them.

Youth Outcome 3, cont'd.

Science Identity
Research has shown that developing a science identity is important for youth to continue to engage with science. The set of statements displayed in Tables 6 and 7 were developed to capture youth attitudes about science and citizen science linked to a science identity. We asked youth participants to rate their level of agreement, in order to capture their attitudes, both prior to starting the program and at the end of their program.

Most of the youth came into the program agreeing with the statements we posed. Positive shifts were noticed, and were found to be statistically significant, across three statements: "I can think like a scientist"; "I am part of a science community (such as a club, team, or study group)"; and "I consider myself a citizen scientist".

More youth "strongly agreed" (45%) that they could think like a scientist after completing the program than before the program (33%). Furthermore, some youth who originally rated in the neutral area agreed with the statement after the program. By the end of the program about 85% or more of youth agreed that they could "think like a scientist," compared to 82% prior to the program.

We also saw an increase in youth who "strongly agreed" that they were part of a science community after the program. About 45% of the youth "strongly agreed" that they were part of a science community prior to the program and 63% "strongly agreed" after. Overall, we saw an increase from 61% to 83% of youth that agreed they were a part of a science community (see Table 7).

Table 6. Youth Pre-/Post-Program Agreement Ratings for Statements Measuring Attitudes about Science: Part I (pre n = 99, post n = 99)

Statement		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Don't know/ Not sure*
I can think like a scientist.[1]	Pre	1%	0%	17%	**43%**	33%	5%
	Post	1%	2%	11%	37%	**45%**	4%
I am interested in finding ways to answer questions about nature.[2]	Pre	1%	2%	9%	37%	**50%**	1%
	Post	1%	3%	10%	**43%**	42%	0%
I feel that I can collect high quality scientific data.[3]	Pre	2%	4%	16%	35%	34%	8%
	Post	0%	2%	13%	**48%**	31%	5%
I am interested in doing a science research project in the near future.[4]	Pre	4%	0%	7%	33%	**52%**	3%
	Post	0%	3%	16%	34%	**44%**	2%

Wilcoxon related sample signed–rank p-values:
1. Pre-program to post-program $p = 0.033$; $n = 92$
2. Pre-program to post-program $p = 0.305$; $n = 97$
3. Pre-program to post-program $p = 0.522$; $n = 88$
4. Pre-program to post-program $p = 0.104$; $n = 93$

* Omitted from statistical analysis

Youth Outcome 3, cont'd.

Lastly, youth considered themselves citizen scientists more strongly after having participated in *Driven to Discover*. Youth agreed that they considered themselves citizen scientists at a 61% rate prior to the program and 83% after. In addition, more youth "strongly agreed" (52%) that they considered themselves citizen scientists after the program compared to before the program (36%). (See Table 7.)

We conclude that the youth formulated a stronger science identity and increased confidence in doing science by participating with this project. The majority of youth came into the program agreeing to many of the statements that measured attitudes about science. Nevertheless, we saw that many youth strengthened their agreement that they could "think like a scientist." In conjunction with this shift, we saw youth strengthen their agreement that they saw themselves as citizen scientists. Finally, we found that participating in the program was linked to youth feeling that they were part of a science community.

Table 7. Youth Pre/Post-Program Agreement Ratings for Statements Measuring Attitudes About Science: Part 2 (pre n = 99, post n = 99)

Statements		Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Don't know/ Not sure*
I feel that I can help answer my own questions about nature by collecting data[1]	Pre	3%	4%	13%	**39%**	**39%**	1%
	Post	0%	2%	10%	**44%**	43%	1%
I am part of a science community (such as a club, team, or study group).[2]	Pre	7%	10%	12%	16%	**45%**	9%
	Post	6%	3%	4%	20%	**63%**	4%
I feel that I can contribute to a citizen science project.[3]	Pre	1%	2%	7%	37%	**44%**	8%
	Post	1%	2%	11%	36%	**46%**	3%
I feel that my own science projects can contribute to science.[4]	Pre	1%	2%	16%	**38%**	36%	6%
	Post	1%	0%	12%	**43%**	36%	8%
I consider myself a citizen scientist.[5]	Pre	4%	3%	16%	25%	**36%**	16%
	Post	3%	1%	11%	31%	**52%**	1%

Wilcoxon related sample signed–rank p-values:

1. Pre-program to post-program $p = 0.033$; $n = 92$
2. Pre-program to post-program $p = 0.305$; $n = 97$
3. Pre-program to post-program $p = 0.522$; $n = 88$
4. Pre-program to post-program $p = 0.104$; $n = 93$
5. Pre-program to post-program $p = 0.001$; $n = 80$

* Omitted from statistical analysis

Youth Outcome 4: Engage in Scientific Inquiry Process

Overall, this outcome was met. Data showed that youth participants engaged in scientific inquiry by attending meetings and engaging in the *Driven to Discover* activities.

Outcome 4: Youth engage in the scientific inquiry process.

Because engagement and skills are closely linked within the same activity, presenting outcomes from each one separately is an artificial separation. Nevertheless, we will examine engagement outputs here in the fourth impact and report on the more intricate aspects of youth skills in the next outcome (Outcome 5).

Attendance

We measured youth attendance (taken by the adult leader) to assess the gross level of engagement that youth had in the programs just by being present. In 2013, 13 of 19 teams reported attendance, while in 2014, 9 of 10 teams did.

We found fairly similar attendance levels for 2013 and 2014, with the largest proportions (around one-third of youth) attending all the meetings each year. The second largest proportion of youth attended 60–79% of the time in 2013 (26% of youth) and 80–99% of the time in 2014 (22% of youth). These percentages indicate, roughly, that youth missed 1 or 2 meetings during their time, depending on the total number of team meetings. Thus, about one-half of youth attended 80% or more of their meeting times (55% in 2013 and 53% in 2014).

The remaining portion of youth participants' attendance spread across attending <20% of the time through 79% of the time. (See Table 8.) Note that attending less than 50% of the meetings would affect the youth's ability to experience the program fully, since learning was cumulative and often incorporated information from previous sessions. Also note that two of the three non-reporting teams in 2013 mentioned poor attendance. The other non-reporting team in 2013 and 2014 had fairly good attendance.

Table 8. Youth Attendance by Year and Percentage of Days Attended

% of Meetings Attended	**% of Youth 2013** (N = 107)	**% of Youth 2014** (N = 87)
100%	36%	31%
80% to 99%	19%	22%
60% to 79%	26%	15%
40% to 59%	8%	10%
20% to 39%	8%	7%
<20%	1%	15%

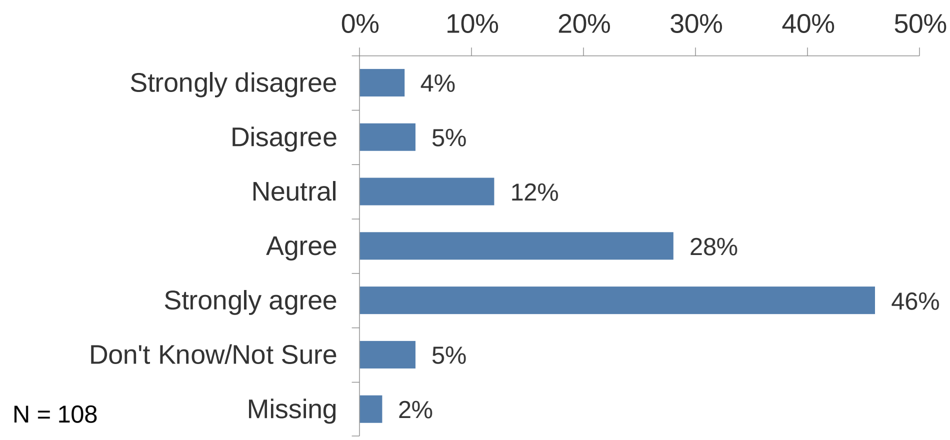
I understood the importance of engagement, I just wasn't prepared for the level of commitment the kids exhibited towards participation in this program. That being said, I am not sure I can narrow down exactly why the kids were willing to participate. I just know they were willing to come to our meetings nearly every Friday throughout the summer at 6:15 a.m.

Youth Outcome 4, cont'd.

Engagement in Science Inquiry
We also looked more specifically at how youth engaged in science inquiry. Three-fourths of youth surveyed agreed that they collected data to answer their own questions about monarchs, birds, or pond organisms (see Figure 12). In addition, more than half (53%) of youth attended the end-of-year science fair in 2013 with a poster that required them to ask a science question and answer it by collecting data.

Since not all youth attended the science fair, however, we also asked adult leaders about the science activities youth engaged in during their meetings. We found that some 80% to 90% of leaders engaged youth in learning the science skills necessary to do science inquiry including observing, data collection, and data organizing and analysis. When needed, they engaged their youth in skills specific to observing the organisms they were studying, such as how to use binoculars, a magnifying glass, or a microscope. (See Figure 13.)

Figure 12. Youth Agreement with the Statement: "I collected data to answer my own questions about monarchs, birds, or pond organisms."

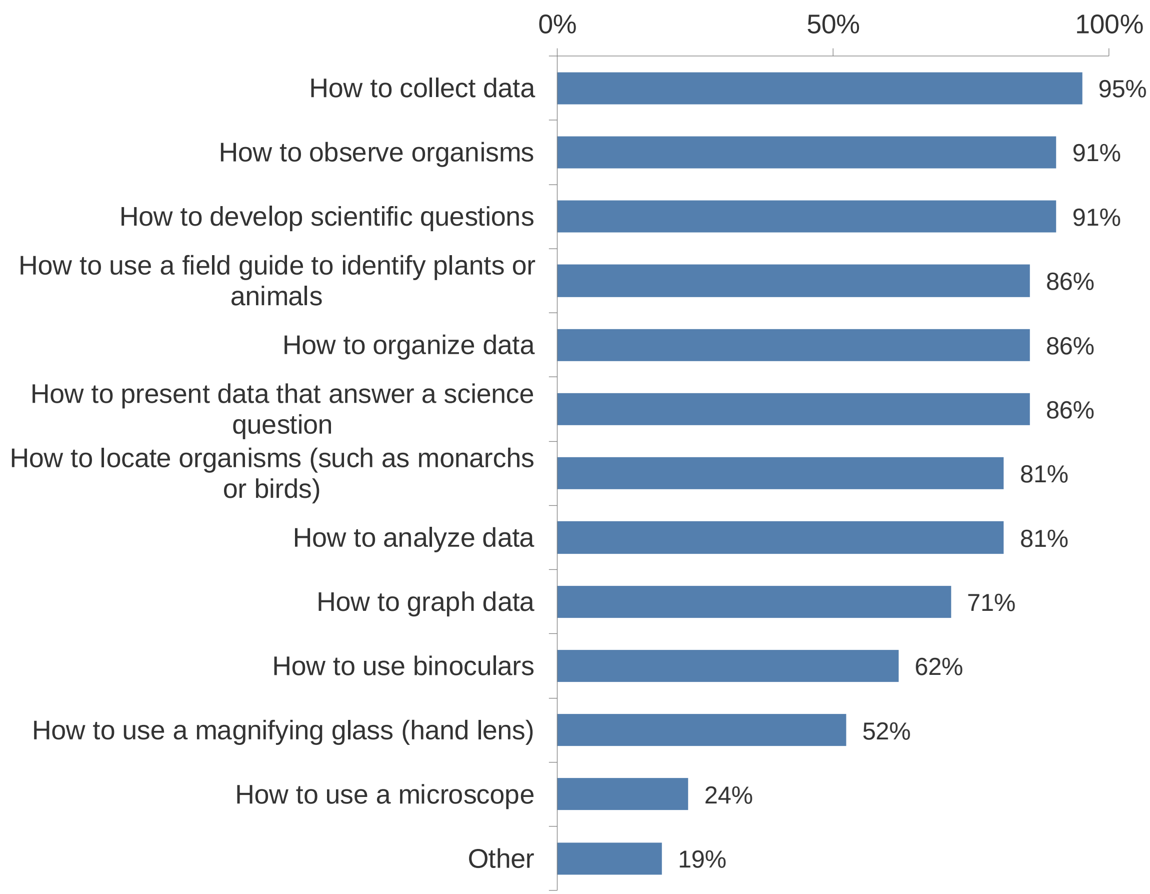


Youth Outcome 4, cont'd.

Other skills mentioned by adult leaders included:

- how to create a professional research paper and poster (1);
- computer skills (1);
- writing skills (1);
- how to develop consistent procedures (1);
- how (and why) to record observations on a both a macro and micro level (1);
- how to think about questions that cross or connect scientific disciplines (i.e. water chemistry vs. invertebrates) (1); and
- how to perform random sampling (1).

Figure 13. Skills the 2013 Adult Leaders Engaged Youth in During Meetings



N = 21

Youth Outcome 4, cont'd.

We also asked adult leaders to report on the activities the team engaged in during their meetings on a activity log returned at the end of the year. Their activity logs show that 91% (2013) and 90% (2014) of their teams' youth engaged in all stages of inquiry within the duration of the program. (Only one team per year failed to engage their youth in all stages of inquiry. Absences of activity were mostly noted in the latter stages of inquiry, including analyzing and interpreting and concluding and reporting for these teams. Either there was not enough time or the developmental level of the youth on these teams hindered them from experiencing the latter phases of inquiry.) (See Table 9.)

Teams differed in how much time they spent on each inquiry phase and how many days were spent working with a specific inquiry skill. All teams, however, spent more time on the basic skills of observing, wondering, and questioning than on collecting, analyzing, and reporting their data (see Table 9). Most teams spent time learning to collect citizen science data during the same time they engaged in observing, wondering, and questioning, allowing them to develop basic science skills before they asked their own questions.

Table 9. Team Time Spent in Inquiry Phases by Year (2013 N = 11; 2014 N = 10)

Inquiry Phase*	Year	Min. days	Min. % of total days	Max. days	Max. % of total days	Mean days	Mean % of total days
Observing & Wondering	2013	2	33%	15	100%	8	72%
	2014	2	25%	11	100%	9	76%
Questioning	2013	1	6%	11	100%	6	62%
	2014	2	38%	11	100%	6	68%
Hypothesizing	2013	0	0%	11	90%	4	42%
	2014	1	20%	10	90%	5	57%
Planning & Testing	2013	1	6%	8	70%	4	42%
	2014	0	0%	9	90%	5	48%
Analyzing & Interpreting	2013	0	0%	7	88%	3	33%
	2014	0	0%	9	90%	3	34%
Concluding & Reporting	2013	0	0%	7	47%	2	24%
	2014	0	0%	9	90%	3	28%
Reflecting & Rethinking	2013	1	6%	15	100%	5	50%
	2014	0	0%	11	100%	4	45%

* One team per year failed to engage in all the displayed stages of science inquiry.

Youth Outcome 4, cont'd.

The observation field notes below illustrate youth engagement in each of the inquiry phases.

Observing & Wondering Phase

The boy found a caterpillar and thought that it was a ladybug larvae, based on past times looking through the Monarchs and More guidebook. He became really excited and wanted to show everyone what he found. It was not a ladybug larva, but he then proceeded to look it up in the guidebook and discover for himself that the caterpillar he found was not the same as the larvae shown in the book.

While monitoring the milkweed, many of the youth made observations about an organism they found and engaged their peers in trying to figure out what it was. One girl made observations, such as the insect had legs and was yellow and brown and said they could look it up in the field guide when they got back to the pavilion. They brought the leaf back to the pavilion to look at under a microscope. They looked at it for quite a while, and they discussed with the adult leader what the mite might be doing.

While observing and trying to identify birds by their colorless silhouettes, the girl asked "I wonder what color sparrows are."

Youth observing birds in a park. This type of activity usually covered the inquiry phases of observing, wondering, and questioning.

Questioning Phase

During the microclimate activity, one youth noticed that it was hotter last week and another noticed that the humidity is higher today than last week. One youth talked about the milkweed near her house that was turning yellow. A peer asks if it's because it's not raining, and the girl says it's because it's raining too much.

The girl read some of the questions that she had written down during the field trip (data collection): Do crows talk to each other? Which birds communicate more? Why are there more birds at dusk than during the day? At the end of the session, some of the questions that the girls wrote on the white board included: Why do birds eat their eggs? Why are there more of one kind of bird? Why do birds like to mob?

Hypothesizing Phase

The boy pointed out that snow amounts in the winter are likely to influence pond water levels the following spring. Since we didn't have much snow this past winter, he wondered if this may be having an impact on the organisms in the pond and perhaps ponds with less water would have warmer water temperature as a result.

Adult Leader: "Start thinking of about these organisms/data and questions we could ask. How do they all interact/affect each other?..."What are some questions we could start to ask?"…Some examples of what they came up with included: "How does pH affect how long an organism lives?"; "How do different dissolved oxygen levels affect other organisms in the water?"; "Does pH change when a pond freezes over?"; and "When the sun heats water in the pond, do insects start dying?"

Youth Outcome 4, cont'd.

Planning & Testing Phase

When the inquiry sheets were brought out, the youth grabbed them and started filling them in right away. They didn't get exasperated when the adult leader corrected them to make the plan better, but eagerly switched it right away. They seemed to like the challenge and wanted the adults to help them create a rigorous study.

Before going to monitor the milkweed, the adult leader spends 5–10 minutes going over how to identify different instars and how to properly check the plants. She says that they are now good at finding eggs, and this week they may find some first and second instars. She asks a lot of questions, such as, "Where can you find them? How do you know they are there?" The youth answer and the leader elaborates and prods. She says that it's better to look at fewer plants carefully than many plants and miss something. She reminds the youth to look at every leaf, at the top and at the bottom. Before they leave, she says, "Be careful, be accurate."

Analyzing & Interpreting Phase

The adult leader wrote all of the data [about the birds] up on the board…The girls looked at this data and brainstormed variables that could have affected their results. They had all hypothesized that there would be more birds at Theodore Wirth; however, the data showed that while many more species were at Theodore Wirth, they found a lot of geese at Sumner Field, which caused that total to be higher. They discussed theories of why there might have been more geese at Sumner Field (one youth suggests because different species live in different habitats). They make a list on the white board of variables that could have affected their results (weather, time of day/year, water source, food source, trees).

The boys noted to each other that in the first pond only leeches and nematodes were observed, whereas the second pond had a much greater variety of organisms. They then pointed out that nematodes and leeches are generally only found in poor water quality. "I think the water is better, I think it is between a 3 and a 4." Therefore they concluded that the first pond must be more polluted than the second pond.

The adult leader facilitated a discussion of whether or not to include one of the data points (a caterpillar with unusual behavior). The youth made a decision on how to include this point.

Concluding & Reporting Phase

All three groups were quite attached to their research topic and were keen to present their findings and then come up with ideas as to how they could improve their studies if they were to do them again.

In the last ten minutes of the meeting, the group analyzed and interpreted the data as well as concluding and reporting the data. This part was heavily adult-led. The adult leader drew the graph and one youth entered the data as others read how many plants they found with each organism. They concluded that aphids and ants were not always found together, but [had] no further discussion.

Reflecting & Rethinking Phase

One youth looked at a picture of a caterpillar and mentioned that the caterpillar they had taken home the past week looked like that (i.e., was at that stage) for a long time. Another youth agreed and said that it looked like that for two days.

The adult leader asked youth to look over their data to see if they could find any patterns, and as a large group they discussed their findings (which did not have much consistency). This led the leader to remind the youth of the importance of collecting many samples in order to have valid data.

Youth Outcome 4, cont'd.

While we focused heavily on attendance and engagement *during* sessions, we also identified an additional factor that extended beyond the sessions themselves. During focus groups, adult leaders talked about youth continuing to enjoy the activities they pursued in *Driven to Discover* despite no longer attending the program. For example, one leader, who was also a teacher, said she could see the effect that the *Driven to Discover* summer programs had on one of her current student's scientific understanding. Others mentioned youth who continued to observe monarchs and birds in their free time at home (and even involving their parents in the activity) after having attended *Driven to Discover*.

I feel like I have gained some confidence in guiding kids to inquiry through the leader training, but I really feel like the students have come a very long way in their level of confidence, and their enjoyment of being outdoors and watching birds, and identifying birds, and feeling like they could really contribute to science studies, and they really feel good about that. As I was saying, this one young lady that did the summer program for three summers, and is now in my regular seventh grade class, fondly refers to herself as a bird nerd, and just her scientific level of thinking and processing, compared to her classmates, is just head and shoulders above the other students….she really understands how to think about experiments and the idea of variables and controls and all that makes a lot of sense to her.

And I know the parents, they make the comments that now, the girls that have in the previous years monitored with me and stuff, they do it on their own at home, even though they're not interested in coming weekly with me and everything, they'll go out and look for eggs and caterpillars and raise them and hatch them out, the chrysalis, and I get a call, "My chrysalis just hatched, and I've got to go let it out!"

I had several [youth in eighth grade] that were interested, and a couple who were participating in bird counts…participation and interest just continued to increase to the point where all who had started there were confident scientific presenters for answering their questions, and that was an amazing speech to scientific literacy and confidence, and several of them have said, "I'm going into science." That was not necessarily on their radar before.

And when I look at the very youngest, they thought birds were cool, [but] had never really noticed [them], and so to watch kids that hadn't been aware of their surroundings all of a sudden be aware, be engaged, and then be contagious to their family, as you say. Now the parents are looking and driving them places and saying, "Yeah, let's get a bird book. Let's buy binoculars."— that's a big investment, so that's powerful.

Youth Outcome 5: Develop Scientific Inquiry Skills

Overall, this outcome was met. Pre/post self-ratings indicated statistically significant gains in youth field and inquiry skill levels. Independent assessments of youth project posters indicated that despite some variation in the extent to which youth addressed different components of the inquiry cycle, they overall successfully applied science inquiry skills.

Outcome 5: Youth will develop scientific inquiry skills.

Youth participants needed to not only understand how to think about formulating science questions and designing their inquiry, but also how to collect data or information to help answer their question. Teams had the opportunity to build their observation and data collection skills by participating in citizen science projects where they could apply both their field skills and their inquiry skills to answer their own questions about nature.

Self-Rated Inquiry Skill Level

We asked youth to rate their own field and inquiry skills at the end of the program including a current (post-program) rating and a pre-program rating. This method allowed us to assess whether the youth found that they increased their skills as a result of participating in the program. We used a 4 point scale, with 1 representing "not very skilled at all" and 4 "very skilled." Results show that as a group, youth rated themselves as "a little skilled" prior to participating in *Driven to Discover* and "moderately skilled" at the end of their program with both field skill or data collection skills and inquiry skills. (See Table 10.) All positive shifts were statistically significant.

Table 10. Pre-/Post- Program Youth Self-Rated Skill Levels (pre n = 99; post n = 99)

	Topic	Pre-program mean (Std. Dev.)	Post-program mean (Std. Dev.)	Wilcoxon signed rank p-value
Field Skills	Finding birds or butterflies, pond organisms and/or their habitats	2.62 (.77)	3.51 (.60)	<0.001
	Identifying birds or butterfly larvae (eggs) or pond organisms	2.39 (.87)	3.44 (.68)	<0.001
	Using binoculars, microscope, or magnifying lens to watch nature	2.82 (1.03)	3.47 (.70)	<0.001
	Using a field guide to identify things in nature	2.71 (1.00)	3.41 (.77)	<0.001
	Filling out data sheets	2.50 (1.02)	3.37 (.79)	<0.001
Inquiry Skills	Asking a question that can be answered by collecting data	2.52 (.83)	3.37 (.71)	<0.001
	Developing testable hypotheses	2.56 (.90)	3.44 (.75)	<0.001
	Designing a scientific procedure to answer a question	2.42 (1.00)	3.20 (.83)	<0.001
	Creating graphs that help me and others understand my data	2.56 (.95)	3.42 (.79)	<0.001
	Creating a display to communicate my data and observations	2.56 (.94)	3.23 (.75)	<0.001
	Analyzing the results of a scientific investigation	2.38 (.96)	3.29 (.67)	<0.001
	Using the results of my investigation to answer the question that I asked	2.63 (.97)	3.44 (.77)	<0.001

Youth Outcome 5, cont'd.

Project Poster Assessments
We asked scientists to provide feedback on the youths' projects to triangulate the development of youth participants' scientific inquiry skills. In this way, the study obtained scientists' perspectives on how youth could apply their skills to answer science questions. The scientists were part of the audience for youth poster presentations and asked follow-up questions about the projects. Based on the presentations and responses to questions, scientists rated four aspects of the project on a three-point scale (where 1 was "not fulfilled," 2 was "partially fulfilled," and 3 was "fully fulfilled"). The four aspects rated were: 1) the degree that the topic was addressed; 2) how the methods were fulfilled; 3) how the results were fulfilled; and 4) how the discussion areas were fulfilled.

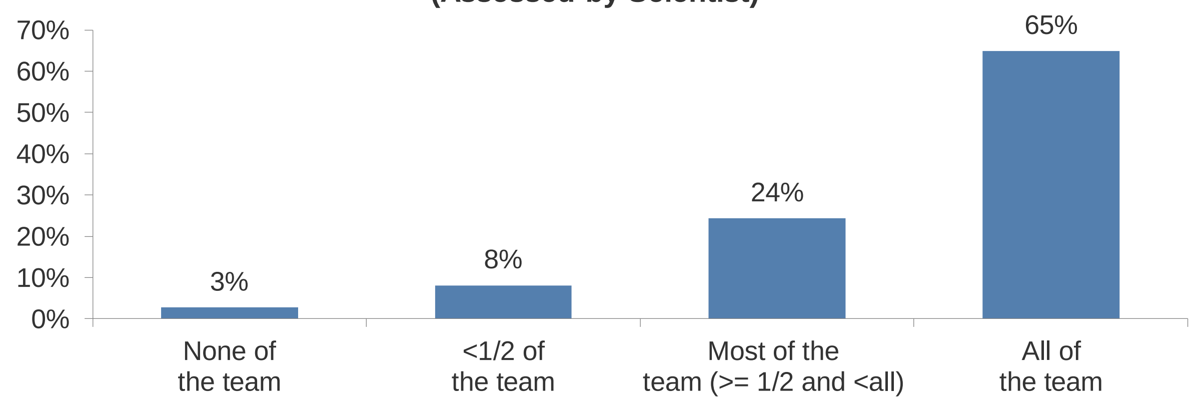
In nearly two thirds (64%) of project teams, youth participants could answer all the scientists' questions about their projects. Only four teams had less than half of their youth able to answer the scientists' questions (see Figure 14).

Topics Ratings
The majority of the posters fully addressed the topics of the study. The scientists scored three components—whether the question was thoughtful, the background information relevant, and the hypotheses appropriate. Around three-fourths of the projects rated a 3 regarding a thoughtful question (74%) and appropriate hypotheses (79%). Only half (50%) of the projects rated a 3 for relevant background information, however. Very small proportions of projects failed to fulfill each of the components. Some 5% rated a "1" for questions, 13% for background information, and 8% for the hypotheses. (See Table 11.)

Methods Rating
The lowest scored of the four youth project areas by the scientists was the methods section. About a half (53%) of the projects' methods rated as fully relevant to the question and a little more than that (61%) of the descriptions of the methods rated as "clear." Some two-thirds of the projects were rated as repeatable given the information provided. Again, fewer than ten percent (8%) of the projects rated a "1" (e.g., failed to fulfill each of the methods areas) (see Table 12).

Results Ratings
Some project teams struggled with the appropriateness of their graphs or tables, only slightly more than half (55%) of the presentations rating a "3" in this area; 11% did not meet this requirement at all. Some other results component percentages that rated a "1" were lower—5% for results that addressed the original question and 8% for results that were justified by the data (see Table 13).

Figure 14. Proportion of Team Able to Answer Questions About Their Project (Assessed by Scientist)



N = 37

Youth Outcome 5, cont'd.

The other two results areas scored much higher. Nearly three-fourths (74%) of the projects had results that fully addressed the original question and summaries and results that addressed—and were justified by—the data. Again, very small proportions of the projects rated a "1" with regards to results that addressed the original question (5%) or summaries and results that addressed and were justified by the data (8%).

Discussion Ratings
The discussion section was a strength of many of the projects. 70% of the projects were awarded a "3" for a clear and organized discussion that related well to the hypotheses. Even more projects (78%) had summaries and results that were justified by the data. Despite the success of the majority of the projects, 11% did lack a clear and organized discussion that related well to the hypothesis. Only 5% failed to have summaries and results that addressed and were justified by the data (see Table 14).

Given the scientists' feedback, we see that the overall strengths of the youth and their projects were in having thoughtful questions and hypotheses; results that fully addressed the original question; summaries and results that addressed and were justified by the data; clear and organized discussions that related well to the hypotheses; and summaries and results that were justified by the data.

Table 11. Scientist Rating of the Extent to Which Topic was Addressed (N = 38)

	1. Not fulfilled	2. Partially-fulfilled	3. Fully-fulfilled
Question is thoughtful.	5%	21%	**74%**
Background information is relevant.	13%	37%	**50%**
Hypotheses are appropriate.	8%	13%	**79%**

Table 12. Scientist Rating of the Extent to Which Methods were Fulfilled (N = 38)

	1. Not fulfilled	2. Partially-fulfilled	3. Fully-fulfilled
Methods are relevant to the question.	5%	42%	**53%**
Description of methods is clear.	5%	34%	**61%**
Study is repeatable, given the information provided.	8%	26%	**66%**

Table 13. Scientist Rating of the Extent to Which Results were Fulfilled (N = 38)

	1. Not fulfilled	2. Partially-fulfilled	3. Fully-fulfilled	Not Applicable
Level of appropriateness of the graphs/tables.	11%	24%	**55%**	11%
Results address the original question.	5%	16%	**74%**	5%
Summaries and results address and are justified by the data.	8%	16%	**74%**	3%

Table 14. Scientist Rating of the Extent to Which the Discussion was Fulfilled (N = 37)

	1. Not fulfilled	2. Partially-fulfilled	3. Fully-fulfilled
Discussion is clear and organized.	11%	18%	**68%**
Discussion relates to the hypotheses.	11%	18%	**68%**
Summaries and results address and are justified by the data.	5%	16%	**76%**

Youth Outcome 5, cont'd.

A fair proportion of the projects were challenged to provide relevant background information; use methods that were fully relevant to the question; and create appropriate graphs or tables to present their data.

Overall Comments

When asked to make overall comments about the poster presentations, 27 out of 39 (69%) scientists provided a response. Of those 27, 15 (56%) provided very positive comments, while 8 (30%) were positive but identified some aspects of the study or presentation that could be improved. Only 4 (15%) provided comments suggesting that the project did not meet the mark.

The girls led their own inquiry project, which was impressive, after observing bees at hummingbird feeders. They followed a line of questions and inquiry until they came up with a research question. It was evident that they thought through their experiment and even developed follow-up questions.

This project really used eBird well. They had stored multiple years of data and analyzed it for their school site. I was impressed.

Project is reasonable and sensible. With more replication, it could have become outstanding.

Sophisticated comprehension of conservation biology issues. Obvious passion and interest (multi-year study).

With more time, they might have been able to be more pointed with the question. They also might have done a little more research about why their results were as they were. Overall, the questions and methods were logical, but could be improved. Their strength was doing well with creating the hypothesis and understanding how to accept or reject a hypothesis.

Could use more thought in experimental design. Needed a control and a way to measure response of the plant to damage.

Execution of this project and replication are very strong. They should be led to some simple statistics—a t-test could be justified. Outstanding project.

Basic philosophical confusion about difference between acceptance of a hypothesis versus failure to falsify a null.

Results: Adult Leader Training

Adult Leader Training

Evaluation results showed that the *Driven to Discover* adult leader training was effective. There were statistically significant shifts in adult leaders' knowledge of science content and citizen science, performing science inquiry, facilitating science inquiry, and working with youth. We also saw shifts in self-reported confidence levels in all four of these areas.

Adult leader training was evaluated on-site immediately after the training session to assess the initial learning (and usefulness) of the training to prepare adult leaders to facilitate youth citizen science and authentic science inquiry. The overall evaluation results show moderate to strong evidence that the training offered appropriate content, approaches, and support so the adult leaders felt prepared and motivated to lead a *Driven to Discover* youth team.

One indicator of the training's success was that all 13 participants "strongly agreed" that they would recommend the program to others (see Table 15). Likewise, nearly all participants "strongly agreed" that the training deepened their understanding of the overall subject matter for the *Driven to Discover* program; they would use what they learned from the training session; they were enthusiastic to use what they learned at the training; and they were, overall, satisfied with the training.

Table 15. Adult Leaders' Agreement Ratings with Training Statements (N = 13)

Statement	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I have a deeper understanding of the overall subject matter for the *Driven to Discover* program as a result of this training.	0	0	1	1	**11**
I will use what I learned from this session.	0	0	0	1	**12**
Overall, I am satisfied with the training.	0	0	0	3	**10**
I am enthusiastic to use what I learned at this workshop.	0	0	0	1	**12**
I would recommend the program to others.	0	0	0	0	**13**

Adult Leader Training, cont'd.

Science Content and Citizen Science
The training evaluation used retrospective questioning to assess adult leaders' increased knowledge and skill levels in science content and citizen science topics; these are necessary skills to effectively mentor their teams. A five-point scale was used ranging from "very little" = 1 to "very much" = 5. Most adult leaders came into the training with "some" knowledge about identifying organisms, the behavior of organisms, and the features of the habitats used by organisms for their citizen science project. The majority of leaders moved up the scale to knowing either "much" or "very much" about the identification, behavior, and habitats of their organisms by the end of the training. These shifts were all statistically significant.

Leaders rated themselves moderately high in knowing about the lifecycle of their organism before the training; we saw no statistically significant change of the training affecting this area of knowledge (see Table 16).

Leaders rated their knowledge of what is involved in citizen science, the purpose of citizen science, how the data collected for

Related Samples Wilcoxon Signed-Rank tests p-values:
1. Pre-training to post-program = 0.004
2. Pre-training to post-program = 0.008
3. Pre-training to post-program = 0.005
4. Pre-training to post-program = 0.058
5. Pre-training to post-program = 0.020
6. Pre-training to post-program = 0.010
7. Pre-training to post-program = 0.026
8. Pre-training to post-program = 0.015

Table 16. Adult Leaders' Ratings of Their Knowledge of Science Content and Citizen Science

Topic			Very Little	A little	Some	Much	Very Much
Science Content (N = 12)	Identification of the organism(s).[1]	*Before this training I knew…*	0	2	**6**	3	1
		Now I know…	0	0	3	**5**	4
	Behavior of the organism(s).[2]	*Before this training I knew…*	1	1	**7**	3	0
		Now I know…	0	0	3	**7**	2
	Features of habitats used by the organism(s).[3]	*Before this training I knew…*	0	2	**7**	2	1
		Now I know…	0	0	3	4	**5**
	Life cycle of the organism.[4]	*Before this training I knew…*	0	2	3	3	**4**
		Now I know…	0	0	3	3	**6**
Citizen Science (N = 13)	What is involved in citizen science in general.[5]	*Before this training I knew…*	1	1	1	**7**	3
		Now I know…	0	0	1	5	**7**
	The purpose of the citizen science program to which I will contribute.[6]	*Before this training I knew…*	2	1	2	**6**	2
		Now I know…	0	0	3	1	**9**
	How the data we collect as a club will be used in the citizen science program.[7]	*Before this training I knew…*	2	1	2	**6**	2
		Now I know…	0	0	2	5	**6**
	The potential for citizens to contribute to the knowledge base of natural science.[8]	*Before this training I knew…*	1	0	**4**	**4**	**4**
		Now I know…	0	0	1	4	**8**

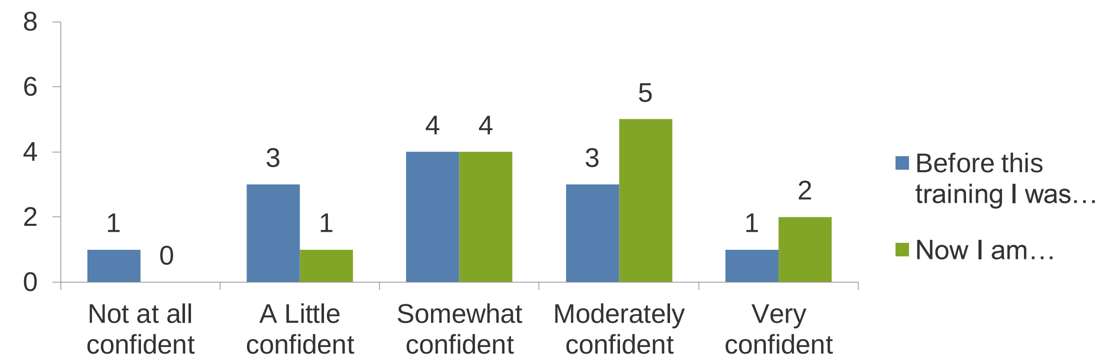
Adult Leader Training, cont'd.

the programs will be used and the potential for citizens to contribute to the knowledge base of natural science a bit higher than for the other training areas. Still, they showed improved (and statistically significant) understanding in all of these areas (see Table 16).

Confidence in Knowledge and Science Research

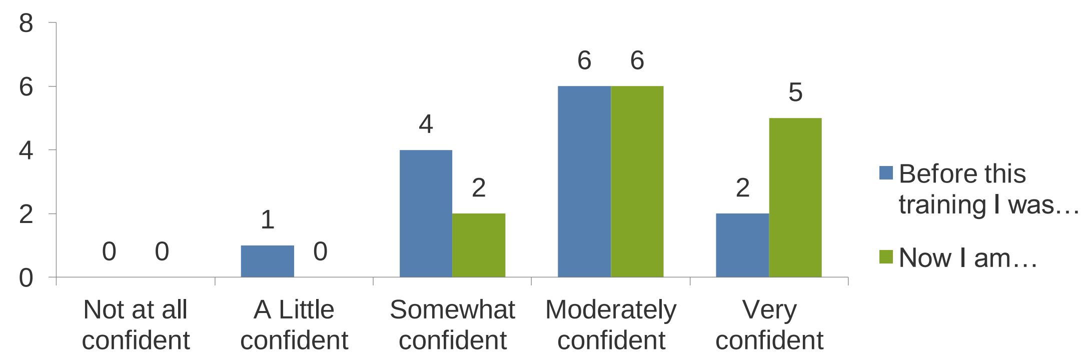
Before leading youth in learning about the organisms they would study in their citizen science and science inquiry activities, adult leaders needed to feel confident in their knowledge about the science content and processes. Leaders came into the training with senses of confidence ranging from "not confident at all" to "very confident" about their knowledge of either birds or monarchs. After the training, the majority of the adult leaders rated their confidence more centrally in the "somewhat confident" to "moderately confident" ranges. These changes were statistically significant (see Figure 15). Most adult leaders reported coming into the training "somewhat" to "moderately" confident about conducting scientific research. After the training, most of them reported being "moderately" to "very" confident, a statistically significant shift towards higher confidence (see Figure 16).

Figure 15. Adult Leaders' Rating of Their Confidence in Their Knowledge of Birds or Monarchs



N = 12
Related Samples Wilcoxon signed-rank p-value: Pre-training to post-program = 0.008

Figure 16. Adult Leaders' Rating of Their Confidence in Conducting Scientific Research



N = 13
Related Samples Wilcoxon signed-rank p-value: Pre-training to post-program = 0.020

Adult Leader Training, cont'd.

Confidence in Doing Science Inquiry
In most cases, adult leaders increased their confidence about leading the science inquiry process. Using a 5-point scale to rate their confidence (1 being "not at all confident" and 5 being "very confident"), leaders rated themselves as "somewhat confident" about leading most processes including the overall process of inquiry, how observations lead to inquiry investigations, developing testable questions, and composing hypothesis. Several rated themselves one point higher at "moderately confident" in how to analyze and report data prior to the training. Overall, the leaders moved themselves up one point on the scale of confidence in all areas after the training. These shifts were all statistically significant (see Table 17).

Table 17. Adult Leaders' Ratings of Their Confidence in Doing Science Inquiry Processes (N = 12)

Process		Not at all confident	A little confident	Somewhat confident	Moderately confident	Very confident
The overall process of inquiry.[1]	*Before this training I was…*	0	0	**6**	3	3
	Now I am…	0	0	0	**7**	5
How observations can lead to inquiry investigations.[2]	*Before this training I was…*	0	0	**5**	4	3
	Now I am…	0	0	0	**6**	**6**
How to develop a testable question.[3]	*Before this training I was…*	0	1	**4**	**4**	3
	Now I am…	0	0	0	**6**	**6**
How to compose hypotheses.[4]	*Before this training I was…*	0	0	**5**	4	3
	Now I am…	0	0	1	5	**6**
How to plan for data collection to answer a question.[5]	*Before this training I was…*	0	0	**4**	**4**	**4**
	Now I am…	0	0	0	5	**7**
How to analyze data.[6]	*Before this training I was…*	0	2	3	**4**	3
	Now I am…	0	0	2	4	**6**
Ways to report analysis results.[7]	*Before this training I was…*	0	0	4	**5**	3
	Now I am…	0	0	0	**6**	**6**

Related Samples Wilcoxon signed-rank tests p-values:
1. Pre-training to post-program = 0.005
2. Pre-training to post-program = 0.005
3. Pre-training to post-program = 0.007
4. Pre-training to post-program = 0.008
5. Pre-training to post-program = 0.008
6. Pre-training to post-program = 0.005
7. Pre-training to post-program = 0.008

Adult Leader Training, cont'd.

Knowledge of Facilitating Youth Science Inquiry
The *Driven to Discover* training also aimed to increase adult leaders' understanding of how to facilitate science inquiry in youth, noting approaches to effectively engage youth in each step of the inquiry process. Adult leaders rated themselves as having "some" knowledge about the overall processes of how to facilitate inquiry in youth, prompt youth to reflect and rethink, and facilitate youth in planning an inquiry investigation, as well as how to help youth analyze data and report their findings. They rated their knowledge coming in about 1 point higher at "much" knowledge for facilitating youth learning in informal settings and in quality data collection. Statistically significant shifts up about 1 point on the scale were seen in all areas except in how to facilitate youth learning in informal settings and in ways to help youth report their data, where results remained relatively unchanged (see Table 18).

Table 18. Adult Leaders' Ratings of Their Knowledge Facilitating Youth Science Inquiry (N = 13 unless otherwise indicated)

Topic		Very Little	A little	Some	Much	Very Much
The overall process of how to facilitate inquiry in youth.[1]	*Before this training I was…*	0	1	**8**	3	1
	Now I am…	0	0	2	**9**	2
How to prompt youth to reflect and rethink.[2]	*Before this training I was…*	0	2	**7**	3	1
	Now I am…	0	0	4	**5**	4
How to facilitate youth in planning an inquiry investigation.[3]	*Before this training I was…*	0	2	**6**	4	1
	Now I am…	0	0	2	**6**	5
How to facilitate youth learning in non-formal settings.[4] (N = 12)	*Before this training I was…*	0	0	4	**5**	3
	Now I am…	0	0	2	**5**	**5**
How to facilitate youth in quality data collection.[5]	*Before this training I was…*	1	2	3	**6**	1
	Now I am…	0	0	3	**5**	**5**
How to help youth analyze their data.[6]	*Before this training I was…*	1	2	**5**	4	1
	Now I am…	0	0	4	**7**	2
Ways to help youth report their findings.[7]	*Before this training I was…*	0	2	**5**	**5**	1
	Now I am…	0	0	4	**7**	2

Related Samples Wilcoxon signed-rank tests p-values:
1. Pre-training to post-program = 0.014
2. Pre-training to post-program = 0.004
3. Pre-training to post-program = 0.003
4. Pre-training to post-program = 0.102
5. Pre-training to post-program = 0.004
6. Pre-training to post-program = 0.024
7. Pre-training to post-program = 0.063

Adult Leader Training, cont'd.

Confidence in Facilitating Youth Science Inquiry
Adult leaders increased their confidence about leading most areas of the inquiry process. Using a 5 point scale to rate their confidence (1 is "not confident at all" and 5 is "very confident"), adult leaders rated Themselves "moderately confident" in leading most inquiry processes, including the overall process of inquiry, how observations lead to inquiry investigations, developing testable questions, and composing hypothesis. Several rated themselves one point higher at "moderately confident" in analyzing and reporting data. In all, the leaders moved up one point on the scale of confidence in all areas following the training. All these shifts were statistically significant (see Table 19).

Table 19. Adult Leaders' Ratings of Their Confidence in Facilitating Youth Science Inquiry? (N = 13)

Topic		Not at all confident	A little confident	Somewhat confident	Moderately confident	Very confident
The process of facilitating non-formal science inquiry with youth.[1]	*Before this training I was…*	0	2	2	**7**	2
	Now I am…	0	0	3	4	**6**
Prompting youth to reflect and rethink.[2]	*Before this training I was…*	0	3	3	**5**	2
	Now I am…	0	0	2	**7**	4
Facilitating youth in planning an inquiry investigation.[3]	*Before this training I was…*	0	4	2	**5**	2
	Now I am…	0	0	4	**6**	3
Facilitating youth in quality data collection.[4]	*Before this training I was…*	0	3	3	**5**	2
	Now I am…	0	0	2	**7**	4
Helping youth analyze their data.[5]	*Before this training I was…*	0	2	**5**	4	2
	Now I am…	0	0	2	**8**	3
Helping youth report their findings.[6]	*Before this training I was…*	0	3	2	**7**	1
	Now I am…	0	0	3	**7**	3

Related Samples Wilcoxon signed-rank tests p-values:
1. Pre-training to post-program = 0.008
2. Pre-training to post-program = 0.014
3. Pre-training to post-program = 0.020
4. Pre-training to post-program = 0.024
5. Pre-training to post-program = 0.023
6. Pre-training to post-program = 0.020

Adult Leader Training, cont'd.

Preparation to Work with Youth
Despite coming in with moderately high experience working with youth, leaders still increased their level of preparedness to work with youth by attending the training. It is most notable that leaders who rated themselves only "a little" prepared before the training shifted to either "somewhat" or "moderately" prepared after the training. Changes were statistically significant across all but one area. Leaders increased their preparedness to recognize areas that affect quality in youth learning; to make changes to improve the quality in their youth programs; to adjust their responses to reframe conflict situations with and between youth; and to anticipate the need of the group/individuals for a positive learning environment. We saw a nearly significant change with one leader reporting a greater ability to proactively assess potential conflict situations (see Table 20).

Table 20. Adult Leaders' Ratings of Their Preparedness to Work with Youth (N = 13 unless otherwise indicated)

Topic		Not at all prepared	A little prepared	Somewhat prepared	Moderately prepared	Very prepared
To recognize the areas that affect quality in youth learning.[1]	*Before this training I was…*	0	1	3	**6**	3
	Now I am… (N = 12)	0	0	0	**7**	5
To make changes to improve the quality in my youth program.[2]	*Before this training I was…*	0	1	2	**7**	3
	Now I am… (N = 12)	0	0	0	5	**7**
To proactively assess potential conflict situations.[3]	*Before this training I was…*	0	2	1	**7**	3
	Now I am… (N = 12)	0	0	1	**7**	4
To adjust my response to reframe conflict situations with and between youth.[4]	*Before this training I was…*	0	2	1	**7**	3
	Now I am… (N = 12)	0	0	1	5	**6**
To anticipate the need of the group/individuals for a positive learning environment.[5]	*Before this training I was…*	0	1	2	**6**	4
	Now I am… (N = 12)	0	0	0	**6**	**6**

Related Samples Wilcoxon signed-rank tests p-values:
1. Pre-training to post-program = 0.020
2. Pre-training to post-program = 0.011
3. Pre-training to post-program = 0.059
4. Pre-training to post-program = 0.020
5. Pre-training to post-program = 0.034

Results: Adult Leader Outcomes

Adult Leader Outcome 1: Increase Knowledge of Inquiry

Post-program survey data indicated that this outcome was met. Leaders reported that their knowledge and science content and inquiry increased through their involvement in *Driven to Discover*. These changes were statistically significant.

Outcome 1: Adult leaders who participated in the project (training and citizen science research clubs) will increase their knowledge about science inquiry.

This outcome examines adult leaders' increased knowledge of science inquiry. The nature of science inquiry is composed of three areas: 1) Scientific content (i.e., facts and principles; 2) Science skills (e.g., observing, questioning); 3) Knowledge of the process of science inquiry.

Science Content

Leaders reported an increase in knowledge around science content in their last post-program survey (2013 or 2014, depending on their last year as an adult leader). Leaders rated their level of knowledge for the type of organism that they worked with (e.g. monarchs, birds, or water), the behavior of their organism(s), features of habitats used by the organism(s), and the life cycle of the organism(s) prior to and at the end of their *Driven to Discover* project. The rating was on a 5-point scale where 1 equaled "very little knowledge" and 5 equaled "very much knowledge." Results showed statistically significant increases in adult leader knowledge across all science content areas. In addition, the mean of all the adult leaders' ratings increased from "some knowledge" to "much knowledge." Likewise, those who came in with "very little knowledge" also moved up the scale by the end of the program (see Table 21).

Table 21. Adult Leader End of Program Self-Rated Science Content Knowledge Shifts (N = 20)

Topic	Pre-program mean (Std. Dev.)	Pre-program min/max	Post-program mean (Std. Dev.)	Post-program min/ max	Wilcoxon signed-rank p-value
Identification of the organisms(s)	3.40 (1.10)	1 / 5	4.42 (.81)	3 / 5	0.001
Behavior of the organisms(s)	3.30 (1.17)	1 / 5	4.00 (.79)	2 / 5	0.001
Features of habitats used by the organism(s)	3.55 (1.05)	2 / 5	4.20 (.77)	3 / 5	0.001
Life cycle of the organism(s)	3.45 (1.14)	1 / 5	4.00 (.86)	2 / 5	0.007

In an open-ended survey question, adult leaders shared what they learned about their subject matter while working with their youth teams. Eight adult leaders reported learning about birds, including increased knowledge about how to identify birds, bird behavior, and bird populations. Some leaders reported more specific details, such as how their projects have helped them learn about the bird populations of their local park or how to keep bees from the hummingbird feeder. One adult leader increased birding skills by learning to identify birds by sound and learning the purposes of bird songs and calls.

Three leaders reported learning more about monarch butterflies, including understanding the monarch life cycles and the impact of the environment on their population. Some of them increased their ability to identify specific instar developmental stages of the monarch larvae, and one noticed how the drought negatively affected the monarch population. Another leader learned not only about monarchs, but also about other insect species such as the cecropia (silk moth).

Adult Leader Outcome 1, cont'd.

Scientific Inquiry
Adult leaders reported increased knowledge about science inquiry and processes at levels similar to those of the survey on learning science content. Statistical analysis showed that leaders' increases from mean levels of "some knowledge" (3 on a 1–5 scale) to mean levels of "much knowledge" (4 on a 1–5 scale) across all topics were statistically significant (see Table 22). Significantly, no leaders reported having "very little knowledge" in the science inquiry process overall or within any specific phases by the end of the program. Only one leader reported knowledge levels in the "a little" range at the end of the program (in the areas of "how to plan for data collection to answer a question" and "how to report analysis results"). This particular individual learned about the program too late to schedule team meetings in time to experience the entire inquiry process and, as a result, did not do the latter phases of science inquiry.

I learned a lot from the training, from leading D2D, from bird identification books and audio, and from the kids themselves!

The weekly observation walks gave me insight into bird behavior, especially since we had access to different habitats on the property.

I have learned probably as much as the youth if not more—feel like this has been a real eye opener to me about monarchs. Until joining D2D, I never thought about how the monarch migrates, nor the life cycle of it. Guess with this experience, I have shared lots with all my family, friends, and any youth that I come into contact with. So am spreading a wealth of information that I never learned as a child.

Table 22. Adult Leader End of Program Self-Rated Science Inquiry and Process Knowledge Shifts (N = 20)

Topic	Pre-program mean (Std. Dev.)	Pre-program min/max	Post-program mean (Std. Dev.)	Post-program min/max	Wilcoxon signed-rank p-value
The overall process of scientific inquiry	3.48 (1.17)	1 / 5	4.33 (.66)	3 / 5	<0.001
How observations can lead to inquiry investigations	3.52 (1.17)	1 / 5	4.38 (.67)	3 / 5	<0.001
How to develop a testable question	3.29 (1.31)	1 / 5	4.19 (.75)	3 / 5	0.001
How to compose hypotheses	3.48 (.98)	1 / 5	4.29 (.64)	3 / 5	0.001
How to plan for data collection to answer a question	3.19 (1.25)	1 / 5	4.14 (.79)	2 / 5	0.001
How to analyze data	3.29 (1.10)	1 / 5	4.05 (.74)	3 / 5	0.001
How to report analysis results	3.52 (1.21)	1 / 5	4.14 (.79)	2 / 5	0.003

Adult Leader Outcome 1, cont'd.

When asked about what they learned about the process of science inquiry, most adult leaders shared ways in which they had gained experience and broader perspective in leading youth through science inquiry and experiments. Five adult leaders, however, did share specifics about things they learned about science inquiry itself as a result of participating in *Driven to Discover*. Areas in which they reported increased knowledge included:

- Using wondering to develop good questions to guide research.
- Using multiple hypotheses, as opposed to one, when designing an inquiry project.
- The importance of reflecting and rethinking.
- That not finding what you expect is a result worth noting.
- That finding "nothing" is a valid result.
- That charts are pictures of data.
- That results are literal interpretation of data; conclusions are meaning inferred from data and patterns of data.
- That results can only suggest conclusions, not prove them.
- That sometimes the new questions raised are the most important result of inquiry.

I had a lot of birding knowledge coming into the program, but I found myself really looking at the bird population of our park more critically than I ever had. I learned along with the kids, and they helped me learn.

I have broadened my knowledge of organisms other that monarchs more and more each year. I have also been able to take a long-term look at the changes to my own site and the affects of population decline and drought like never before.

Primarily, D2D provided me a broader perspective on how to approach the scientific process and a great deal of practice in applying it to unusual—sometimes funny—questions.

I had a lot of personal experience with inquiry as a student. What really compelled me, though, was how advanced of inquiry these students were able to participate in—far, far more advanced that what I had done at their age. And they get it. By this year, I was providing them with minimal guidance and just letting them run with their own knowledge.

Having the benefit of scientists and other adult leaders to provide suggestions has helped me to improve my skills in working with kids. I have especially gained confidence in my ability to help students analyze their data.

I learned how to use wondering to develop good questions to guide research.

I had always thought that inquiry questions were developed so that there would be only two possible hypotheses; now I know that there can be several.

Adult Leader Outcome 2: Increase Knowledge of Inquiry-Based Teaching Methods

This outcome was met. Leaders reported positive shifts in their knowledge of inquiry-based teaching methods. These shifts were statistically significant for all topics.

Outcome 2: Adult leaders who participated in the project (training and citizen science research clubs) will increase their knowledge about inquiry-based teaching methods.

Adult leaders needed to know not only science content and science inquiry processes to lead their team, but also how to facilitate learning about science inquiry with youth or science inquiry-based teaching methods. We used the familiar knowledge scale (1 being "very little" and 5 being "very much") to assess self-reported positive shifts in youth science inquiry teaching method knowledge, as we had in assessing science content and inquiry process knowledge (see Table 23).

Results clearly showed that adult leaders increased their knowledge levels regarding inquiry-based teaching methods. Again, pre- to post-program means increased about one scale point across all the science inquiry phases in which the leaders engaged the youth. All shifts were statistically significant.

It is important, however, to note a wider spread of post-program knowledge scores for facilitating science inquiry with youth than in understanding science content or inquiry alone. The variation is associated with two leaders who failed to finish the inquiry process with their youth due to either lack of time to schedule enough meetings or unexpected staff turnover. Since the scores of all other adult leaders were somewhat higher, we infer that these external factors were the main contributors to these adult leaders failing to have similar learning experiences as their peers.

Table 23. Adult Leader Post-Program Self-Rated Youth Science Inquiry Facilitation Knowledge Shifts (N = 20)

Topic	Pre-program mean (Std. Dev.)	Pre-program min/max	Post-program mean (Std. Dev.)	Post-program min/max	Wilcoxon signed-rank p-value
The overall process of how to engage youth in authentic scientific inquiry	3.24 (1.00)	1 / 5	4.24 (.89)	2 / 5	<0.001
How to prompt youth to reflect and rethink	3.28 (1.01)	1 / 5	4.20 (.87)	2 / 5	<0.001
How to engage youth in planning an inquiry investigation	3.00 (1.14)	1 / 5	4.14 (.91)	2 / 5	<0.001
How to engage youth learning in informal settings	3.57 (1.21)	1 / 5	4.29 (.84)	2 / 5	0.004
How to engage youth in quality data collection	2.86 (1.15)	1 / 4	4.00 (1.05)	2 / 5	<0.001
How to help youth analyze their data	2.62 (1.12)	1 / 4	3.81 (1.03)	2 / 5	0.001
Ways to help youth report their findings	2.90 (1.09)	1 / 5	4.00 (1.14)	1 / 5	0.001

Adult Leader Outcome 2, cont'd.

Adult leaders provided a wide variety of youth science inquiry engagement insights gained from participating in *Driven to Discover*.

Most adult leaders agreed that the mini-inquiry sessions were an effective strategy to immerse youth in science inquiry. Not only were they fun, but they allowed youth to put their learning into practice. Moreover, the mini-inquiry sessions helped adult leaders identify areas in which the youth needed more help. For example, one leader said that she realized her youth participants needed more help understanding variables when they struggled with the mini-inquiries. Leaders also reported using the youth booklets to teach participants to define a hypothesis, to develop a good question, and to put together a poster. One leader specifically said she had the youth complete the booklet and use it as the basis for their project.

Leaders also had insights about science inquiry engagement that related to the necessity of preparation before starting a project. For instance, questioning youth about what they would find in the field before they went out, having youth identify birds at a feeder (where they were easier to see) before trying to identify them out in the field, and ensuring that the leaders were trained to use any equipment.

Many leaders' insights related to empowering the youth participants learning science Inquiry: setting expectations, allowing youth to follow their own questions, and encouraging them to become experts in a specific area. Adult leaders also mentioned that becoming co-learners with the youth in their teams, particularly when exploring an area that the adult had no expertise in, was especially effective in keeping youth engaged. Some adult leaders said that framing science inquiry as problem-solving challenges kept youth interested and engaged. They said that the sense of overcoming different challenges together was enjoyable for their youth participants.

Moreover, emphasizing the science inquiry process and critical thinking—as opposed to focusing on the outcome—was important to many leaders. For example, one leader described how, as part of the team reflection, she had youth consider if the outcome they found made sense, as opposed to whether the outcome was what they wanted or expected. In addition, leaders found that they had to set high yet realistic expectations for their team based on context. For instance, in some teams, leaders might have to teach more scientific basics if youth entered the program with little (or no) experience. As one leader explained, the goal was not a particular outcome, but rather to encourage youth enthusiasm about science and move them "along the journey of learning."

My biggest take-home message, and the biggest piece of advice I'd give to any adults engaging students in inquiry, is this: don't dumb it down. Set the standard you want them to achieve, role model it yourself, and be pleased with them when they meet and exceed your expectations.

One of the things that I found that was successful was using those booklets…because then you could talk about what is a hypothesis, or how are we going to decide if it's a good or bad question…and then when we got to the actual putting the poster together and figuring all those things out, all of the stuff was right there.

I have learned that the best experiences are the impromptu ones that are generated by youth. Engagement is higher when the youth choose to be involved in the program.

Being a co-learner with the youth is part of the engagement process.

I think to be the adult leader, you have to have a certain level of confidence in what you're doing. You have to have enough confidence that you can say I don't know, and it's okay—or, let's look it up. And we do a lot of that.

Authentic question development is achievable even with young youth.

Have youth specialize in a particular organism and become an expert in it.

It is important that the youth choose what they believe is important.

When youth are interested in something it is easy for them to proceed to get their outcomes.

Get into the process, not just the end product.

Adult Leader Outcome 2, cont'd.

These insights show that many of the leaders experienced why—and how—youth engagement practices play out in facilitating youth science inquiry. Their experiences and insights indicate that they succeeded in applying some of these practices during their meetings.

I incorporate the same concept of research in any inquiry on one day a week, too, so then there's like another aspect where they're noticing all the same pieces, but it's not the exact same, so they're getting more familiar with, like, consistency and, this is how you do research…you always have to have these variables, and take these notes, and so…trying to make it more of a consistent thing, especially because some kids can't do the program [every meeting].

One of the hardest things is to also let them [youth] do something that I know will fail, because that's something that I learned from last year's project…it was a great question, they did everything, but it wasn't really like what would be a published research project, because there's major flaws in everything…letting them learn from that, instead of saying that "No, that's not going to work. Let's do a different thing." It's like, "Let us figure out why that won't work, and how we can change it?"

[I would say,] "What do you think?" before we ever went out there. "What do you think we're going to find tonight? Do you think there's monarchs out there? Do you think there's aphids out there? Are there any spiders on those milkweeds? Have the milkweeds grown, or are they dying?"

Adult Leader Outcome 3: Increase Awareness of Citizen Science

Outcome 3: Adult leaders who participated in the project (training and citizen science research clubs) will increase their awareness of citizen science and its potential to contribute to the body of scientific knowledge.

This outcome was generally met. We saw statistically significant increases in adult leaders' self-rated understanding of citizen science across five measures. Understanding of their individual citizen science program was strong except for one area—knowing something about the scientific outcomes of their project.

Understanding of Citizen Science

Citizen science was used as a way to engage youth in the initial phases of science inquiry (observation, questioning, and data collection). Engaging youth in citizen science processes helped them learn about the organisms they observed and provided a conduit for questioning what they saw. They also learned how to collect data within a structured format and were part of a larger science project, allowing them greater potential to form a science identity. As a result, it was important for the adult leaders to understand their citizen science project so that they could pass their understanding on to their youth team members.

We asked the adult leaders to rate their knowledge of five citizen science topics both before and at the end of the program.

Leaders reported gaining knowledge across all citizen science topics, including what is involved in citizen science, the purpose of their citizen science program, how their citizen science data would be used, and the potential for citizens to contribute to the knowledge base of natural science (see Table 24). The positive shifts of about a point (on 1–5 scale) in mean scores for each of these areas was statistically significant. Similarly to other knowledge areas, adult leaders came into the program with an average of "some" (about a 3 on the scale) citizen science knowledge in each area and finished the program with "much" (about a 4).

Table 24. Adult Leader Post-Program Self-Rated Citizen Science Knowledge Shifts (N = 20)

Topic	Pre-program mean (Std. Dev.)	Pre-program min/max	Post-program mean (Std. Dev.)	Post-program min/max	Wilcoxon signed-rank p-value
What is involved in citizen science in general	3.48 (1.47)	1 / 5	4.29 (.90)	2 / 5	0.004
The purpose of the citizen science program to which I contributed	3.20 (1.44)	1 / 5	4.20 (.78)	2 / 5	0.001
How the data we collect as a club will be used in the citizen science program	3.19 (1.47)	1 / 5	4.29 (.84)	2 / 5	0.002
The potential for citizens to contribute to the knowledge base of natural science	3.48 (1.40)	1 / 5	4.48 (.68)	3 / 5	0.002

Adult Leader Outcome 3, cont'd.

Understanding of Their Program
To assess adult leaders' understanding of the citizen science program to which they contributed, we asked them to describe the program's purpose. We found that all leaders had a good understanding of their programs, and could describe a variety of attributes of citizen science. When their responses were coded, the most popular attribute they described (11 citations) involved monitoring an organism or an element (e.g., water) (see Table 25). Two other common descriptions (9 citations each) noted that citizen science projects contributed to a centralized database, with data that could be used by anyone to answer questions.

A few leaders also explained that scientists use the database to answer scientific questions, and a couple mentioned that it could help increase our understanding of an organism. Single mentions of other areas included how the database could be used as a resource for managing natural habitats, how participation in citizen science could create a sense of global citizenry, and how citizen science could engage youth in science activities to empower them in their journey to adulthood.

When we asked adult leaders about the various components of participation in citizen science projects, their understanding in all but one area was strong. All adult leaders agreed that they understood how to collect data for the project. Only one leader disagreed that they understood the reasoning behind data collection. (This leader was shadowing another leader who left the program unexpectedly.) All except one leader (the same as above) agreed that they understood how citizen science data were used. Several adult leaders did not "agree" that they knew about some of the scientific outcomes of the project (e.g., Monarch Larva Monitoring Project, eBird, or other citizen science project.)

[The purpose of the project is] To learn more about the abundance and distribution of monarch populations in the U.S. and Mexico. To look for population trends over the long-term and questions the reasons for declines or increases in population sizes. The program also can serve as evidence for management practices in making sure the habitat is suitable for the species. There are so many testable questions also surrounding the organism and its interactions with other organisms.

As I understand it, the purpose of eBird is to collect and analyze data from all across North America/the Western Hemisphere about the abundance and distribution of bird species and the number of individuals of a species observed. It is a place for us to record the data we collect as well as a place where we can access data collected by others.

Table 25. Purpose of Citizen Science as Described by Leaders

Purpose	Number of Occurrences
Monitor an organism or element of nature (distribution, population, behavior, breeding, health, or quality (i.e., water))	11
Contribute to a centralized database	9
Compile a database that can be used by anyone to answer questions	9
Compile a database that can be used by scientists to answer questions	3
Increase understanding of an organism	2
Used as a resource for managing natural habitats	1
Create a sense of global citizenry	1
Engage youth in science activities to empower them to continue into adulthood	1

Adult Leader Outcome 3, cont'd.

Insights via Citizen Science
Adult leaders reported gaining insights in five areas by participating in citizen science projects with their teams. Insights included learning about centralized databases; how citizens can contribute to science; pathways to science advocacy through citizen science; science content; and science skills.

Centralized Data
Several leaders said participating in citizen science helped them understand how their data was valuable to a central database. Others learned how their data may be used over time to answer future scientists' questions. One leader was excited to learn that the eBird database had expanded from a national database to a worldwide one. Finally, one leader understood how some types of data collection had a high potential for variation due to subjective interpretation (e.g., the dissolved oxygen test for water).

How Citizens Can Contribute
A few leaders said they learned more about how citizens can contribute to science by participating in the citizen science project. One was happy to hear how their data could influence what is known about monarch behavior.

Advocacy
Three leaders reported ways that their participation in citizen science helped them (or their team) become science advocates or increase local environmental awareness in general. One leader was even inspired to connect her team with the community's water management body.

Science Content
Participating in the citizen science activities helped some leaders increase their awareness, understanding, and knowledge about the organism(s) they observed. One adult leader learned about the negative effects of drought on the butterfly population through observing them and their habitats over more than a year. A leader who participated in eBird learned to examine the birds that were present over time, something she had not paid attention to during her previous birding outings.

Science Skills
Two of the leaders said participating in the project gave them the chance to learn how to use the eBird citizen science database. Another leader said her team's work on the citizen science project in the upcoming year would help improve their observation and birding skills.

I never really thought about the need to record what we were observing to help learn about the total picture of nature. Never really thought about how scientists got their information to figure out concerns about nature and changes.

That today we don't even know how our data will be used tomorrow! A hundred years from now scientists will potentially review our data and make observations we only dream of today.

It led me to volunteer to lead a broader citizen science class at my library. In preparation for that I discovered a surprising number of citizen science sites and volunteer opportunities for our residents.

The population of monarch larva seems to be low throughout the Midwest. The adult butterflies are not arriving in the numbers of the past.

Our park has impressive bird populations, but eBird data was lacking. We're helping to fill a gap.

Adult Leader Outcome 4: Increase Understanding of Mentoring Youth

This outcome was met. Adult leaders reported a range of strategies for engaging youth in citizen science that they learned through implementing the *Driven to Discover* program.

Outcome 4: Adult leaders who participated in the project (training and citizen science research clubs) will increase their understanding of how to mentor youth to carry out citizen science protocols.

Strategies to Motivate Youth

Adult leaders reported a number of strategies that served to motivate youth to participate in citizen science. Simple rewards, such as snacks during a break or at the end of a work session, helped keep youth motivated to complete work sessions. One leader used fun activities, such as a movie the youth could watch on a rainy day, as rewards during the inquiry project, which she said was "more work and starts feeling a little more like school." The opportunity to travel to the annual science fair, a state fair, or a county fair motivated youth; furthermore, attending these fairs allowed them see themselves as part of a larger group of youth interested in and pursuing science inquiry.

Another strategy that motivated youth to engage in citizen science was the opportunity to receive recognition from scientists. When visiting scientists treated the youth seriously, it made a impression on them and motivated them to continue their work. As a result, adult leaders stressed the importance of making access to scientists—no matter if they were professors, graduate students, or other types of professionals—easier for the teams. They also stressed that the scientists need to not only be experts in the topic the youth were studying, but also be skilled at working with young people.

Enabling a sense of independence in youth was another effective strategy for youth engagement. Techniques for enabling a sense of independence included allowing youth interests to guide (and thereby develop a sense of ownership in) the project; allowing youth to "fail" and learn from the failure; giving youth a choice in activity (e.g., "What do you want to do today, a stationary or traveling count? Where do you want to go?"); and allowing youth to collect data on their own by providing them walkie-talkies.

Encouraging a sense of fun and creativity with regards to the project also helped keep youth engaged in citizen science protocols. For example, one leader reported that allowing her team to think about seemingly silly questions such as, "Do birds fart?" let them to start thinking more creatively about their projects.

Last year [the scientist] happened to [stop by] unscheduled…It was fabulous because he could go from group to group [while they were analyzing their data] and ask them questions. And it made what they were doing seem really important to them, and we missed that this year.

I want a scientist to come in and interact with them, being curious about what they're doing and asking questions to help them to dig deeper into what they're doing.

Every year, we had a couple [of scientists visit], and watching the kids either play in the water or ask questions about embryology—these are fifth and sixth graders—clearly they see themselves as on par as having the authority to ask these questions, and that's really neat.

This is a huge critical issue for the whole field of citizen scientist….There's no way that we can send our scientists to talk to all of these people, but we can train grad students that would go out as part of maybe service learning to do that.

We give them walkie-talkies and let them go out on their own…it was…really empowering for them, because they're like "We can go out without [the adult leader] stalking us, keeping an eye on us."…at the same time, it was also, I think like giving them something that they've also only seen us as adults have…they're expensive radios.

Adult Leader Outcome 4, cont'd.

Finally, adult leaders used the flexibility of the program to modify the citizen science project if their team's target organism was not available during data collection. For instance, teams working on the monarch project sometimes looked for other insects when the monarch adults, larva, or eggs could not be found.

Strategies to Accommodate a Range of Ages and Abilities

While the program was designed for 12–14-year-olds, adult leaders found that the age range of the groups often varied widely, with some as young as 5 and as old as 18. While the program was flexible, adult leaders identified a number of specific strategies to use with these diverse ages. For example, the middle-school youth needed time to socialize as they engaged with the *Driven to Discover* activities. Meanwhile, the elementary-school-aged children needed play time to blow off stream during work sessions.

Another leader who had older youth engaged them more deeply by having them perform an environmental action piece—for instance, writing letters to the editor about cleaning rain drains around the lake where they had done their water clarity test or questioning why milkweed was on the state noxious weed list if monarchs were the state insect. One set of older youth wrote an on-line science magazine article.

Using the older youth in a team to mentor younger team members proved effective for many leaders. This allowed not only the leaders to act as models for the youth, but also the older youth to act as near-peers. This strategy was particularly effective when the older youth had participated in *Driven to Discover* the previous year. One leader whose team encompassed a wide range of ages provided this example of mentoring: She had the five- and six-year-olds spot the monarch eggs and larvae and then used older youth or adults to record the data. This specialization allowed youth to feel like members of a team who each had something to contribute.

The two-week time period for the conclusions phase was too short for many groups who found writing and typing to be painfully slow for some youth. Having older youth or parents transcribe the conclusions for these children was a common strategy. One leader even experimented with voice transcription to make the process easier.

Another strategy to deal with younger children when older youth were not on the *Driven to Discover* team was to focus on the observational stages of the inquiry, as opposed to the later analysis stages, because of the skill needed to analyze data and write conclusions. One adult leader whose group was particularly young (average age less than 9) struggled because of the level of their reading and writing abilities coupled with their

I was reminded of the importance of play in learning and cherished the multiple creative resources in one place, especially the student handbook and the games.

Play is an important component of the process.

For the youth, it is all about doing this with their friends.

Some of the kids would be mentoring the other kids….These fifth-graders had never done the lifecycle, so I had thirteen older kids…they would have one student with two younger students…and then the others were doing their action plan, whatever, they would rotate.…And we didn't always monitor with the younger kids. Sometimes the older kids already had the monitoring done before we got there, depending on what we had in store for the day…I think it does help them to see that each one of them has a role.

I actually turned them [two returning youth] into my teen mentors, and so my fourteen-year-old …mentored my first- through fourth-graders. They did a fabulous job, and I think they [the younger children] identify very strongly with it being another teen, or another older kid that they respect, so having teen mentors was fantastic, because not only are they relating more, it's almost like it's the step between the scientist and them in the envisioning process.

Adult Leader Outcome 4, cont'd.

short attention spans. She adapted the program by shortening each step and leading them through the steps.

Strategies for Gaining Parental Support
Adult leaders said that meeting and developing a relationship with the youths' parents was important because parents ensured children's attendance and participation in the program. For example, one team held an ice cream social for their youth and families at the beginning of the year, helping everyone become comfortable; thus, parents were more likely to support their children's attendance.

In some cases leaders even had parents help youth. For instance, one leader sent bird guides home with the youth so that their parents could participate in the program, helping youth learn to identify birds. Other parents helped youth type up conclusions or make posters.

A few adult leaders mentioned the importance of being aware of community norms when working with parents. For instance, they noted that parents in some communities were not comfortable sending their children with other adults to out-of-state events. In the future, when adult leaders reach out to communities that have not been involved in *Driven to Discover*, they will need to be aware of differing community norms such as these.

Strategies to Overcome Logistical Issues
Through participating in *Driven to Discover*, adult leaders learned a number of strategies to deal with logistical challenges. They found that transportation issues sometimes kept youth from attending *Driven to Discover* sessions. Some leaders found that holding their meetings in the same location in which the fieldwork could be done, without additional transportation, helped ensure that all youth could get to the site and that the group did not waste time moving from meeting site to data collection site. In another case, a leader found that borrowing a van from her sponsoring organization allowed her to transport all the youth to the data collection site more easily that relying on several private vehicles.

Other logistical strategies found by a few adult leaders found included: scheduling the *Driven to Discover* sessions in longer blocks of time (more than 2½ hours) with breaks, allowing their groups more time to work and feel less rushed, or changing a meeting day to accommodate youth's busy schedules.

So having that history with the kids and maybe even more importantly with their parents made a huge difference because all of the kids who stuck with the program are kids whose parents we had a really good relationship with…. [The parents] Make sure that their kids will show up to our meetings even though they didn't show up every week, but as often as they could.

It sounds tiny, but having that ice cream social—like, we do a social at the beginning of the year—and it's a nice way to kind of meet, greet, talk, and get all friendly…And that's a good time for me to have face time with the parents and say, "Okay, this is what's going to be happening" and let me share and get the parents excited.

We moved mine [the monitoring site] to my backyard because we had been driving out 10 miles from our town to monitor a prairie and that worked great, but you'd have parents call saying, "Did you guys leave already because she's coming." And I'm like, "We're almost there. No, you've got to drive her out there," and they're like, "We're not driving her out there." So, you know, they miss that chance of monitoring and I thought, "You know what, I'm right there in town, if they come late, they come late, but we're right there."

Adult Leader Outcome 5: Gain Confidence to Mentor Youth

This outcome was met. Adult leaders' self-reported confidence in areas related to mentoring youth in inquiry showed statistically significant increases. Overall, leaders' experiences in the program were positive and most were motivated to continue the following year.

Outcome 5: Adult leaders who participated in the project (training and citizen science research clubs) will gain confidence about his/her abilities as an inquiry mentor for youth.

Adult leader confidence in mentoring youth through science inquiry is key to sustaining the program. In addition to leader confidence, other attributes contribute to their staying engaged in the program, including level of enjoyment and motivation to continue the program the following year.

Adult Leader Self-Reported Confidence
We asked the adult leaders to report their level of confidence—prior to and after the program—across the three areas related to science inquiry: science content, science skill, and the process of science. We found that as a whole, leaders increased their confidence in all three areas, showing a statistically significant increase of about one point on a scale of 1–5, where 1 is "not confident at all" and 5 is "very confident." Some increased even more than a point on the scale (see Table 26).

The areas where leaders rated themselves with lower confidence coming into the program involved facilitating youth in quality data collection and in helping them analyze data. The adult leaders averaged just below a 3 in these areas, due to 6 and 8 of the adult leaders rating themselves with either "no confidence" or only "a little confidence"

Table 26. Adult Leader Self-Reported Post-Program Confidence Level Shifts (N = 20)

Topic	Pre-program mean (Std. Dev.)	Pre-program min/max	Post-program mean (Std. Dev.)	Post-program min/max	Wilcoxon signed-rank p-value
Conducting scientific research	3.19 (1.47)	1 / 5	4.10 (1.09)	1 / 5	0.003
Knowledge of birds, monarchs, or other main organisms you studied	3.24 (1.37)	1 / 5	4.14 (.91)	2 / 5	0.001
The process of facilitating informal/nonformal science inquiry with youth	3.19 (1.36)	2 / 5	4.43 (.98)	2 / 5	<0.001
Prompting youth to reflect and rethink	3.38 (1.24)	1 / 5	4.57 (.75)	3 / 5	0.001
Facilitating youth in quality data collection	2.95 (1.28)	1 / 5	4.14 (.91)	2 / 5	<0.001
Helping youth analyze data	2.76 (1.34)	1 / 5	4.00 (1.00)	2 / 5	<0.001
Helping youth report their findings	3.38 (1.12)	1 / 5	4.57 (1.00)	2 / 5	<0.001

Adult Leader Outcome 5, cont'd.

respectively. By the end of the program, only 1 and 2 leaders rated themselves with only "a little confidence" in these respective areas.

The fairly high overall level of post-program confidence suggests that the program went reasonably well for most adult leaders.

While adult leaders reported gaining confidence through both their training and their experience working with youth participants, the majority focused on their experience with the participants. A few other leaders said they increased their confidence by meeting with the scientists and other adult leaders who taught them new ideas and methods for inquiry with youth.

Eight leaders provided examples of how the experience of leading the youth participants through the process of inquiry and finding outcomes helped increase their confidence.

It is important to note that there may be a threshold where more experienced educators do not gain confidence; we learned this from a leader with more than 30 years working with youth as an environmental educator. Most educators, though—even teachers—reported increasing their confidence in leading the youth through authentic inquiry.

For the most part, the adult leaders' post-program confidence levels reflected their confidence in the data their team collected to inform their science projects. A total of 16 leaders either "agreed" (4) or "strongly agreed" (12) that they were confident in their team's data. Only one leader disagreed and two remained neutral with regards to their confidence in their team's data. These results also suggested the leaders' confidence in overseeing their teams' process to produce a quality outcome.

Adult Leader General Experience

We also wanted to understand adult leaders' general experience in the program to. One general measure of their overall experience is the extent to which they enjoyed the program. The majority of adult leaders (17) reported enjoying the program "a lot," the highest level on the 4-point scale. Four leaders gave lower ratings on the scale: "a fair amount" (2), "a little" (1), and "not at all" (1).

Challenges

The four leaders who rated their enjoyment less than "a lot" reported challenges that reduced their enjoyment. Some challenges were external to the *Driven to Discover* program. For instance, the leader who did not enjoy the program at all reported challenges ranging from the initial adult leader leaving abruptly and unexpectedly to participating in a program where the youth did not choose to attend with an organization that did not hold them accountable to engage in the activities. This leader struggled with poor youth attendance and little knowledge of or experience with the program. (This leader attended the training, but initially was shadowing the more experienced colleague.)

I am becoming more confident and would like to use what I learned to advance Citizen Science with students.

I have been working with and teaching youth all of my adult life, but I hadn't done much with authentic science inquiry until D2D. The experience has made me very confident in doing so.

The excellent training I received prior to starting with the youth was probably the biggest contribution [to my increase in confidence].

I grew in learning along with the youth using the information I was given and training I received. My confidence grew with each year and all we did.

I was not confident at all, due to not facilitating youth within the scientific community, due to my own previous experience in the field (academically), and that anxiety following me up until this point. I thought it was going to be more difficult than I thought, but a lot of it is just trying to get students how to ask questions, and think outside the box, not necessarily knowing all the answers myself off the bat.

I feel the D2D project has given me the tools I need to be more confident in engaging youth in science inquiry. D2D has helped me to see how all the steps work together and the need to incorporate each one for a more holistic experience.

Adult Leader Outcome 5, cont'd.

Other leaders were challenged by the time necessary to do the activities, especially with youth younger than the program's target audience. The leader who did not enjoy the program much reported running out of time to fully participate in all the activities. The experience was similar for another leader who reported enjoying the program a fair amount. Their youth participants were younger and less mature, which made it difficult to complete the activities in a condensed, two-week format.

Program Curriculum

When asked what they enjoyed about the program, many leaders mentioned aspects of the program curriculum. Seven leaders praised the program and some described how it was easy to implement and flexible enough to be tailored for the team setting and needs or modified for use in the state park programs. One leader also reported that teaching without the constraints of formal education was a positive aspect, while another specifically commended quality of the training.

Youth Engagement and Learning

About half of the leaders attributed their enjoyment to seeing the youth engage with the program. These were their selections:

- Seeing the youth enjoy the program (5);
- Seeing youth work as a team (3);
- Observing the youths' sense of pride;
- Observing youth developing relationships;
- Observing youth mentoring others;
- Working with youth who wanted to be in the program; and
- Observing youth discover things.

Some leaders also said they enjoyed seeing the youth participants engage and learn about science (i.e., seeing youth interested in scientific inquiry, noting how the blend of activities resulted in participants' increased confidence in their science skills, observing the youth apply what they were taught in a way that interests them).

Leader Engagement, Learning & Networking

The leaders not only enjoyed observing youth participants engage in citizen science and inquiry, but also enjoyed engaging in their *own* learning; it rewarded them to learn more about science. One of the leaders also reported the benefits of networking and learning from other adult leaders. Having fun and spending time outdoors were added benefits.

Environmental Science Advocacy

Some adult leaders valued being able to give back to their community by increasing awareness of conservation and environmental issues. They enjoyed helping youth learn about the importance of ecology and science, for instance, youth learned that drought or heat affected the organisms they studied and could use that knowledge to understand how climate change affects the world on a larger scale.

This is the best program I've ever participated in as a professional environmental educator and community center administrator. This is truly a special program.

A day of D2D affords a perfect mix of indoor and outdoor engagement, book learning and life skills, serious effort and fun. The end product of a string of these days is a confident young person who thinks scientifically and envisions him/herself as a capable problem solver. Oh, and the kid has a smile on his face!

I personally enjoy all of the adult contacts and networking. It makes my experience as a teacher so much richer.

I get to spend two weeks watching and learning about birds with kids who love watching and learning about birds. What could be better than that!

Happy to be outdoors observing the natural world with youth. Enjoy the organization of lessons and goals of the curricula. It feels like it's set up to succeed.

Adult Leader Outcome 5, cont'd.

Adult Leader Motivation to Continue Program
An adult leader's motivation to continue a program the following year is related to 1) the leader's confidence in mentoring youth and 2) the general experience with their team. The quantity of adult leaders motivated to continue with *Driven to Discover* was similar to the total of those who enjoyed the program. Eleven leaders were "very motivated" to continue, five were "moderately motivated," two were "somewhat motivated," and three were "not motivated at all."

When asked to explain their motivation ratings to continue with *Driven to Discover*, many said that what they enjoyed about it motivated them to continue. A few emphasized that they personally enjoyed the experience of working with youth and that they benefited from learning with them, which motivated them to return for another year despite the work involved.

Other adult leaders were impressed by their youth participants' enthusiasm and wanted to help keep it high by continuing the program.

Several adult leaders commented that the program was a prime way to educate youth and engage them in citizen science. The model and success of the program, as well as the fact that both the leaders and the youth enjoyed the process, infused them with energy to return next year. One even talked of their investment in building a strong program that would continue.

Of the three not motivated to return, one was retiring, the other had left the organization under which he or she had led the youth team, and one did not provide a reason.

Ideas for Next Year
A handful of adult leaders mentioned ideas for the upcoming year relating to their motivations to continue. Two said they were committed to finding the funding resources to continue the program. Others thought about ways to run their programs better. One leader who found it difficult to recruit and run a consistent team at her state park planned to form partnerships with 4-H and other local parks and recreation departments to recruit a team more likely to stay involved over the length of the program. Another planned to recruit and schedule meetings with an earlier start time. Two adult leaders mentioned ways to strengthen an ongoing, sustainable team (e.g., having older youth mentor younger youth and recruiting graduate students to serve as adult leaders).

Challenges
Leaders reported youth recruitment and the time commitment for leaders as challenges to continuing the program. One leader described struggling for two years to form a neighborhood team and keep youth involved

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I really want to share with the kids all the knowledge I got in the training, and also make them realize that science is a lot of fun.

This is a fantastic program and we are looking forward to continuing even if we are not selected as a D2D project for the upcoming year.

It is gratifying as an educator to be able to teach skills and concepts to kids and then have them be in the position to apply that learning authentically in a manner in which they are totally invested.

Seeing the final success of the kids, and their feelings of accomplishment, are incredible motivators for me, which help get past the exhaustion factor.

We are very excited to continue D2D and have some good ideas on recruiting graduate students to serve as the adult leader for the project. As the program coordinator for our project, I am really committed to continuing and find resources to support the project!

I have not had a lot of luck getting kids to enroll in my D2D program. When I look at my very full summer schedule, I think I wouldn't mind another couple weeks off. On the other hand, I have a great time during the program. Conflicted. I'll offer the opportunity again, and if kids sign up, we'll do great things.

Love the program, but maybe only [as] an informal group.

Adult Leader Outcome 5, cont'd.

to finish an entire inquiry process because of competition from other summer and family activities. Conflicts with personal activities not only affected the youth participants, but also some adult leaders who wanted more personal time in the summer.

Recruiting youth was also a problem for one camp program that had pressure to fill camp enrollment for revenue purposes.

Another leader had difficulty during the fall, when her regular teaching activities took time from meeting with and helping *Driven to Discover* participants with their analysis.

Lastly, leader and staff turnover proved challenging for three groups, two of which were exploring ways to overcome the issue. One leader was approaching retirement, but had a sustainable program in place and needed help to maintain it. Another program had regular staff turnover, but was exploring a long-term relationship with graduate students to lead the programs.

Adult Leader Outcome 6: Exhibit Ability to Mentor Youth

This outcome was met. The results from TSI self-efficacy questions showed that leaders agreed they were using best practices to facilitate science inquiry with youth.

Outcome 6: Adult leaders who participated in the project (training and citizen science research clubs) would exhibit the ability to mentor youth inquiry projects.

Adult Leader Self-Efficacy in Facilitating Authentic Youth Inquiry
We used 15 items (of 69) from the Teaching Science as Inquiry (TSI) validated instrument and three *Driven to Discover*-specific items to assess adult leaders' self-efficacy around facilitating youth science inquiry. Adult leaders used a 1–5 scale (1 = "strongly disagree" to 5 = "strongly agree") to rate each item. The results are summarized in Tables 27 and 28 with items grouped by phase of science inquiry. The results for each phase are discussed below along with examples of success noted by the leaders.

Questioning
Three items were used to assess leaders' ability to facilitate the questioning process among youth: providing experiences through which the youth could generate questions, setting expectations that youth come up with testable questions, and to help move youth

Table 27. Adult Leader Experiences Engaging Youth in Science Inquiry: Questioning, Hypothesizing, & Planning (N = 20)

	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Questioning	I possessed the ability to provide meaningful experiences from which scientific questions are posed by youth. (TSI 4)	0%	5%	10%	**43%**	**43%**	4.24
Questioning	I possessed the ability to allow youth to devise their own problems to investigate. (TSI 19)	0%	0%	5%	**71%**	24%	4.19
Questioning	I expected youth to ask scientific questions. (TSI 25)	0%	0%	0%	**55%**	45%	4.45
Hypothesizing	I was able to provide youth with the opportunity to construct alternative explanations for their observations. (TSI 2)	0%	5%	14%	**62%**	19%	3.95
Hypothesizing	I expected youth to think about other reasonable explanations that can be derived from the evidence presented. (TSI 35)	0%	0%	0%	**62%**	38%	4.38
Planning & data collection	The youth on my research team determined what evidence was most useful for answering their scientific question(s). (TSI 57)	0%	5%	14%	**57%**	24%	4.00
Planning & data collection	Youth on my research team designed their own investigations and gathered the evidence necessary to answer a particular question. (D2D)	0%	14%	14%	**38%**	33%	3.90
Planning & data collection	I was able to facilitate open-ended, long-term investigations that provided opportunities for youth to gather evidence. (TSI 36)	0%	14%	5%	**48%**	33%	4.00
Planning & data collection	Youth on my research team used internet-based resources or other materials to further develop their investigations. (D2D)	0%	19%	19%	**52%**	10%	3.52

Adult Leader Outcome 6, cont'd.

toward asking a testable question. All leaders expected that their youth would come up with a testable question. Only one leader of 20 (5%) failed to agree that they were providing experiences that would help youth generate questions. Overall, all but three (85%) either "agreed" or "strongly agreed" that they were helping their youth generate testable questions.

Hypothesizing
All adult leaders agreed that they expected that youth generate multiple hypotheses or all the reasonable explanations when they reflected on their inquiry question. A few leaders, however (approximately 20%) did not feel that they provided youth with the opportunity to construct alternative explanations for their observations. We know that two teams were unable to progress much beyond the observing and wondering and the collecting citizen science data stages. These results confirmed that their reporting is consistent.

Planning & Data Collection
The teams that focused on observing, wondering, and citizen science data score lower in this section, since they were unable to start thinking about their own inquiry questions. The team leaders (81%) who were involved in personal inquiry projects, however, did agree that they helped facilitate open-ended activities that provided youth with opportunities to gather evidence to answer investigations. Furthermore, they agreed (81%) that their youth determined what information would be useful to answer their question and designed their own investigations and gather the evidence necessary to answer their questions (71%). The statement with lower ratings (62% agreeing) was that of youth using internet-based resources or other materials to further develop their investigations.

My confidence in this process had significantly increased so that this year almost all of our questions were testable and I was able to engage the students in a long, really focused and thoughtful discussion...not about which questions were testable, but about which questions we would be able to test given our time and resource constraints.

After sampling, we were back in the lab observing invertebrates in petri dishes. One student noticed two invertebrates in a dish with odd interactions. Very quickly, all eight team members were gathered around to watch the drama. I used this as an opportunity to craft an on-the-spot mini-inquiry, eliciting from them their question, and hypotheses, then procedure for observation, and writing it all down on the board as they continued to watch. The kids quickly got their notebooks, and wrote down the parameters, and notes for observations. We settled on a time frame for interactive observations, and they started recording behaviors. They found that a predacious diving beetle larvae attacked and ate a blood midge by sucking its insides dry. The procedure we developed for this fast inquiry became the crafted procedure for one of the formal investigations later.

Time spent observing pigeons [in] downtown St. Paul yielded a long list of questions from the youth. This long list eventually lead us to our experiment.

Adult Leader Outcome 6, cont'd.

Analyzing
Team leaders continued to score highly on one statement about facilitation of analysis; about 90% of them said they were able to provide opportunities for youth to think critically about scientific explanations. A slightly lower percentage (70%) agreed that they facilitated a process of sharing explanations as a way to critique explanations and investigative methods.

Concluding
More than 80% of the leaders agreed that they were providing youth with various opportunities to develop conclusions for their projects, including:

- Requiring youth to create scientific claims or develop explanations based on evidence.
- Expecting youth to independently develop explanations using what they know.
- Encouraging youth to independently examine resources to connect their explanations with scientific knowledge.

Fewer leaders (57%) helped their youth evaluate the consistency between their own explanations and scientifically accepted ideas.

Table 28. Adult Leader Experiences Engaging Youth in Science Inquiry: Analyzing, Concluding, & Reporting (N = 20)

	Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean
Analyzing	I was able to provide opportunities for youth to become critical decision makers when evaluating the validity of scientific explanations. (TSI 10)	0%	5%	5%	**68%**	21%	4.05
	Through the process of sharing explanations, I was able to provide youth with the opportunity to critique explanations and investigation methods. (TSI 33)	0%	5%	25%	**55%**	15%	3.80
Concluding	I required youth to create scientific claims based on evidence. (TSI 34)	0%	0%	14%	**43%**	**43%**	4.29
	I required youth to develop explanations using evidence. (TSI 39)	0%	5%	0%	**57%**	38%	4.29
	I expected youth to independently develop explanations using what they already know about scientifically accepted ideas. (TSI 15)	0%	0%	19%	**76%**	5%	3.86
	I was able to instruct youth to independently evaluate the consistency between their own explanations and scientifically accepted ideas. (D2D)	0%	10%	33%	**52%**	5%	3.52
	I was able to encourage youth to independently examine resources in an attempt to connect their explanations to scientific knowledge. (TSI 3)	0%	0%	19%	**71%**	10%	3.90
Reporting	I required youth to defend their newly acquired knowledge during large and/or small group discussions. (TSI 6)	0%	5%	14%	**67%**	14%	3.90
	I was able to provide opportunities for youth to describe their investigations and findings to others and to use evidence to justify their explanations and how their data were collected. (TSI 12)	0%	0%	5%	**67%**	29%	4.23

Adult Leader Outcome 6, cont'd.

Reporting
Nearly all adult leaders (96%) provided opportunities for their youth to describe their investigations and findings to others; 81% facilitated youth defending their newly acquired knowledge in group discussions.

It is important to note that the TSI self-efficacy tool was originally used to assess science inquiry at the high school level, and most *Driven to Discover* youth were between ages of 9–13. Therefore, even if their questions were simple, youth were engaged in a process that calls for maturity in examining and critically thinking about science information.

Adult Leader Facilitation Challenges
Although most of the adult leaders successfully engaged youth in citizen science and science inquiry, their processes were not without challenges. The adult leaders reported two challenges related to managing the youths' general engagement processes, two challenges involving meetings, and seven naming specific aspects of facilitating the youth science inquiry process. The most widely reported challenge with *Driven to Discover* was in keeping youth focused and on-task (seven teams reported this challenge), particularly when it came to working on the science inquiry steps involving hypothesizing, planning the research design, analyzing data, and presenting data in poster form. The youth seemed to focus better when they were observing and identifying things and collecting data for citizen science programs.

The following were challenges by category:

Youth engagement process
- Keeping youth focused on the tasks. (7)
- Helping youth come to consensus about how to test their hypothesis. (1)

Meetings
- Learning about and starting *Driven to Discover* too late to complete the program. (1)
- Inconsistent student attendance. (1)

Science Inquiry Processes
- Progressing further than observations. (1)
- Analyzing data and coming to conclusions. (2)
- Engaging youth in sharing what they learned with their peers. (1)
- Developing hypotheses. (2)
- Planning their experiment. (1)
- Approaching inquiry without bias toward a particular hypothesis. (1)
- Overcoming failed data collection methods. (1)

Three different questions developed as a result of the previous ones not working during data collection. The youth were able to define what they learned from the data collection and what went "wrong" in the process. We spent a lot of time in the reflect and rethink center of the inquiry wheel. It is always a balance in encouraging/supporting the youth in defining their own hypothesis and providing some structure to the question initially and throughout. The youth were frustrated when they had to reformulate a new question. But we focused on what we think happened and what we learned.

When they were figuring out how many species they had seen since they began birding in 2011, they added together how many species they saw in 2011, 2012, and 2013. That gave them the total of 91 species. Through discussion…. they realized they were counting some species two or three times depending on if they had seen it two years or all three years. They finally came to understand the problem with their answer and how to use the data correctly…they had really seen 43 different species.

The most notable experience was when the youth took a look at the results of their study and made connections to the types of damage that the milkweed sustained, both as a result of other natural elements and as a result of human activity.

The best teaching education I've gotten was from these other teachers—the ideas that come from all the different experiences, different kids, different groups, different ways of approaching it.

The phone calls and the e-news…it's just been such a great way of connecting with [other leaders]…we…have known each other for how many years now? And it's just like a big family.

Adult Leader Outcome 6, cont'd.

During focus groups, leaders emphasized the importance of discussions with their peers, in which they could share experiences and hear how other leaders were meeting their challenges. Some participants suggested ways of strengthening this existing network of leaders. For instance, one suggested regular webinars for leaders that could be recorded and played back later if someone was not on the live call. Another suggested pairing novice leaders with more experienced leaders who could act as mentors.

Youth Engagement Process Remedies

Many of the leaders offered remedies for the challenges, which demonstrated their skills in overcoming these issues. The remedies that leaders suggested also indicate how they helped youth through the process, but did not do the work for them. For instance, many remedies involved helping youth think through their activities, having them work with a partner, or describing their work aloud before writing it down. Some remedies involved scaffolding or providing structure to assist with the youths' information processing, such as printing out their eBird check lists to look for something interesting or by breaking work into small pieces to help them stay engaged. In these cases, the adult leader met the youth where they were, supporting them and helping them develop a little more competence with the task at hand.

The following suggestions were process remedies:

General Engagement Process Remedies

- Break up work into small pieces to overcome short attention spans.
- Bring treats.

Science Inquiry Process Remedies

- Have youth share what they learned with their peers.
- Asking often what they notice and to use the "I wonder board."
- Print out eBird checklists to look for something interesting.
- Keep referring them back to the RERUN (an acronym for the science inquiry process).
- Help youth think through their hypotheses.
- Help youth think through planning their experiments.
- Meeting in a computer lab where the youth could explore how to graph their data by using software.
- Have students describe their work aloud before writing it down.
- Have youth work with a partner.

Processing of what we had done—data that I had thought was so clearly recorded seemed to be scattered among my teams notebooks. Getting them to work together to process and create their boards, and get the required work done was tough.

My most challenging experience in engaging inquiry was with getting the kids to approach the data collection without bias toward a particular hypothesis, and therefore in a manner which resulted in quality data. I had to continually remind them to approach the problem without discrimination so that their data would not be skewed by their prejudgments.

The best part for kids is to share their work in a face to face situation and to get feedback and interesting questions, not to write it up to sit statically on a project board.

Biggest challenge was coming to consensus with wonderfully expressive, stubborn and uncompromising youth about how to best test their hypothesis. It took good negotiation and leadership skills on my part to settle their differences of opinion and move forward.

The data collection didn't work out (the bird feeders were either stolen or eaten by squirrels), so we weren't able to have good data analysis and conclusions other than what we think happened.

Results: Team Contexts

Team Contexts

Overall Program Goals and Processes
We observed six teams in order to understand how the *Driven to Discover* program worked in different contexts. These teams were stratified by potential adult leader backgrounds that would use *Driven to Discover* in an informal education setting, including teachers, natural education instructors, youth leaders in informal youth learning organizations such as 4-H, and lay citizens with an interest in science.

First, we assessed whether the teams engaged in the core program goals and processes involving science inquiry (answering questions about natural phenomena through investigation), authenticity (engaging in activities and investigation that resemble real-world science), and team engagement (youth and adult team members contribute to the activities). Outcome measurements are documented in Appendix B by team.

All the teams we observed were able to meet all the program goals, but did so at differing levels. Three teams met the program goals at fairly high levels, participating in all phases of inquiry and were observed to have a strong grasp of the concepts by the end of the program. The adult leaders of these programs were seen to have a high facilitation skills and science content knowledge. These teams' youth all completed posters (youth-led) and attended the science fair.

One team met the program goals at a moderate level. The adult leader of this team had high youth inquiry facilitation skills, but only moderate science knowledge. The youth in this team engaged in all phases of inquiry during their meetings and completed a youth-led science project to present at the science fair. They were unable to complete all phases of inquiry for their science project, however, due to difficulties with data collection.

Two teams achieved the program goals at a lower level. These teams' adult leaders had lower levels of science knowledge and youth science inquiry facilitation skills. One team completed a project for the science fair, but this was largely adult-led. The other team did not complete an authentic science project and only engaged in science activities at their site.

The success of various teams can be attributed to elements identified through the program's Grounded Theory analysis (during project development) or observations (during field tests). These elements are displayed in Table 29 (see Appendix C for their definitions). The elements observed to contribute to reaching program goals for each team are identified in Appendix B. In this section, we will view more generally how the elements played out in different contexts.

Elements that Help or Hinder Authentic Science Inquiry
The *Driven to Discover* research team led a Grounded Theory research study during the development phases of the program. As a result, they identified 14 elements that helped or hindered authentic science inquiry in the team setting. These elements were organized into three areas:

1. program setting/situation;
2. team characteristics; and
3. program design/structure.

(Meyer, Nippolt, Strauss, Oberhauser, & Blair, 2013). The observations highlighted six additional elements that are organized under team characteristics. These additional elements could fit within some of the team characteristics identified in the Grounded Theory analysis, but they differ in association with how the observed teams functioned and met their goals. Because of this, we highlight them separately for evaluation purposes.

The added elements we observed were:

- Validated Youth Skills/Knowledge;
- Supportive Environment for Learning;
- Adult Leader Pre-meeting Preparations;
- Incorporating "Fun" Activities;
- Science Content Knowledge of the Leader; and
- Challenging Activities.

Team Contexts, cont'd.

Program Setting/Situations
The research team defined the program setting or situations as "the characteristics of the site and group that influence how the program operates, and research team members participate. These are largely uncontrollable, but sometimes predictable factors" (Meyer, et al., 2013). Most observed program settings and situations supported the team working toward its goals.

Overall, all teams had access to outdoor spaces that provided the ecological context they needed to engage in citizen science and science inquiry. Team E ran into problems with their ecological setting; birdhouses they put up for observations were stolen, compromising the data collection for their inquiry project. Team members, however, still engaged in all inquiry processes with their team activities.

We observed a more significant ecological impact with Team F, which met the program goals at a moderately low level. They collected their data at a roadside site by a busy highway. The site, while ecologically suitable due to its milkweed and monarch eggs, was negatively impacted by traffic noise (making it difficult for youth to hear each other), lack of a place to sit and take notes, and the lengthy walk to the site (which used a large amount of their meeting time). These factors decreased discussion at the site, reduced time to reflect and take notes, and reduced the time youth had to identify organisms when they returned from the site.

Table 29. Elements that Help or Hinder Science Inquiry in *Driven to Discover* Teams

Program Settings/ Situations	Team Characteristics	Program Designs/Structures
• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated Skills/Knowledge** • Supportive Environment for Learning** • Adult Leader Pre-meeting Preparations** • Incorporating "Fun" Activities** • Science Content • Knowledge of Leader** • Challenging Activities**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

* Grounded Theory-Generated **(**Meyer et al., 2013)
** Observation-Generated

The group contexts varied from team to team. Some teams had a wide range of participant ages and others relatively narrow. In general, the age range did not seem to have a large impact on the overall team outcomes. We observed teams with youth age ranges as large as 8–14. In these groups, the adult leaders led the discussions at a level at which most youth could contribute.

We noted that in some cases, the adult leader would ask the more knowledgeable youth to hold back their contributions until the less knowledgeable youth had a chance to provide input. In some cases, the younger participants did not fully understand the concepts as did the older ones, but they were still learning and received tasks appropriate for their cognitive levels.

Team Contexts, cont'd.

We observed that teams whose youth did not self-select to attend the meetings performed at lower levels than those who did. Youth on these two teams were either court-ordered to attend or were there to accommodate their parents' wishes. Observations show that these youth engaged in the activities, and even appeared to enjoy some of them, but there was no evidence that they deepened their science identity or interest in science as a result of attending. Several other elements also reduced these teams' performances, so there is no way to determine the effects of individual elements on teams without further exploration. The rest of the youth were attending the program by choice and thus had self-interest in being present and working with the subject matter.

Team Characteristics
Team-characteristic elements were defined as "the aptitudes, attitudes, and skills of team members that facilitate how the program operates" during the Grounded Theory research (Meyer et al., 2013). Our observations show that these elements had the most influence on how well the teams functioned.

We saw evidence that all team leaders experienced success with the following elements:

- Validating Skills/Knowledge;
- Creating a Supportive Environment for Learning;
- Adult Leader Pre-meeting Preparations;
- Incorporating "Fun" Activities; and
- Challenging Activities.

We postulate that validating youth skills and knowledge is important not only in increasing their confidence, but also in helping to create their sense of identity as a citizen scientist. Although many youth entered the program highly interested in science, we saw how the adult leader or scientist could validate what youth are doing, which can help them make the connection to how their activities and thinking are similar to those of a scientist. Thus, the mirroring is essential not only for youth's learning, but also in creating a sense of themselves as scientists. For many youth, the science fair was the culmination of this process, when a scientist looked at their work and helped them verify what about their projects was "good science."

The adult leaders that we observed were also adept at creating a supportive atmosphere for youth learning. They warmly greeted youth as they arrived, made sure that disruptive youth behavior was addressed; they used positive affect, noticing what was "right" about an answer before helping refine a participants' thinking about something. Adult leaders also excelled at making sure that they had a plan; in most instances they were prepared with meeting materials.

Adult leaders incorporated "fun" activities—a key factor—in many ways. Initial team meeting games helped youth develop specific skills such as observing or identifying organisms. Other fun activities were woven into the middle of meetings after an activity that involved a lot of deep thinking. A third way that teams incorporated fun into their meetings was to provide experiences otherwise rare in the youths' daily life, such as taking a field trip or using a canoe to get to a birding site. We observed youth asking for and anticipating such activities, which corresponds to the youth surveys documenting that the program was "fun."

We also saw all teams engaging youth in challenging activities. Many participants had a "bring it on" attitude. Youth wanted to be challenged and looked forward to it assuming the activity was within reach of their abilities. Furthermore, they felt a sense of accomplishment after doing something challenging. Weaving in challenging activities, along with validating their successes, resulted in the youth feeling good about what they were doing. One key example of this occurred when youth presented their inquiries within the team. Refining their questions, hypothesis, and data collection plan challenged most youth; presenting to the team and fielding questions from adult leaders (and other adult volunteers or scientists) provided a means for validation or feedback that they created something doable and within the guidelines of science inquiry.

Team Contexts, cont'd.

The elements separating the teams achieving program goals at a high or moderate level from those achieving them at lower levels were fairly consistent in our observations. They included:

- Adult leaders' ability to facilitate youth inquiry;
- Adult leaders' science content knowledge;
- Team engagement levels in scientific practices;
- Evidence of youth having "science identity"; and
- Youths' level of self-directed learning.

There was evidence supporting the idea that that the adult leader needs a threshold of competence in both youth science inquiry facilitation skills and science content for the youth and team to meet program goals at each level. The youth and team outcomes matched the general science knowledge and science inquiry facilitation levels of the adult leaders. The highest predictor was the adult leader's ability to facilitate youth science inquiry. Adult leaders with skills in this area worked with youth by questioning—rather than just feeding them information—to help them understand a concept or identify an organism. In effect, they guided an organic inquiry process built around the youths' discoveries and questions. Some adult leaders even modeled the process with their own discoveries and questions. When concepts proved particularly difficult for the youth to realize, these adult leaders provided opportunity after opportunity to practice understanding the concept until the youth provided evidence that they understood it. Likewise, high-performing adult leaders used any possible opportunity to capture something in which a youth showed interest (identifying a new bird, wondering why water is stinky, showing excitement about predator and prey behaviors, or discovering an unknown insect) and fit the interest into the realm of science inquiry.

Team C's adult leader, who labeled herself as having relatively low science content knowledge around birds, realized that she did not need to know all the science content to guide her youth through the "process" of science inquiry. Because she understood how to guide the process, her team met its project goals at a moderate level despite not having formal science instruction in their schools and having a wide age range of youth. We also observed missed opportunities with the same adult leader to engage in the inquiry process with the youth when she lacked enough science content knowledge to guide them through the process. When this happened, the question went to the "I wonder board," which allowed the possibility to return to it, but removed it slightly from the energy around its discovery.

In addition, when adult leaders' science content and youth inquiry facilitation skills were low, they could not lead the youth in self-directed learning activities, missed opportunities to engage in science practices, and consequently missed chances to validate youths' new knowledge and science skills. In these cases, it was helpful to have a scientist present to add expertise, but unless the scientist was also skilled in leading youth inquiry and was leading the team (rather than mentoring one youth, as we observed), we found that their effect was limited to the specific individual they mentored.

By watching visiting scientists mentor selected youth, we gained evidence that youth on these teams could accomplish more if led by someone with youth science inquiry facilitation skills and science content knowledge. We also saw that some youth needed time to build a basic understanding of science concepts before they could reflect on questions at a higher level. Thus, teams trying to meet program goals at lower levels had two limitations: the limitation of the adult leader's skills and knowledge and the skill level of the youth to think critically with complex constructs. As a result, we believe more than one year in the program may be required for both the adult leaders and the youth to develop under an experienced mentor.

As mentioned earlier, youth with observable positive science identities were 1) largely in the higher-performing teams and 2) attended on their own terms. It is unclear whether not attending on their own terms would develop stronger science identities given mentoring with adult leaders who had expansive understanding of science and

Team Contexts, cont'd.

stronger youth inquiry facilitation skills. This possibility would need to be tested in another project as there were too many confounding elements to disaggregate them in this particular project.

Program Designs and Structures
The Grounded Theory research defined the program designs and structures as "the series of experiences, activities, and resources in which the research team participates" (Meyer, et al., 2013). We saw fewer elements of this theory contributing to differences in how the teams met the program's goals. For instance, we did not observe examples of how the teams saw their contributions to citizen science project in teams meeting the program goals at a high level or those meeting them at a lower level. On the other hand, a couple of teams that met the program goals at high levels showed clear examples of how working with the citizen science data fed into youths' science identities. Likewise, we lacked evidence to expand on the effects of the team activating on past knowledge. We saw it play out well on some teams and not on others; this phenomenon may be more related to when we observed this than the team itself.

The remaining program design and structure elements—active skill-building, discovery, and team member involvement in planning, making choices about, and reflecting on activities—were interrelated and depended on the adult leader's youth inquiry facilitation skill and science content knowledge.

For instance, adult leaders with higher levels of knowledge and skill were able to include their youth in the planning and decision-making processes as they reflected on activities. This element was completely absent in the two teams meeting the program goals at a low level, which had adult leaders with lower youth inquiry facilitation skills and lower science content knowledge.

Conclusions and Implications

Conclusions and Implications

This evaluation found that *Driven to Discover* met its goals. The program helped youth learn about science, increased their understanding of citizen science, strengthen their science identities, and supported their ongoing development of science inquiry skills.

The program achieved its goals by providing the training, curriculum, and resources to adult leaders from various backgrounds. In effect, the adult leaders gained enough knowledge about their citizen science content and projects to mentor the youth to become citizen scientists and contribute data to citizen science databases. In addition, the adult leaders gained the necessary knowledge and experience to mentor their young team members through the process of science inquiry so they could answer their own questions about nature using the process of inquiry.

Driven to Discover achieved its goals in several different ISE settings and with adult leaders from a variety of educational backgrounds, but the level at which the teams achieved the goals differed depending on their strengths. This section will briefly highlight and reflect on some of the findings and their implications to inform future *Driven to Discover* programming. We have organized the discussion of the findings and implications around the three areas that impacted the teams: team characteristics, program settings and situations, and program design and structure.

Team Characteristics

Various team characteristics either helped or hindered the teams' citizen science and science inquiry activities. Below, we highlight two of the most influential team elements and their implications.

Strengthening Science Identity

One prominent way in which the teams succeeded was in positively affecting youths' science identities. Most youth in the programs attended of their own will, which means that most were already interested in science or the program's science content. Those who did not attend through their own will (many coming in with less positive attitudes toward science) participated in programs that involved several other elements confounding the potential effects of the program on science identity; therefore we were limited in our ability to say whether a program run under ideal situations would effectively shift youth who start with negative attitudes towards science to positive attitudes.

What we *can* say is that via our triangulated outcomes, participation in *Driven to Discover* definitely *strengthened* youths' positive identity toward science. We observed mentors and/or scientists (on site and at the annual science fair) validating youths' science knowledge and skills, youth gaining a sense of purpose with their contributions to their citizen science programs, youth identifying with other youth with similar interests, and youth having fun while engaging in science.

Adult Leader's Abilities to Engage Youth in the Science Inquiry Process

Our observations across adult leader types and settings highlighted that the strongest predictor of meeting program goals at moderate to high levels was the adult leader's ability to mentor youth through the process of science inquiry.

We observed youth leaders with lower understanding of the science content, or subject matter of their program, who were moderately effective due to their ability to mentor their youth through science inquiry processes and pull the youth through the program with moderate success. This was achieved with youth with no previous background in science due to its omission in their school system. Contrary to this, we observed an adult leader, with moderate understanding of science, but a lower ability to engage her youth team members in science inquiry, struggle to meet the program goals with her youth.

Conclusions and Implications, cont'd.

Until the adult leader determines how to facilitate this process, he or she will continuously miss opportunities to achieve the intended effects of the program. We observed that when the process of science inquiry was truncated, youth stopped observing and wondering. The potential of capitalizing on something of interest to the youth was lost, the practice and process of science was lost, the validation of coming to a result from the science project was lost, and even learning something new about the subject matter was lost. This would occur unless the adult leader exhibited at least a moderate command of engaging youth in inquiry. We also observed that adult leaders with moderate to high ability to engage youth in science inquiry also engaged their youth in self-directed learning and their own inquiry projects, something not seen with adult leaders with lower ability levels. Therefore, among the most important skills for an adult leader is to mentor the youth through the process of inquiry, which is different from simply knowing about the process of science inquiry.

Our findings support the idea that adult leaders who come into the training program with a background in formal education or natural science education can mentor their youth through the inquiry process more easily than those with background only in leading youth clubs or activities. Adult leaders with no background in formal or informal education will likely fall short of meeting the intended goals of the program if they simply use the curriculum or engage in a one- to three-day training session. We suspect that leaders without former educational training could achieve higher-level results as team leaders if they are able to shadow more experienced leaders for a season to observe and practice their skills prior to leading their own team.

Program Settings/Situations

Program Sustainability

The program setting or situation had a major effect on the program's sustainability. Programs with a longitudinal track record have the advantage of retaining expertise, visibility in their community, and the ability to contribute to citizen science projects over the years. Programs that have shown the most potential for long-term sustainability include school/teacher associated programs, community centers (e.g., 4-H), and natural resource education centers.

These programs fill important needs in their communities. Youth need the opportunities to increase their science skills and engage in projects they can use for school; some schools lack science curricula while others have a mission to increase environmental education in their community. Other elements that influenced the sustainability of the programs included youth recruitment abilities, youth retention abilities, and adult leader retention.

Youth Recruitment

The ability of a team to recruit youth could make or break the program. Successful recruiting programs established connections to youth interested in science through linkages such as home-schooling networks, environmental centers, informal education programs linked to schools or teachers, or community centers with youth programming. Parents often knew about and trusted such centers, which strongly influenced whether they would enroll their youth in a program. Other teams struggled with recruiting youth, leading to the discontinuation of the teams. Youth in this age group may have a lot of competing choices for activities. One natural education center found that they were unable to fill their *Driven to Discover* summer camp program and decided to replace it with other programming, since they were dependent upon program revenue. Neighborhood teams also struggled to find youth interested in engaging in citizen science.

Marketing resources and activities developed in the final year of the program may help with future recruitment, but were not captured as part of the program evaluation.

Youth Retention

One strength of *Driven to Discover* is that youth and adults can deepen their knowledge and skills over time. We noticed how the youth developed their science skills and even became neighborhood (or center) experts over time. This program can strengthen positive attitudes toward science and improve science skills in middle-school youth, leading to a greater possibility that they will want to

Conclusions and Implications, cont'd.

engage in high school coursework to prepare themselves for STEM-associated careers.

A high percentage of youth (78%) were motivated to return to the program in the following year, but only about a third actually returned each year. This rate resembled that of non-livestock 4-H youth retention (about 42% for 1–3 years) for the same age range. *Driven to Discover* youth reported similar reasons for retention or dropping out, top reasons being competing activities and becoming bored with working with the same material over time (Jones & Meeks Baney, 2013).

Driven to Discover will need to find ways to challenge and create incentives for returning youth. Some incentives that successful programs offered included linking the youth's summer research to their required school projects the following year, presenting their study results for recognition and contribution in their community, and asking returning youth to serve as near-peer mentors for new youth.

Adult Leader Retention
The *Driven to Discover* program takes a significant amount of time and effort, which can easily lead to turnover among adult leaders after a few years if *Driven to Discover* is not part of their "regular job duties." Overall, we found that many adults liked to stay in the program because they enjoyed watching youth learn and enjoyed continuing to learn themselves. We also saw adult leaders with strong interests dropping out after a few years due to other interests competing for their time. Programs with an interest in being sustainable should put thought into ongoing training and recruitment to ensure that they recruit and retain well-prepared adult leaders. Teachers and educators who are paid or are able to apply for grants to support their efforts are more likely to stay engaged and help develop sustainable programs. Programs can also explore other options for recruiting and retaining leaders. For example, one community center with high staff turnover, but a desire to sustain the program was exploring partnering with a university to offer adult-leader positions to graduate students who had youth inquiry mentoring skills and science content knowledge.

Program Design/Structure
Although this program has several program design strengths, two were especially notable. First, the program was highly adaptable and offered the possibility of expansion into new subjects. Two, the program could potentially link into systems that support youth science career pathways.

Program Adaptability
A strength of *Driven to Discover* was its usability across diverse settings. Adult leaders commented on the usefulness of curriculum activities, describing them as easy to implement and flexible enough for tailoring to team settings and needs. We also found that teams adapted their meeting schedules to accommodate the most participants. Some teams met once or twice a week over a number of weeks, while others met for shorter times in the summer and longer times in the fall. One team even met in a camp setting during the summer, then assigned individual projects to the youth to complete at home, using phone meetings so that the rural participants did not have to travel for face-to-face meetings.

The program could also be adapted to use with other subject matter and citizen science programs. One *Driven to Discover* adult leader, working on the topic of water, adapted the materials written for monarchs and birds for her team. Highly skilled adult leaders, such as this one, took advantage of what interested the youth to keep them engaged in the process. In this way, the citizen science program served as a conduit; the organic process of following one's interest with the scientific process was where the "magic" happened. By adapting *Driven to Discover* and using existing citizen science programs as sources, leaders can find subjects that interest and engage a wide variety of teams.

STEM Career Pathways
The *Driven to Discover* program could easily be tied to a larger STEM career pathway program. The program already uses graduate students as scientists, and one organization was interested in employing graduate students as adult leaders. In addition, some graduate students are young enough to feel like near-peer mentors to the youth. These elements make *Driven to Discover* a prime candidate to become a larger system of partnerships linking community programs to

Conclusions and Implications, cont'd.

the university, creating a STEM career pathway for youth. In addition, some youth participants in the eBird project became so interested that they looked into becoming more involved with eBird. Strengthening the communication between scientists who use the citizen science databases could not only positively affect continued participation in citizen science programming with these youth, but also establish a pathway for youth to move toward careers in science.

Gender Implications

We also found evidence that *Driven to Discover* program is well-suited for girl-friendly STEM programming. These are some relevant characteristics of *Driven to Discover*:

- It consistently attracted more middle-school girls than boys.
- It was successful with an all-girl team and could incorporate girl-friendly approaches to learning (i.e. teamwork and hands-on activities).
- It attracted many female adult leaders interested in guiding teams and mentoring the girls.
- It used subject matter that interested girls.

On the other hand, the program had a more difficult time getting boys involved for reasons that are still unclear. Some suggestions for making the program more boy-friendly include recruiting more male adult leaders, finding citizen science topics more attractive to boys, and/or integrating the program with other activities that boys like to do. One team with a good proportion of boys worked with water; another incorporated canoe trips with their bird observations, which was an attractive activity for all the youth, no matter what their gender.

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Appendices


We are scientists because...
We Love Butterflies!
We are scientists because
Mrs. Petersen has brought our interests together through her passion and experience about science. She has shared her knowledge and love of nature.

Appendix A: Outcomes

Table 30. Intended Outcomes of the *Driven to Discover* Program

Outcome		Statement
Youth	Outcome 1: Knowledge	Youth will gain knowledge about science content relevant to their citizen science and independent research projects.
	Outcome 2: Awareness/ Understanding	Youth will increase their awareness of what citizen science is and ways it can contribute to science.
	Outcome 3: Attitude	Youth will develop positive attitudes about their role in science.
	Outcome 4: Engagement	Youth engage in the scientific inquiry process.
	Outcome 5: Skills	Participating youth will develop scientific inquiry skills.
Adult Leaders	Outcome 1: Knowledge	Adult leaders who participate in the project (training and citizen science research clubs) will increase their knowledge about science inquiry.
	Outcome 2: Knowledge	Adult leaders who participate in the project (training and citizen science research clubs) will increase their knowledge about inquiry-based teaching methods.
	Outcome 3: Knowledge	Adult leaders who participate in the project (training or citizen science research clubs) will increase their awareness of citizen science and its potential to contribute to the body of scientific knowledge.
	Outcome 4: Knowledge	Adult leaders who participate in the project increase their understanding of how to mentor youth to carry out citizen science protocols.
	Outcome 5: Attitudes	Adult leaders who participate in the project (training and citizen science research clubs) will gain confidence about his/her abilities as an inquiry mentor for youth.
	Outcome 6: Skill	Adult leaders who participate in the project (training and citizen science research clubs), will exhibit the ability to mentor youth inquiry projects.

Appendix B: Team Data Observation Outcomes

This appendix documents observation outputs and outcomes in order to show how the programs played out in different contexts.

Engagement in Science Inquiry
Adult leaders' strategies to engage youth were observed in conjunction with youth engagement for specific measurements in each science inquiry phase. The highest levels are documented in the tables.

General Youth Engagement and Adult Leader Facilitation Strategies
General youth engagement and adult leader facilitation outcomes are also documented, along with other items describing the teams and their activities.

Successful Team Elements
Finally, we summarized the overall team elements and identified the ones critical to successful science inquiry. We used the 14 elements identified in the grounded theory under the headings of program settings or situations, prominent team characteristics, and program design or structures (Meyer, et al., 2013).

We added five elements (double asterisk) identified during observations as being particularly supportive of helping the team meet its program goals. These elements may fit under another grounded theory category, but seemed important to highlight more specifically for the purposes of the evaluation. The elements observed to not be successfully when applied to the team are documented in gray text (See Table 29 for the complete list of Grounded Theory and observed elements that led to successful program outcomes).

Appendix B: Team Data Observation Outcomes, cont'd.

Team A: Adult Leader Type–Teacher

Table 31. Team A: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activity		Effectiveness of Adult Leader Strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	High	All/All
	Asking thoughtful questions	High	Most/Few
	Reflecting and rethinking	High	Most/Most
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	High	All
	Pose testable scientific questions	High	All
	Devise their own questions to investigate	Not Observed	
Gathering Evidence to Test Questions	Critique explanations and investigation methods	High	All
	Design their own investigations	Not Observed	
	Gather evidence necessary to answer a particular question	High / Moderate	All /All
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	Not Observed	
	Develop possible explanations for observations using evidence	High	All
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	High / High	Most / All
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	Not Observed	
	Develop scientific claims based on observational evidence	Not Observed	

Team Descriptors

Team Citizen Science Project: Monarch Larva Monitoring Project

Meeting setting: Arboretum (Meadow)

Youth age range: 12–13 years

Youth gender: 18 Female, 2 Male

Program selection criteria: Youth Self-Selected (incentivized by using the activities for their formal education science fair requirements.)

Youth safety: Fulfilled

Supportive environment: Fulfilled

Meeting length: 2.5 hours

Citizen Science data collection: 0.5–1 hour

Number of meetings: 15 meetings

Average youth attendance: 9 meetings

Experienced all phases of inquiry: Fulfilled

Number of D2D posters, 2013: 18

Youth Engagement

Listening attentively when necessary: Most

Youth participating actively in conversations: Most

Evidence of positive youth emotions (excitement, enthusiasm, wonder): Most

Youth doing what they were "supposed" to do: All

Youth not wanting to leave (due to high interest): Few

Adult Leader Facilitation Skills

Conveying science content: High

Conveying Science Inquiry concepts: High

Facilitation/engagement skills/strategies: High

Dealing with youth dynamics: High

Presence of challenging youth dynamics: Low

Adult-Youth decision-making interactions: High

Appendix B: Team Data Observation Outcomes, cont'd.

Team A

Table 32. Team A: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successful Contributing Program Settings/ Situations	Successful Contributing Team Characteristics	Successful Contributing Program Designs/Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated Skills/Knowledge** • Supportive Environment for Learning** • Adult Leader Pre-meeting Preparations** • Reflecting and Rethinking** • Science Content Knowledge of Leader**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

*Grounded Theory-Generated **(**Meyer et al., 2013)
**Observation-Generated

Appendix B: Team Data Observation Outcomes, cont'd.

Team A

Overall Program Goals and Processes
Team A met its program goals at a high level. The team leader was observed to have a high level of ability to implement strategies for engaging youth in all phases of science inquiry. All youth were observed engaging in at least one measurement for each phase of inquiry. The youth completed the program with their own science projects that they brought to the science fair.

Program Setting/Situation
The team had a relatively narrow age range (7th-8th graders) and was an extension of a teacher/student relationship in school, so long-term relationships were being (or already had been) established between the youth and/or the adult leader. In addition, these youth self-selected into the program with an interest in science and an incentive that they could use their projects for their science fair requirements in the upcoming school year.

The team had access to a meadow at an arboretum, which generally offered *good access to milkweed plants*. The meadow was re-growing from a controlled burning in 2013 when we observed the team, but it still found milkweed to monitor for monarchs.

The adult leader also seems to regularly find a new endeavor to engage the youths' help during the meetings—such as identifying a new flower—which brings a sense of *novelty* to the meeting, expanding on the citizen science data or science inquiry data they were collecting.

Team Characteristics
The adult leader engaged in two practices that seemed to help youth develop a *science* identity: 1) She asked a lot of questions, so the youth had to "be the scientists" and think about how they would answer the questions, rather than just giving an answer, and 2) She validated the skills and knowledge that they had developed, saying things like, "you are now good at finding the eggs," or validated that they knew the data collection procedures before going into the field.

The adult leader also established a culture of self-directed learning early in the program. Instead of lecturing, she modeled engaging in science inquiry and led her youth in doing the same. The youth followed the established norm and answered their own questions by observing, looking up information in the field guides, and learning to answer their inquiry questions by collecting data.

Program Design/Structure
The adult leader in this team had a strong command in leading youth with a positive affect as well has having a good deal of scientific knowledge of monarchs and MLMP in addition to her years of experience as a teacher with age range of youth she led. The adult leader took the time to put structures in place that allowed youth to focus on tasks, including ensuring that materials were present and structuring the agenda to match where the team needed to focus its activities for the day.

The team leader created continuity, mentioning what the team had done in previous weeks to foreshadowing what they would be doing in the upcoming weeks, helping youth see the big picture by connecting the ideas and concepts they worked with week to week. The outcome was that the youth were getting a picture of the ecosystem rather than just a particular organism.

The youth picked up plant specimens and organisms that they found while monitoring in the field then looked at them under a microscope or looked them up in a field guide when they came back to the pavilion. This was done without prompting from the adult leader and seemed to be merely for the sake of learning (as opposed to doing it as a required activity).

Before the youth checked the milkweed, the adult leader reviewed the proper procedure...so the newer youth knew how to do and to remind the returning youth to be careful and accurate. Her frequent reminders to be careful and accurate in their data collection methods, in connection with helping them understand the citizen science, probably helped them understand the importance of their contributions.

Appendix B: Team Data Observation Outcomes, cont'd.

Team B: Adult Leader Type–Teacher

Table 33. Team B: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activity		Effectiveness of Adult Leader Strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	High	All
	Asking thoughtful questions	High	Most
	Reflecting and Rethinking	High	All
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	High	Most
	Pose testable scientific questions	High	All
	Devise their own questions to investigate	High	Most
Gathering Evidence to Test Questions	Critique explanations and investigation methods	Not observed	
	Design their own investigations	Not observed	
	Gather evidence necessary to answer a particular question	Not observed	
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	High	All
	Develop possible explanations for observations using evidence	High	Most
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	High	All
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	High	All
	Develop scientific claims based on observational evidence	High	All

Team Descriptors

Team Citizen Science Project: Water

Meeting Setting: School-based classroom; community ponds

Youth Age Range: 9–10 years

Youth Gender: 3 Female, 4 Male

Program selection criteria: Youth self-selected

Youth safety: Fulfilled

Supportive environment: Fulfilled

Meeting length: 1–2.5 hours

Citizen Science data collection: <0.5 hours

Number of meetings: 8 + a few fall meetings

Average youth attendance: 8 + a few fall meetings

Experienced all phases of inquiry: Fulfilled

Number of D2D posters, 2012: 3

Youth Engagement

Listening attentively when necessary: All

Youth participating actively in conversations: All

Evidence of positive youth emotions (excitement, enthusiasm, wonder): All

Youth doing what they were "supposed" to do: All

Youth not wanting to leave (due to high interest): Most

Adult Leader Facilitation Skills

Conveying science content: High

Conveying Science Inquiry concepts: High

Facilitation/engagement skills/strategies: High

Dealing with youth dynamics : High

Presence of challenging youth dynamics: Moderate

Adult-youth decision-making interactions: Moderate

Appendix B: Team Data Observation Outcomes, cont'd.

Team B

Table 34. Team B: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successfully Contributing Program Settings / Situations	Successfully Contributing Team Characteristics	Successfully Contributing Program Designs / Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated Skills/Knowledge* • Supportive Environment for Learning** • Adult Leader Pre-meeting Preparations** • Incorporating "Fun" Activities** • Reflecting and Rethinking** • Science Content Knowledge of Leader** • Challenging Activities**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

*Grounded Theory-Generated (Meyer et al., 2013)
**Observation-Generated

Appendix B: Team Data Observation Outcomes, cont'd.

Team B

Overall Program Goals and Processes

Team B met the program goals at a high level. The team leader was observed to have a high level of ability to implement strategies to engage youth in all but one phase of science inquiry (data collection was not observed, but the team worked with the water samples they collected and talked about the sampling experience). Furthermore, all youth were observed engaging in at least one measurement for each phase of inquiry (except data collection). The youth completed the program with their own science projects that they brought to the science fair.

Program Setting/Situation

The team collected the data from two nearby ponds, but met the rest of the time in a classroom setting. The combination of the outside and inside activities provided a blend of activities that the youth could relate to science. The classroom, with microscopes and additional materials, was an ideal place to explore the water samples. In addition, classroom whiteboards and computers allowed the youth to visually display and share their findings.

The adult leader was a fourth-grade science teacher who recruited youth from her class, so a established relationship and familiarity with the meeting place already existed. The adult leader felt the extra time spent on science over the summer would benefit youth as they entered the fifth grade. The participants were on the younger side of the expected age range of the program (9–10), but the program seemed to offer the right level of challenge for them to develop scientific skills and think scientifically.

Team Characteristics

The youth were excited about being there and particularly enthusiastic about playing interactive games, which the adult leader would use after focusing youth on mentally challenging tasks. Youth were also enthusiastic about presenting their findings to others on the team, which could suggest that they were forming a positive identity around science.

The youth were fully supported in answering their own questions in a scientific way and the adult leader constantly helped them turn their questions into hypotheses. It took some of the students more than one meeting to understand the difference between a question and a hypothesis. The outcome was that the youth displayed excitement when they got to move forward and answer their own questions after reflecting on a data collection plan with the adult leader.

The adult leader provided a variety of learning opportunities. Youth worked alone, in teams, or one-on-one with her to come up with a question, analyze their data, and learn to present it. Presenting their findings to others in the group seemed to energize the

After observations of the enclosed water becoming stinky in a previous session, a youth asked, "Could we put water from [the park] in one bucket with no holes and some in another bucket with holes and see how they are different?" The adult leader then asked: "How can you turn that into a hypothesis?" The student stated "Will dissolved oxygen in a water sample that is closed to air for two days change?" He was excited about this topic and about testing his question.

Youth teams working on a science inquiry task often needed the assistance of the adult leader to process the assignment. Topics such as 'determining which axis was the most appropriate for the data' was often problematic for these youth. This is one example in which it was important for the adult leader to have a good understanding of both science inquiry and the topic they were exploring.

Appendix B: Team Data Observation Outcomes, cont'd.

Team B

small-group teamwork. The youth learned through the process when their notes or data were insufficient to answer their questions.

Program Design/Structure
We observed no activities relating to contributing to a citizen science database, but the adult leader did talk with her team about topics related to water in the cities; therefore, youth felt connected to the important task of studying water, especially concerning topics like water quality and pollution. Furthermore, the continuity of meeting twice a week for four weeks in the summer allowed youth to review the major concepts with different information until they really understood them, as well as building on the information they were learning to generate a new perspective on their subject matter. The long (2.5 hours) meetings gave the youth time to learn about science content, discover new things, and implement science inquiry activities. The adult leader ate lunch with youth prior to the meeting, which produced a welcoming atmosphere.

Finally, the adult leader was skilled at helping the youth follow their own questions while adding hints to help them toward answering questions that were testable at their level and within their time allotment. The adult leader's one-on-one time with each youth appeared to be a very important component of their learning in this context, as were the adult leader's understandings of science and science inquiry.

The youth experienced plenty of opportunities to reflect and rethink. For example, after finishing an inquiry, the adult leader asked how they would do the test the next time. The youth said they would recommend a swampier area since it would have more mosquitoes and, therefore, a larger sample size. The adult leader offered the possibility of the same site, but a different time of the day (when there would be more mosquitoes), which the youth liked because they could then use some of the data they already collected as a comparison.

Despite the adult leaders' high level of science inquiry facilitation skills, the students struggled with forming appropriate scientific hypotheses. This may be due to the concepts being at the edge of the cognitive capacity for youth around ages 9-10.

Appendix B: Team Data Observation Outcomes, cont'd.

Team C: Adult Leader Type–Youth Leader

Table 35. Team C: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activity		Effectiveness of Adult Leader Strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	Moderate	All
	Asking thoughtful questions	Low	Few
	Reflecting and rethinking	Low	Half
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	Low	Most
	Pose testable scientific questions	Low	Few
	Devise their own questions to investigate	Low	Half
Gathering Evidence to Test Questions	Critique explanations and investigation methods	Low	None
	Design their own investigations	Low	None
	Gather evidence necessary to answer a particular question	Low	All
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	Moderate	Most
	Develop possible explanations for observations using evidence	Low	None
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	Low	Few
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	Low	None
	Develop scientific claims based on observational evidence	Low	All

Team Descriptors

Team Citizen Science Project: Monarch Larva Monitoring Project

Meeting setting: Wildlife Rehabilitation Center and Youth and Family Services Building

Youth age range: 12–17 years

Youth gender : 2 Female, 5 Male

Program selection criteria: Court-ordered

Youth safety: Fulfilled

Supportive environment: Fulfilled

Meeting length: 1.5–2 hours

Citizen Science data collection: <0.5 to 0.5 hours

Number of Meetings: 8

Average youth attendance: Unknown

Experienced all phases of inquiry: Fulfilled

Number of D2D posters, 2012: 0

Youth Engagement

Listened attentively when necessary: Most

Youth participated actively in conversations: Half

Evidence of positive youth emotions (excitement, enthusiasm, wonder): Half

Youth doing what they were "supposed" to do: Half

Youth not wanting to leave (due to high interest): Few

Adult Leader Facilitation Skills

Conveying science content: Low

Conveying science inquiry concepts: Low

Facilitation/engagement skills/strategies: Low

Dealing with youth dynamics : High

Presence of challenging youth dynamics: High

Adult-youth decision-making interactions: Low

Appendix B: Team Data Observation Outcomes, cont'd.

Team C

Table 36. Team C: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successfully Contributing Program Settings / Situations	Successfully Contributing Team Characteristics	Successfully Contributing Program Designs / Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated Youth Skills/Knowledge** (only for one youth working with the scientist) • Adult Leader Pre-meeting Preparations** • Supportive Environment for Learning** • Incorporating "Fun" Activities** • Science Content Knowledge of Leader** • Reflecting and Rethinking** • Challenging Activities**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

*Grounded Theory-Generated (Meyer et al., 2013)
**Observation-Generated

Appendix B: Team Data Observation Outcomes, cont'd.

Team C

Overall Program Goals and Processes
Team C met all program goals at a low level. The team leader was observed to have a low level of ability to implement strategies to engage the youth in all but one phase of science inquiry (observation for the purpose of collecting citizen science data). Most youth were observed engaging in at least one measurement for each of phase of inquiry. The youth were not completing their own projects, instead collecting data for the citizen science project or for questions the adult leader set up for them.

Program Setting/Situation
The youth met at a Wildlife Rehabilitation Center (which had easy access to a field with milkweed) and a meeting space in a Youth and Family Services Building. The youth were observed to be more engaged when doing hands-on activities outside and seemed to be interested in what science content they were learning.

Most youth were, or had been the previous year, court-ordered to attend the program, so the subject area did not necessarily reflect their personal interest.

Team Characteristics
The team leader was skilled in working with youth and keeping them on task. When there was a clear activity goal, the adult leader was more confident and modeled the process of science well, but lacked the confidence to lead the youth in more complex elements of science inquiry. She successfully helped the team stay focused on the monitoring activities or with an activity that helped the youth learn about science content, but struggled when trying to lead them through developing hypotheses or thinking more deeply about the subject matter. The youth were not engaged during the inquiry-based activities when the adult leader was not confident in her own knowledge or skill.

The adult leader relied on a visiting scientist to help the youth with the science content and process. The leader's lack of science knowledge and the lack of ability to help the youth stay engaged in inquiry may have limited the number of questions the youth asked and the depth of their engagement in science.

Likewise, although the leader sometimes asked the youth questions, youth were not prompted to think deeply or critically about the subject matter. When spending individual time with one female youth participant, the visiting scientist did some prompting to help her think more deeply.

Especially at the field site, the adult leader was very good at corralling a difficult group of kids and keeping the majority of them interested, engaged, learning, and on topic.

The adult leader struggled with the science content and the science inquiry concepts and often deferred to the scientist. During these cases, she was less effective in managing the energy levels in the youth.

The adult leader may have taken the role of recording to allow the youth to focus on the content, but it also made it easier for the youth to disconnect from the discussion, since they were not physically participating.

By the end of the program the youth were able to understand how to state a hypothesis. They were, however, clearly at the edge of their cognitive ability to understand how to state more than two hypotheses.

Appendix B: Team Data Observation Outcomes, cont'd.

Team C

Program Design/Structure
This team depended heavily on the visiting scientist to teach them science content and the inquiry process. Although the adult leader adeptly led the youth in a supportive environment through predesigned activities, the activities alone (without the adult leader modeling the inquiry process or expecting it from the youth) failed to promote deeper questioning or provide the validation of expanding knowledge and skills and the motivation or expectation necessary to engage in inquiry to answer their own questions.

The program was designed to have an adult accompany two youth in field activities. It seems like good design to provide this type of group with individual-level mentoring. The one youth who benefited the most was paired with a same-sex scientist mentor who helped her think critically about the activities. The other two groups were not led through the scientific thinking processes by their adult mentor and may not have been pushed to the edge of their capability during the activities.

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Appendix B: Team Data Observation Outcomes, cont'd.

Team D: Adult Leader Type–Natural Resource Educator

Table 37. Team D: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activities		Effectiveness of Adult Leader strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	High	All
	Asking thoughtful questions	High	Most
	Reflecting and rethinking	High	Most
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	High	All
	Pose testable scientific questions	High	All
	Devise their own questions to investigate	High	All
Gathering Evidence to Test Questions	Critique explanations and investigation methods	High	All
	Design their own investigations	High	All
	Gather evidence necessary to answer a particular question	High	All
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	Moderate	Half
	Develop possible explanations for observations using evidence	Not observed	
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	High	All
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	High	All
	Develop scientific claims based on observational evidence	Not Observed	

Team Descriptors

Team Citizen Science Project: eBird
Meeting setting: Urban nature center
Youth age range: 8–14 years
Youth gender: 5 Female, 7 Male
Program selection criteria: Youth self-selected
Youth safety: Fulfilled
Supportive environment: Fulfilled
Meeting length: 1.5 hour
Citizen Science data collection: <0.5 hour
Number of meetings: 10
Average youth attendance: Unknown
Experienced all phases of inquiry: Fulfilled
Number of D2D posters, 2013: 2

Youth Engagement

Listened attentively when necessary: Most
Youth participated actively in conversations: Most
Evidence of positive youth emotions (excitement, enthusiasm, wonder): All
Youth doing what they were "supposed" to do: All
Youth not wanting to leave (due to high interest): Most

Adult Leader Facilitation Skills

Conveying science content: High
Conveying science inquiry concepts: High
Facilitation/engagement skills/strategies: High
Dealing with youth dynamics: Moderate
Presence of challenging youth dynamics: Medium
Adult-youth decision-making interactions: High

Appendix B: Team Data Observation Outcomes, cont'd.

Team D

Table 38. Team D: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successfully Contributing Program Settings / Situations	Successfully Contributing Team Characteristics	Successfully Contributing Program Designs / Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated Skills/knowledge** • Supportive Environment for Learning** • Adult Leader Pre-meeting Preparations** • Incorporating "Fun" Activities** • Science Content Knowledge of Leader** • Reflecting and Rethinking** • Challenging Activities**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

*Grounded Theory-Generated **(**Meyer et al., 2013)
**Observation-Generated

Appendix B: Team Data Observation Outcomes, cont'd.

Team D

Overall Program Goals and Processes
Team D met the program goals at a high level. The team leader was observed to have high levels of ability to implement strategies to engage the youth in all phases of science inquiry. All youth engaged in at least one measurement for each phase of inquiry. The youth completed the program with their own science projects that they brought to the science fair.

Program Setting/Situation
This program, based on the eBird citizen science project, met at an Urban Environmental Center well-connected to the community. The youth, who self-selected, all appeared to have an interest in science. Many of the youth returned from year to year and already knew each other. The environmental center, a prime area for observing a wide variety of birds with water, field, and forest habitats, was within easy walking distance.

Team Characteristics
Both the youth and leaders of this team had a strong science identity. The youth came into the program with a desire to do science and the mentors at the center regularly validated their skills and knowledge. The youth's contributions were also shared with the center, engendering value to their work in their community in addition to the value of their work to eBird.

The adult leaders had a high command of science content, science inquiry, and informal youth education, a blend observed to be highly effective in practice. Furthermore, the youth were provided structured activities, but with plenty of opportunity to direct their activities within the structure. For example, the adult leaders may determine that they would be doing a mini-inquiry that day, but the youth teams decided on the question, hypotheses, and data collection plan and how to present the data.

Program Design/Structure
The center was welcoming and the youth seemed proud to identify with it. There is a sense that they are part of a larger community of scientists engaging in activities in their community. The ongoing activities and connections with various mentors continued to deepen the skills of the youth, some of who could then share their expertise with others at the center. Also, due to the variety of habitat, there were plenty of new things to discover each year.

This program had the highest level of youth-driven activities seen in the observations. The youth were essentially directing their own learning with mentorship and logistical leadership available to serve their needs. In addition, regular contributions to the eBird data base were entered online directly by the students, which helped the youth understand that what they were doing was part of a larger science project.

The adult leaders and the setting somehow supported having a large age range with the youth. The younger participants contributed less to the conversations, but the youngest soaked up information and repeated information about identifying birds even though he was not yet skilled at it.

The adult leader used repetition to help the youth review the inquiry process and remind them of the purpose of what they were doing for the day (observing for eBird AND thinking about a question they could test with the inquiry process).

The adult leaders used questions, rather than supplying the youth with answers, to redirect youths' reflections toward the best outcome that the youth could supply with their knowledge. They allowed the youth to find their own over-sights as they worked with mini-inquiries around their questions. In this way, they gradually got better at thinking critically about how to design a study.

Appendix B: Team Data Observation Outcomes, cont'd.

Team E: Adult Leader Type–Youth Leader (4-H Setting)

Table 39. Team E: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activities		Effectiveness of Adult Leader strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	High	All
	Asking thoughtful questions	High	Most
	Reflecting and Rethinking	High	Most
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	High	All
	Pose testable scientific questions	Moderate	All
	Devise their own questions to investigate	Moderate	All
Gathering Evidence to Test Questions	Critique explanations and investigation methods	Not observed	
	Design their own investigations	Not observed	
	Gather evidence necessary to answer a particular question	Not observed	
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	Moderate	Most
	Develop possible explanations for observations using evidence	High	All
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	Not observed	
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	Not observed	
	Develop scientific claims based on observational evidence	Not observed	

Team Descriptors

Team Citizen Science Project: eBird

Meeting setting: Urban Community Center

Youth age range: 9–17 years

Youth gender: 14 Females

Program selection criteria: Youth self-selected into the community program at an established and well-connected community center.

Youth safety: Fulfilled

Supportive environment: Fulfilled

Meeting length: 0.5 hour–1.5 hours

Citizen Science data collection: <.05 hour

Number of meetings: 16

Average youth attendance: unknown

Experienced all phases of inquiry: Fulfilled

Number of D2D posters, 2012: 1

Youth Engagement

Listened attentively when necessary: Most

Youth participated actively in conversations: All

Evidence of positive youth emotions (excitement, enthusiasm, wonder): All

Youth doing what they were "supposed" to do: Most

Youth not wanting to leave (due to high interest): Half

Adult Leader Facilitation Skills

Conveying science content: Moderate

Conveying science inquiry concepts: Moderate

Facilitation/engagement skills/strategies: High

Dealing with youth dynamics : High

Presence of challenging youth dynamics: High

Adult-youth decision-making interactions: Moderate

Appendix B: Team Data Observation Outcomes, cont'd.

Team E

Table 40. Team E: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successfully Contributing Program Settings / Situations	Successfully Contributing Team Characteristics	Successfully Contributing Program Designs / Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* • Group Context* • Novelty Space* • Ecological Suitability*	• Science Identity* • Facilitation Practice* • Scientific Practice* • Self-Directed Learning* • Validated skills/knowledge** • Supportive environment for learning** • Adult Leader pre-meeting preparations** • Incorporating "Fun" Activities** • Science Content Knowledge of Leader** • Reflecting and Rethinking** • Challenging Activities**	• Value of Contribution to Citizen Science* • Activation of Knowledge* • Welcoming Atmosphere* • Active Skill-building* • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities*

*Grounded Theory-Generated **(**Meyer et al., 2013)
**Observation-Generated

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Appendix B: Team Data Observation Outcomes, cont'd.

Team E

Overall Program Goals and Processes
Team E met all program goals at a moderate level for all but two phases of inquiry (the other two were completed but not observed). The team leaders were observed to have moderate to high levels of ability to implement strategies to engage the youth in the phases of science inquiry. All youth were observed engaging in at least one measurement for each phase of inquiry we observed. The youth were able to complete the program with their own science project that they brought to the science fair.

Program Setting / Situation
This group met at a community center, a hub for many youth activities including 4-H. The *Driven to Discover* program was a great fit, since youth in the community do not have science in their schools. The youth attended the program by their own choice.

The team regularly practiced their birding skills in a nearby park, but also took a field trip to a bird sanctuary.

The group was all-female and ranged in age from 9–17. This dynamic created an atmosphere of bonding and also an environment where youth were easily led off topic in their conversations. Some of this straying, however, involved discussing what they had learned in previous sessions, which reinforced their learning.

Team Characteristics
This group did not come in with strong science identity, since they lack science as part of their school curriculum. The youth seemed to be very interested, however, in learning about birds and were engaged throughout the activities.

The adult leader was well-versed in working with youth, keeping them on task, and guiding them into thinking more deeply about science and science inquiry via the use of questions. As a result, the adult leader created a culture in which the group frequently reflected and thought about what they were doing.

There were areas where the learning could have deepened with additional adult leader refinement in helping the youth understand some elements of science inquiry. For instance, youth were not cued to define multiple hypotheses, so it is unclear whether they understood the concept.

At times, the adult leader sat back and allowed the youth to run their process in activities such as brainstorming or generating questions for their projects. During other times, the adult leader instinctively knew she needed to intervene—such as when they really needed to choose a project question in order to collect the data necessary to complete it.

At the end, the adult leader opted to let the group out early because they were getting distracted. However, one girl wanted to decide on the title of the project and went up to the white board and four of the six youth joined her to help. They were engaged when they led it themselves and they seemed to really like writing on the white board.

There were some cases when the reflections could have gone deeper had the adult leader had deeper science knowledge, since she was really good at leading the youth through reflective discussions. When she didn't know the answer to science content questions, however, the question went up on the "I wonder board," which could be used later for discussions.

The youth were clearly interested in finding answers to their questions. For instance, popular questions were "Why do birds like to mob?" and "What's the most common bird that crows mob against?"

Appendix B: Team Data Observation Outcomes, cont'd.

Team E

Program Design/Structure

Because of the relatively short meeting times (about 30 minutes) during the summer, the girls mostly learned about science content in the summer then did their data collection activities in the fall when they had longer periods (90 minutes) to engage in their activities. This seemed to work well for the team and built on the knowledge over a longer time period.

Our observations failed to provide a clear picture of how the team was working with eBird, but it did convey a large amount of knowledge and skill building, including a field trips to learn from other scientists. The youth showed high engagement and excitement about learning about birds.

This team had a high level of energy that took some skill in managing, but the adult leader was able to provide what was needed. It helped the youth to take the lead in processing information when the energy was high, since it kept them focused on getting to the outcome.

Appendix B: Team Data Observation Outcomes, cont'd.

Team F Adult Leader Type–Community Youth Leader

Table 41. Team F: Adult Leader Facilitation and Youth Engagement by Inquiry Activity

Inquiry Activities		Effectiveness of Adult Leader Strategy	Proportion of Youth Engaged
Observing and Questioning	Making observations	High	All
	Asking thoughtful questions	Moderate	Half
	Reflecting and rethinking	Low	Half
Scientific Questions and Hypothesis(es) Development	Constructing possible alternative explanations for their observations	Low	Half
	Pose testable scientific questions	Low	None
	Devise their own questions to investigate	Low	Few
Gathering Evidence to Test Questions	Critique explanations and investigation methods	Low	None
	Design their own investigations	Low	None
	Gather evidence necessary to answer a particular question	Moderate	All
Analyzing and Interpreting Data	Use graphs or charts, computer programs or other tools/methods to make sense of the data	Low	All
	Develop possible explanations for observations using evidence	Low	None
Concluding and Reporting Results	Explain newly acquired knowledge during large and/or small group discussions	Low	All
	Describe investigations and findings to others using evidence to justify how data were collected and their conclusions.	Low	None
	Develop scientific claims based on observational evidence	Low	None

Team Descriptors

Team Citizen Science project: Monarch Larva Monitoring project

Meeting setting: Community park

Youth age range: 8–14 years

Youth gender: 1 Female, 4 Male

Program selection criteria: Self-selected, parent-appointed

Youth safety: Fulfilled

Supportive environment: Fulfilled/partially fulfilled

Meeting length: 1.5 hours

Citizen Science data collection: <0.5 hour

Number of meetings: 6

Average youth attendance: 4

Experienced all phases of inquiry: Fulfilled

Number of D2D posters: 2013, 2014: 0

Youth Engagement

Listened attentively when necessary: Most

Youth participated actively in conversations: Half

Evidence of positive youth emotions (excitement, enthusiasm, wonder): All

Youth doing what they were "supposed" to do: All

Youth not wanting to leave (due to high interest): None

Adult Leader Facilitation Skills

Conveying science content: Moderate

Conveying science inquiry concepts: Low

Facilitation/engagement skills/strategies: Low

Dealing with youth dynamics : Moderate

Presence of challenging youth dynamics: Low

Adult-youth decision-making interactions: Low

Appendix B: Team Data Observation Outcomes, cont'd.

Team F

Table 42. Team F: Successful Team Elements (Black Text = Observed/Gray Text = Not Observed)

Met Core Program Goal and Processes	Successfully Contributing Program Settings / Situations	Successfully Contributing Team Characteristics	Successfully Contributing Program Designs / Structures
• Science Inquiry • Authenticity • Engagement	• Learning Suitability* (not observed) • Group Context* (not observed) • Novelty Space* (not observed) • Ecological Suitability*	• Science Identity (only 1 youth seemed to exhibit a science identity)* (not observed) • Facilitation Practice* (not observed) • Scientific Practice* (not observed) • Self-Directed Learning* (not observed) • Validated Skills/Knowledge** • Supportive Environment for Learning** • Adult Leader Pre-meeting Preparations** • Incorporating "Fun" Activities** • Science Content Knowledge of Leader** (not observed) • Reflecting and Rethinking** • Challenging Activities**	• Value of Contribution to Citizen Science* (not observed) • Activation of Knowledge* (not observed) • Welcoming Atmosphere* • Active Skill-building* (not observed) • Discovery* • Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities* (not observed)

*Grounded Theory-Generated (Meyer et al., 2013)
**Observation-Generated

Appendix B: Team Data Observation Outcomes, cont'd.

Team F

Overall Program Goals and Processes
Team F met all the program goals at a low level for the inquiry phases. Team leaders were observed to have moderate to low ability to implement strategies to engage the youth in the phases of science inquiry. All youth engaged in at least one measurement for each phase of inquiry except for developing scientific questions and hypotheses (half the youth engaged in developing questions and hypothesis). The youth were able to complete the program for a science project, but most of the work was done by the adult leader.

Program Setting/Situation
The team met outside a neighborhood library (after it was closed) at a picnic table on the side of a park. All the youth came from the neighborhood, making this a convenient place to meet. The milkweed site was about a half-mile away alongside a highway. The highway noise made it difficult to hear or have a discussion and it was difficult to find a place to sit, look through the field guide, or write up observations. Milkweed were present, however. The time it took to walk to and from the milkweed site shortened activity time and the group often ran short on processing information at the end of the meeting.

The age range and conceptual ability of the youth were very large. Two of the youth were siblings and sons of the adult leader (not attending by their own will), which somewhat affected the dynamics of their interactions.

Team Characteristics
The adult leader and the two younger youth seemed to have an interest in science, but the adult leader's boys were not particularly interested. It is not clear whether they would have been more enthusiastic under a non-parent adult leader.

The adult leader had good ideas but lacked experience in fully engaging youth in the process. Attempts to engage the youth often failed, with youth either not interested in or unable to understand the main concepts. The youth were interested in the insects in the field, however, which could have been capitalized on with self-directed learning activities if there had been a little more meeting time to follow individual questions and inquiries and to engage in the practice of science.

As a result, authentic engagement in the practice of science was low, with missed opportunities for the youth to use the scientific process with something that held their interest.

The youth were particularly excited when they found organisms on the milkweed, especially unidentified ones. They would announce to the group each time they found another organism and have other youth or the adult leader come and look at it. The adult leader did not know what they were, and they did not look them up in the field guide, but took pictures to show the visiting scientist at the next meeting.

The explanation at the beginning of the data collection activity failed to hold the youths' interest. Some were staring off into space and it was hard to tell if they were listening. The youth shared activity sheets with the adults as an adult read the data collection directions from the page. Some youth did not understand the activity and no effort was made to make sure they did. The adults took the lead and did not make sure the youth were doing things. The adults answered each other's questions if the youth did not respond and failed to pull the youth into the discussion.

Appendix B: Team Data Observation Outcomes, cont'd.

Team F

Program Design/Structure
The adult leader for this group took the time to prepare for each meeting and provided a welcoming atmosphere for youth. She provided structure to the program and gave positive feedback to the youth during activities and discussions.

The adult leader entered the citizen science data at home with her two youth. They understood citizen science at the end of the program, but the rest of the youth were not exposed to the recording of the information they collected as a team.

Although the adult leader modeled doing the science and asked questions, she did not have a strong science background and needed more practice engaging the youth in the science activities in order to more successfully build the team's science skills. The visiting scientist helped somewhat, but did not make up for the low amount of engagement strategies. Without successful application of youth science engagement strategies, the adult leader had to take the lead in planning and making choices about the activities.

The adult leader needed more practice to increase her skills in engaging the youth in inquiry. The adult leader would come up with questions and ask the youth, but after the youths' guesses, the discussion would end without anyone developing any knowledge or skill in thinking about the question.

Appendix C: Definitions of Key Science Inquiry Elements

Below are definitions of the key elements that help or hinder authentic science inquiry as identified by Meyer et al.'s Grounded Theory research (2013).

Program Setting/Situations

Learning Suitability: Youth and adult team members' reactions to physical and psychological demands of the setting influence engagement in citizen science and other learning activities.

Group Context: Youth and adult team member's pre-existing group identity and make-up influence engagement in citizen science and other learning activities. Pre-existing group identity and make-up, due to factors like group history and goals, familiarity with each other, and recruitment into the group, influences outcomes of data collection, discovery, active skill building, and engagement of youth team members.

Novelty Space: New cognitive, geographical and psychological elements of the experience can positively and negatively influence engagement of youth and adult team members.

Ecological Suitability: The observable variety of species over time, due to factors like population changes or site management, influences outcomes of citizen science data collection, discovery, active skill building, and engagement of youth team members.

Team Characteristics

Science Identity: Adult and youth team members tend to demonstrate competence, affinity, and recognize themselves and/or others recognize them as "doing science."

Facilitation Practice: Adult leaders practice "social, interactive, and holistic" methods that promote youth observation, questioning and authentic scientific investigation within contexts of citizen science data collection.

Scientific Practice: Research teams capitalize on the skills and also knowledge of individual members specific to the citizen science project in which they are involved.

Self-Directed Learning: Youth and adult team members tend to take the initiative, with or without the assistance of others, in diagnosing their needs, formulating goals, and learning improved practice.

Program Design/Structures

Value of Contribution to Citizen Science: Strategies promote the worth, importance, and accuracy assigned to data collected by citizen scientists.

Activation of Knowledge: Field experiences create practical applications for previously inert knowledge, and knowledge that can activate in other settings.

Welcoming Atmosphere: Learning environments in which youth and adult team members feel a sense of belonging supports engagement.

Active Skill-building: Activity approaches that provide opportunities for youth and adult team members to engage in a hands-on, minds-on manner with materials and ideas supports engagement and authenticity.

Discovery: The systematic act of observing/recording phenomena sparks youth and adult team members to notice and become curious about new things.

Team Member Involvement in Planning, Making Choices About, and Reflecting on Activities: Approaches that involve youth with adult team members in decision-making and reflection about goals, activities and outcomes support engagement and authenticity.