Arctic Harvest - Public Participation in Scientific Research Project

Final Evaluation Report

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Executive Summary

The Arctic Harvest-Public Participation in Scientific Research (which encompasses the Winterberry Citizen Science program), a four-year citizen science project looking at the effect of climate change on berry availability to consumers has made measurable progress advancing our understanding of key performance indicators of highly effective citizen science programs. These indicators include preparation to participate in the program, alignment of goals and activities between the project scientists and participants, evidence of volunteers making a valuable contribution to science, an effective feedback loop between project staff and participants, a feeling a social and cultural importance of the project among participants, and evidence of participants extending the project in some way into a broader community.

All three of the citizen science program models being tested in the Arctic Harvest-Public Participation in Scientific Research project (a basic model, highly supported model, and highly supported storytelling model) effectively implemented four programmatic characteristics that are evidence-based good practices for engaging diverse audiences in citizen science at high levels.

- Participants in all three models were **prepared** to participate in a Winterberry investigation as a facilitator or contributor with both training and materials. Interviews suggest that training provided by the project prior to start-up was essential for adult participants to feel prepared and that in person on-boarding and presentations in classrooms were helpful in preparing both adult and youth participants.
- Winterberry **project goals and activities aligned** with, responded to, and were relevant to the needs and interests of the adult participants. Interviews indicate that most of the adult participants had curricular or learning goals related to climate change.
- Adult participants felt strongly that they were making a **valuable contribution to science**. Interview data indicates that most of the adult participants had a strong understanding of the ways in which the data they were collecting would be used by scientists.
- All three models established a **feedback loop** between the participants and the program's science team or program staff. Interview data indicated that interactions with scientists ranged from emails and phone calls to working one-on-one with scientists to establish research sites and reviewing data with the participating youth.

Two of the six programmatic characteristics for engaging diverse audience in citizen science, social and cultural importance and community engagement, were evidenced to a greater degree among rural youth groups and groups whose educators were cross trained in a co-produced educator training program designed to facilitate climate change learning through both Indigenous and Western Science also offered by the project PIs (the Arctic and Earth SIGNs program). However, there were significant differences between participant types and program models in the implementation of these programmatic characteristics.

- **Social and cultural importance** rubric scores were significantly ($p < .05$) greater for adult participants who participated in a co-produced educator training program designed to facilitate climate change learning through both Indigenous and Western Science also offered by the project PIs (the Arctic and Earth SIGNs program) in addition to Winterberry than those adult participants who only participated in a Winterberry project. Rural participants also reported significantly ($p < .0001$) higher levels of social and cultural importance of the project than did urban participants. Adult participants who identified social and cultural characteristics motivating their participation in the project explicitly provided a clear description of why their project is important to their local community in terms of food security, tradition, or climate change.
- Participants receiving the storytelling model treatment ($p = .011$) and who were also participating in the A&E SIGNs project ($p = 0.001$) were significantly more likely to report **engaging their local community** in project activities. Those interviewed describe engaging their local communities by bringing in Elders or local experts to help explore a community need or problem and presenting their projects and findings to a larger audience.

Data indicates that youth were engaged in the Winterberry citizen science project activities in various ways. These types of engagement included youth participating in scientific data collection, but went far beyond in the form of discourse in the field while monitoring berries, joining conference calls with scientists while on the road for youth sports because they didn't want to miss the opportunity, data analysis, youth leadership of the project, extending the project to cooking and food preservation, and presenting the project to professional audiences. As youth engagement in citizen science projects has the potential to increase their interest in STEM, their self-efficacy for science and stewardship, and their cognitive skills to generate and apply data and engage in systems and scenarios thinking, this is a key finding. Further we found that youth engagement was significantly different for two factors: model type and participation in A&E SIGNs.

- Youth engagement was significantly higher for the storytelling ($p < .001$) and supported ($p < .014$) models than for the basic model.
- Youth engagement was significantly greater in groups whose leader had participated in A&E SIGNs in addition to Winterberry than in groups whose leader only participated in a Winterberry project ($p = .007$).

In addition, preliminary data suggest youth engagement is highly correlated with adult interaction, including higher levels of engagement through the supported and storytelling models, as well as engagement with scientists and Winterberry staff as evidenced by the positive feedback loop developed by the Winterberry citizen science project and by the community engagement reported by many of the adult participants interviewed.

- There was a significant positive association ($p = .002$) between youth engagement and the feedback loop indicator scores.
- There was a significant positive association ($p = .023$) between youth engagement and local community engagement indicator scores.
- There was a significant positive association ($p = .036$) between youth engagement and social and cultural importance indicator scores.

Youth data indicate that

- Adult preparation contributed specifically to
    - positive changes in youth STEM self-efficacy ($p = 0.007$) and
    - youth critical thinking scores ($p = 0.039$).
- Adult goal alignment contributed
    - to positive changes in youth stewardship self-efficacy ($p = 0.016$) and
    - negatively to youth goal alignment ($p = 0.009$).
- Adult identification of social and cultural important contributed
    - to positive changes in youth STEM self-efficacy ($p = 0.007$) and
    - to positive youth goal alignment ($p = 0.007$).
- Adult identification with contribution of science did not specifically contribute to any youth outcomes.
- Adult identification of a feedback loop did not specifically contribute to any youth outcomes.
- Adult identification of community engagement contributed to several youth outcomes:
    - Youth goal alignment ($p < 0.001$).
    - Youth report of meaningful impact ($p < 0.001$).
    - Youth report of communication with others about their project ($p < 0.001$).

Recommendations

To improve the participation in and effectiveness of citizen science across diverse audiences, particularly at high-latitudes where a high proportion of communities have populations underrepresented in STEM, we recommend the following:

- Provide in-person as well as written training materials for all participants, including youth. Update training regularly to address emerging issues and to encourage ongoing participation. This recommendation is particularly important for programs with education outcomes goals.

- Continue to highlight the important contributions of the citizen science to the research being conducted. This recommendation is particularly important for motivating adult participants.
- Encourage science and program staff to work directly with youth participants to encourage engagement, as well as to model science careers. This recommendation is particularly important for youth engagement goals.
- Share program goals for research, community impact, and youth outcomes with participants, including youth participants to help participants align their personal and professional goals with the citizen science program.
- Encourage community engagement by providing specific training to participants, including youth participants, about ways that they can engage their community. This recommendation is particularly important for engaging rural Alaska communities and underrepresented youth.
- Design programs to explicitly focus on a social and/or cultural issue for underrepresented communities. This recommendation is especially true for engaging rural Alaska communities and underrepresented youth.

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Acknowledgements

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Introduction

Winterberry-Arctic Harvest, a four-year citizen science project looking at the effect of climate change on the abundance and condition of wild berries, implemented three citizen science program models with varying degrees of 1) volunteer participation in the scientific process, 2) interaction between the program staff (scientists and mentors), and 3) local community engagement.

The **basic citizen science delivery model** ("basic model") included a brief training, weekly observations of berries, data entry and visualization through the project website, and a data discovery session using the group's data and included the following gear up, explore, reflect, and apply activities:

- **Gear Up**: a 1-hour training of group leaders either through a live webinar or community workshop, virtual or live visit by a scientist or program staff
- **Explore**: weekly observations of berries, data entry, and visualization through the project website
- **Reflect**: virtual visit by scientist for data discovery session using the group's data
- **Apply (Optional):** use of data to inform berry resource stewardship activities or planning, and presentations to local decision-makers and/or elders.

The **highly supported delivery model** ("supported model") increased in-person interaction with program mentors and scientists included the following gear up, explore, reflect, and apply activities:

- **Gear Up:** an on-site training for youth and educators, an optional additional 1-hour training of group leaders either through a live webinar or community workshop, in-person visit by scientist and mentor
- **Explore:** weekly observations of berries, data entry and visualization through project website
- **Reflect:** open access to and communication with an educator mentor, in-person reflection activity on science process by youth with a scientist, and a final visit by scientist and educator mentor for data discovery session using the group's data
- **Apply (Optional):** use of data to inform berry resource stewardship activities or planning, and presentations to local decision-makers and/or elders.

The **highly supported storytelling delivery model** ("storytelling model") that weaves in storytelling based on community experiences, youth observations, and citizen science data at all stages of the program learning cycle, included the following gear up, explore, reflect, and apply activities:

- **Gear Up:** an on-site training for youth and educators, an optional additional 1-hour training of group leaders either through a live webinar or community workshop, in-person visit by scientist and educator mentor, and community storytelling event

- **Explore:** weekly observations of berries, data entry and visualization through project website,
- **Reflect:** open access to and communication with an educator mentor, storyboarding in-person with a scientist and 360-video recording by youth of reflections of changes in their berry plants, in-person visit by a scientist and an educator mentor for a data discovery and scenario stories mini-workshop using data,
- **Apply (Optional):** use data and scenario stories to inform berry resource stewardship activities and planning, present scenario stories and plan to local decision-makers and/or elders.

During the three-year implementation period August 2017 to May 2020, the project engaged 1,525 unique individuals (155 adults and 1,370 children).

Table 1: Count of citizen science teams, adult participants, and youth participants by year and model type

Year/Model Type	Number of Teams Active	Number of Adult Participants	Number of Youth Participants
2017-2018	30	52	460
Basic	15	28	263
Supported	5	6	48
Storytelling	10	18	149
2018-2019	42	80	689
Basic	13	26	223
Supported	15	37	274
Storytelling	14	17	192
2019-2020	26	59	436
Basic	8	21	141
Supported	6	23	103
Storytelling	12	15	192

Evaluation Methods

The evaluation is guided by a program logic model and uses an outcomes-based evaluation approach (Fitzpatrick, Sanders, and Worthen, 2004) to assess the implementation and impact of the Arctic Harvest-Public Participation in Scientific Research Project's Winterberry Citizen Science component, with an eye to program improvement and to achievement of its intended outcomes. The final evaluation report focuses on the citizen science components that were particularly effective and contributed most to the achieved outcomes.

Instruments: We used a semi-structured interview protocol to collect data from adult Winterberry participants. The interview protocol asked participants to describe their experience in terms of key programmatic characteristics that should lead to increased engagement of populations underrepresented in STEM:

- Preparation: Participants were well prepared to participate in a Winterberry investigation and stewardship project as a facilitator or contributor with both training and materials (Meyer et al, 2013, Ruzic et al, 2016, Bonney et al, 2009).
- Goal Alignment: The project goals and activities aligned with, responded to, and were relevant to the needs and interests of the participants (Bonney et al., 2009, Shirk et al., 2012; Nov, Arazy, & Anderson, 2014, Wilderman et al., 2004, Corburn, 2007, Cheng et al., 2008, and Nerbonne and Nelson, 2008, Meyer et al., 2013, Lorenz, 2016).
- Social and Cultural Importance: The project or the resource being studied had social and cultural importance to the participants (Chase and Levine, 2016, Falk, 2001, and Bonney, 2009).
- Contribution to Science: Participants felt like they were making a valuable contribution to science (Nerbonne and Nelson, 2008, Lorenz, 2016, Ruzic et al., 2016)
- Feedback Loop: A feedback loop between the participants and the program's science team or program staff was established. The science team and program staff were available for support, to provide access to the data, and to accept participant feedback and suggestions (Ruzic et al., 2016; Evans et al., 2005).
- Community Engagement: Partnerships engage the local community (Pandya, 2012).

In addition to asking adult participants to describe how their Winterberry project was implemented, we also asked them to describe how youth participants engaged in the Winterberry project. Youth engagement in STEM activities is a short-term outcome that leads to increased interest in STEM and in STEM careers. Adult participants reported **satisfactory to strong** youth engagement, with an average youth engagement score various ways. These types of engagement included youth participating in scientific data collection, but went far beyond in the form of discourse in the field while monitoring berries, joining conference calls with scientists while on the road for youth sports because they didn't want to miss the opportunity, data analysis, youth leadership of the project, extending the project to cooking and food preservation, and presenting the project to professional audiences.

Sample: We interviewed 78.4% of the 51 unique individuals who served as adult leaders of Winterberry groups (e.g., leaders of out-of-school youth groups (Girl Scouts, 4-H, afterschool clubs, etc.), K-16 teachers, adult group leaders/members, or family group leaders). We conducted 64 interviews with 41 individuals over the three program years (2018, 2019, and 2020). Of those interviewed, seven were interviewed three times, ten were interviewed two times, and 23 were interviewed one time to investigate the influence of sustained participation in the citizen science program on the program outcomes and effectiveness indicators.

The sample spanned all three program model types: basic, supported and storytelling (Table 2). It also spanned participants in remote, rural, primarily Indigenous communities in Alaska and participants in urban or semi-urban locations ("urban," Table 3). We defined rural as communities with a population under 5,000 people (Alaska Department of Community and Regional Affairs, https://mtgis-portal.geo.census.gov/arcgis/apps/MapSeries/index.html?appid=49cd4bc9c8eb444ab51218c1d5001ef6) whether on or off the road system (e.g, Bethel).

Finally, several of the groups involved in Winterberry were also involved in a second program called Arctic and Earth STEM Integration of GLOBE and NASA assets (Arctic and Earth SIGNs or A&E SIGNs; Table 4). This program, which is also facilitated by the Winterberry project PIs, led educators and community members through a week-long, in person training on culturally responsive science education with an emphasis in engaging youth in climate change problem solving using citizen science. Winterberry was one of the project options available for Arctic and Earth SIGNs groups to select from for their projects. Teachers who were engaged in the Arctic and Earth SIGNs program and received this extra training spanned urban and rural communities, and all three of the Winterberry program models.

Table 2: Number of interviews by program type

Year	Total	Basic	Supported	Storytelling
2018	17	7	4	6
2019	29	13	5	11
2020	18	6	3	9
Total	64	26	12	26

Table 3: Number of interviews by rural or urban location

Year	Total	Rural	Urban
2018	17	6	11
2019	29	15	14
2020	18	6	12
Total	64	6	11

Table 4: Number of interviews by Arctic and Earth SIGNs participation

Year	Total	A&E SIGNs Participant	Not an A&E SIGNs Participant
2018	17	8	9
2019	29	16	13
2020	18	9	9
Total	64	33	31

Analysis: We used ATLAS.ti to code interviews using a priori codes, which included codes that represented key programmatic characteristics that should lead to increased engagement of populations underrepresented in STEM. These coded quotations were then used to complete a rubric that rated the interviewee's experience on a 1-4 scale (Appendix A includes the criteria for scores).

To increase validity when applying a priori codes for rubric use, we employed several methods. First, two evaluators coded several test interviews to check for intercoder agreement; numerical values reflected mediocre agreement, but further discussion with the evaluation team revealed that, given the number of a priori codes, number of interviews, coding goals, and time available, a more discursive approach would better fit this project. Moving forward, the two coding evaluators completed both the coding and the rubrics for interviews independently, and then convened to discuss the ratings as they progressed. The evaluators pinpointed areas where the rubric needed more clarity; meetings with the evaluation team and project PI and co-PIs were held to discuss questions in detail and firm up the rubric indicator descriptions for each rating. The coding evaluators continued to meet to discuss their ratings until discrepancies became consistently rare (one or two close-but-not-exact ratings per three interviews' worth of codes), and then one of the two evaluators completed the coding.

We created two SPSS files for analysis of the rubric scores. The first file included 40 unique participants and 64 rubric scores. Of the participants 23 participated in one interview, 10 participated in two interviews, and seven participated in three interviews. With this data, we used a Kruskal-Wallis H test to determine if there were differences in rubric areas by program year. The Kruskal-Wallis H test (sometimes also called the "one-way ANOVA on ranks") is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. When the Kruskal-Wallis H test confirmed significant differences, by year, we used a post-hoc pairwise comparisons using Dunn's (1964) procedure with a Bonferroni correction for multiple comparison to determine which years or treatment types were different (Laird Statistics, 2015).

We then averaged the rubric scores for the 40 unique participants in Excel, created a second SPSS file, and removed participants with no youth participants from the analysis. With this data, we used a Kruskal-Wallis H test to determine if there were differences in rubric areas by 1) model type, 2) rural or urban location, and 3) participation in A&E SIGNs or not.

We then used we used Kendall's tau-b (τ_b) correlation coefficient (Kendall's tau-b, for short) to assess if there were correlations between youth engagement as reported by adult leaders and the key programmatic characteristics that should lead to increased engagement of populations underrepresented in STEM.

To investigate the influence of key programmatic characteristics for increasing engagement of populations underrepresented in STEM on the individual learning outcomes of youth participants (see Table 5), we used Kendall's tau-b (τ_b) correlation coefficient (Kendall's tau-b, for short), a nonparametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale. We averaged the rubric scores of each adult/teacher who worked with youth and whose youth participants completed a pre- and post- survey. Each adult/teacher thus had a rubric score for each of the programmatic characteristic (preparation, goal alignment, social-cultural, contribution to science, feedback loop, and community engagement). We then assigned those rubric scores to the appropriate youth surveys.

Table 5: Youth self-reported outcome constructs

Outcome Constructs
Engagement Constructs
Interest in STEM
Science self-efficacy
Stewardship self-efficacy
Cognitive Constructs
Critical thinking
Quality of Youth Experience
Goal alignment
Contribution to science
Feedback alignment

Findings

Over a three-year period, the Arctic Harvest-Public Participation in Scientific Research Project facilitated 51 Winterberry citizen science projects, 32 of which continued for two or more years. To varying degrees these projects reflected key characteristics of citizen science that engage diverse audiences: Participants were well prepared to participate; project goals and activities aligned with, responded to, and were relevant to the needs and interests of the participants; the project or the resource being studied had social and cultural importance to the participants; participants felt like they were making a valuable contribution to science; a feedback loop between the participants and the program's science team or program staff was established; and partnerships engaged the local community. Following we discuss the extent to which these key characteristics were implemented.

Preparation

Adult participants consistently reported **satisfactory** preparation to implement Winterberry projects with youth, with an overall rubric score of 2.91. A score between 2.5 and 3.4 indicates that most group leaders reported an ease of starting their project, though there were some challenges that influenced their feelings of preparation. A Kruskal-Wallis H test determined that there were no significant differences in preparation by year ($\chi^2_{(2)}$ = 0.441, p = .802).

Table 6: Preparation rubric scores by program year (based on all interviews scored with the rubric)

Year	n	Mean Rubric Score
2017-18	17	3.00
2018-19	29	2.83
2019-20	18	2.94
Overall	64	2.91

A Kruskal-Wallis H test determined that there were no significant differences in participant feeling of preparation by **model type** ($\chi^2_{(2)}$ = 0.197, p = .906).

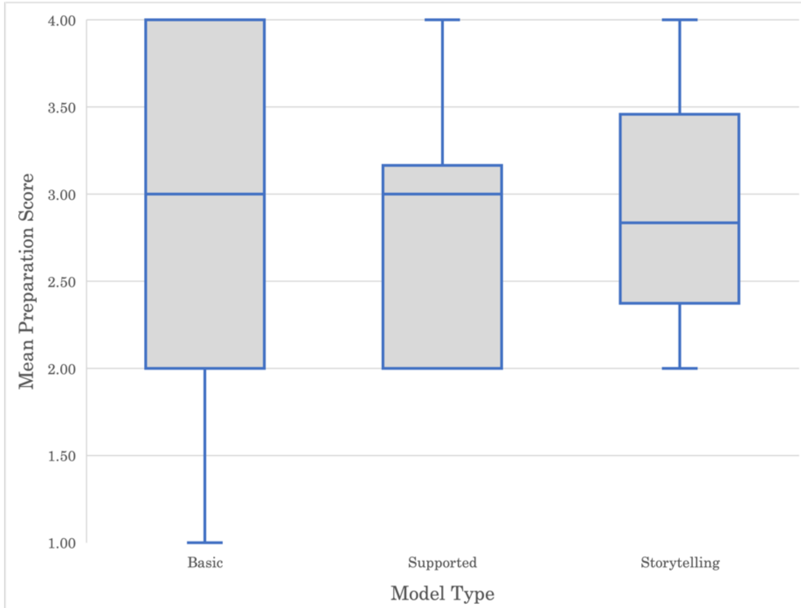

Figure 1: Mean preparation score by model type

A Kruskal-Wallis H test also determined that there were no significant differences in participant feeling of preparation by **rural or urban location** ($\chi^2_{(1)}$ = 0.472, *p* = .492).

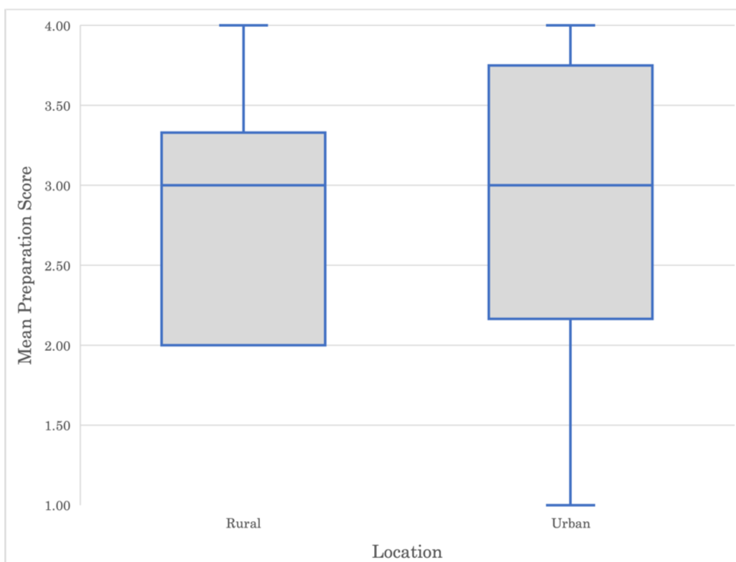

Figure 2: Mean preparation score by location

A Kruskal-Wallis H test also determined that there were no significant differences in preparation by whether or not the adult participant also received training through the **A&E SIGNs project** ($\chi^2_{(1)}$ = 0.017, *p* = .897).

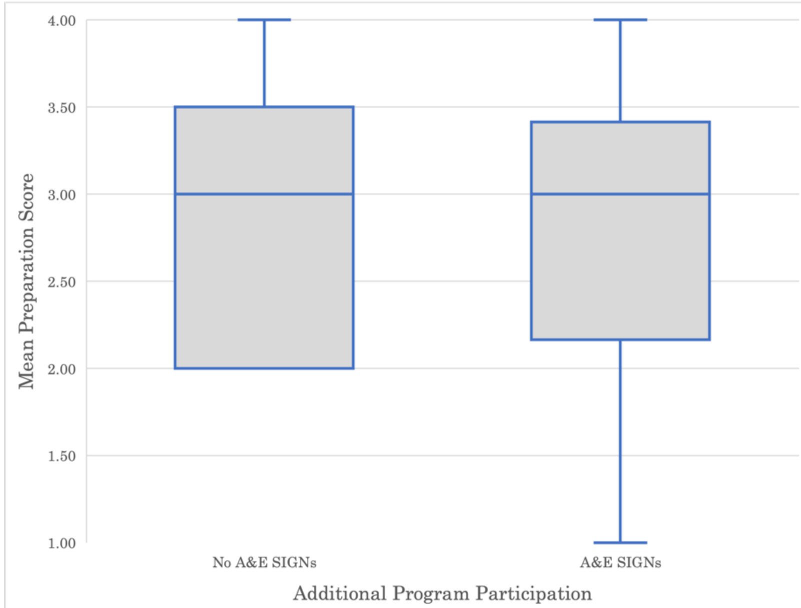

Figure 3: Mean preparation score by additional program participation

Interviews suggest that training provided by the project prior to start-up was essential for adult participants to feel prepared.

> *The training was really beneficial to me. Having the opportunity to interact with these scientists as a teacher was really important to me. I feel like it just put me on another level of understanding. Because I don't always have time to really dive into each of these projects. It's like I've got ten kids, ten different projects, I'm not the expert. But hey, you can call this person and I felt good about that. Call [scientist name]. She'll know the answers I don't. (Quote 25:50)*

> *We got started with our project was we had an overall training with the university. It was part of our partners with Twenty-First Century Afterschool Program. And part of our training of the whole program was ten sites. We went to university and we had an all-day class on the Winterberry and on GLOBE clouds formations. Then we signed up, then we were able to go outside and do [it]. (Quote 33:9)*

> *I think, you know, for me personally not being a scientist it was doing the hands-on protocol, like, practice in the class, when we would actually go out into the field and do the protocols for the different measurement gathering. And again, that's, like, me not being a scientist – like, that was really helpful, I think, was being able to do the things so that I could then translate that for the kids instead of just having it have been, you know, like a binder full of how-to manual stuff. So yeah, that was I think for me the biggest help, was actually hands-on doing the protocols. (Quote 56:21)*

Interviews also suggest that in-person on-boarding and presentations in afterschool clubs, classrooms or to families were also helpful in preparing adult participants and the youth with whom they worked.

> *[Scientist name] originally came in and then she went over the whole project with them. And she was back this year too and she came and introduced the project to them as well as the story element. And of course, she conducted that activity, I don't know if you've seen it, but she has different cards of berries and animals that might eat the berry. And it involved and almost do a short little skit of what would happen you know different times of the year, who's going to eat the berries or what's going to happen to the berry. You know, the big question, what happens to these berries on big snow years and things like that. (Quote 11:13)*

> *It would have been hard had I not had the training. I took the training twice and had not [scientist name] come out here I'm the type of teacher that needs help. I need that physical person to be right here in front of me showing me what to do. I'm that kind. I'm not the kind that somebody tell me what to do and then I'll go do it. I have to see it and be there. I would have probably given up and not done anything with it had it not been for the physical visits and the help that [scientist name] and [teacher consultant name] have been to us." (Quote 30:29-38)*

Also important to adult participants feelings of preparedness were the materials and general organization of the project.

> *I guess the most valuable, I mean I think the program was just really well put together such that it provided me a great learning opportunity to share with my students. And really most of the pieces were all there or well enough spelled out just that it was not a burden for me to implement. In fact, it was an asset for me as a teacher. (Quote 12:20)*

> *Yeah, I think the website is really great. I realize I need to take more advantage of it because I think they have a lot of great resources for getting people started. And like a berry family night and yeah, just the activities and stuff and the bingo. And the teaching resources too. So, I'd like to just kind of use those resources more with my students. (Quote 8:23)*

> *They sent us the instructions for setting up the site. Like I said, I had my class go out there originally and we set up the perimeter and went through the process of picking the berry bushes and making sure that we had 20 bushes and 100 berries. That took a little bit of a time. Students were involved in all of it. (Quote 47:6)*

Participant preparation is clearly important for successful implementation of a citizen science project. We anticipated that the participant feelings of preparation might decrease as the number of participants increased between years 1 and 2 and the Winterberry staff to participant ratio decreased. Contrary to what we expected, participants did not feel less prepared in years 2 and 3, which is strong evidence that the program created effective methods and materials to effectively prepare participants.

Goal Alignment

Adult participants consistently reported **strong** goal alignment, with an overall rubric score of 3.81. This score indicates that the Winterberry project objectives and design was very strongly aligned with the goals that the adult participants had for participating in the project. These alignments included very specific reasons provided by the adult participants on how the project address their goals for the youth who participated, for a curricular area, for a specific skill, for a community need, for a climate change or conservation issue, or for a personal reason. A Kruskal-Wallis H test determined that there were not significant differences in **goal alignment** by year ($\chi^2_{(2)} = 4.084$, $p = .130$).

*Table 10: **Goal Alignment** rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	17	3.76
2018-19	29	3.72
2019-20	18	4.00
Overall	64	3.81

A Kruskal-Wallis H test also determined that there were no significant differences in **goal alignment** by **model type** ($\chi^2_{(2)} = 3.314$, $p = .191$).

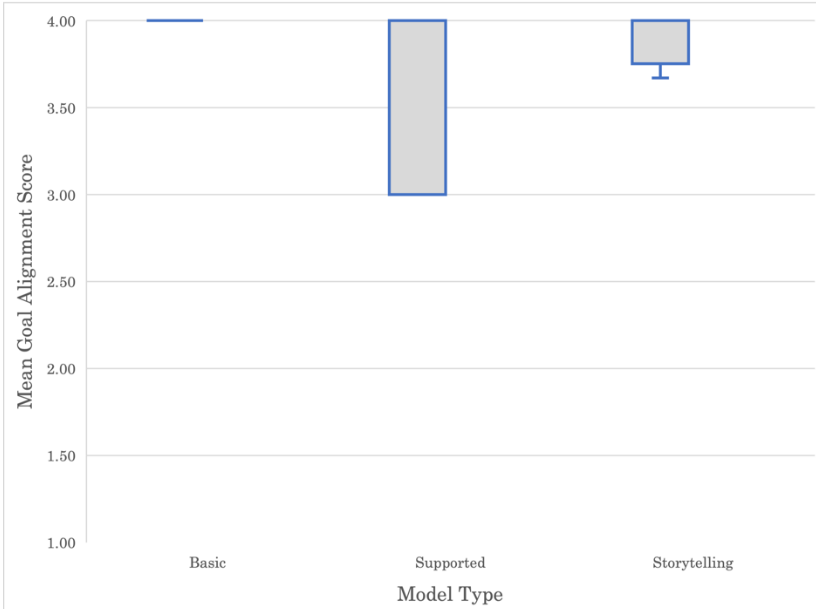

Figure 4: Mean goal alignment score by model type

A Kruskal-Wallis H test also determined that there were no significant differences in **goal alignment** by **rural or urban location** ($\chi^2_{(1)}$ = 3.459, *p* = .063).

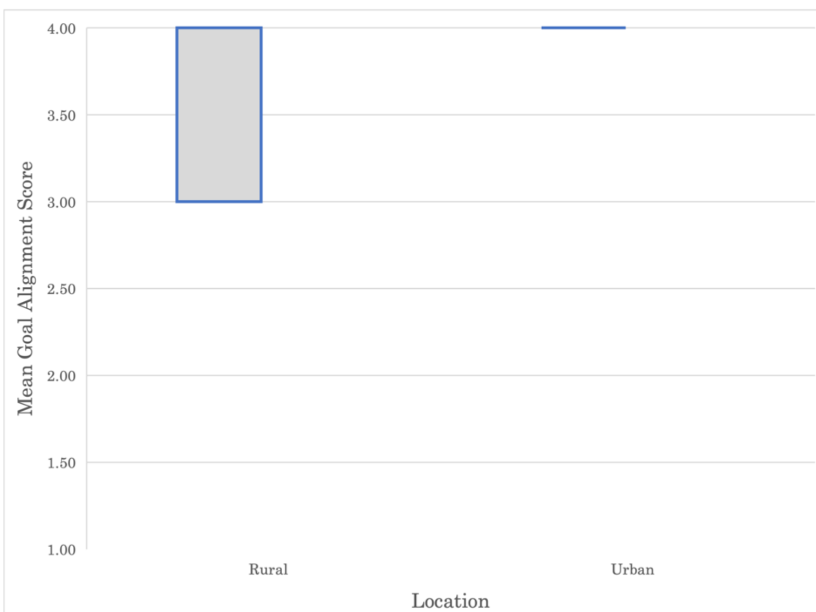

Figure 5: Mean goal alignment score by location

A Kruskal-Wallis H test also determined that there were no significant differences in **goal alignment** by whether or not the adult participant also received training through the **A&E SIGNs project** ($\chi^2_{(1)} = 1.537$, $p = .215$).

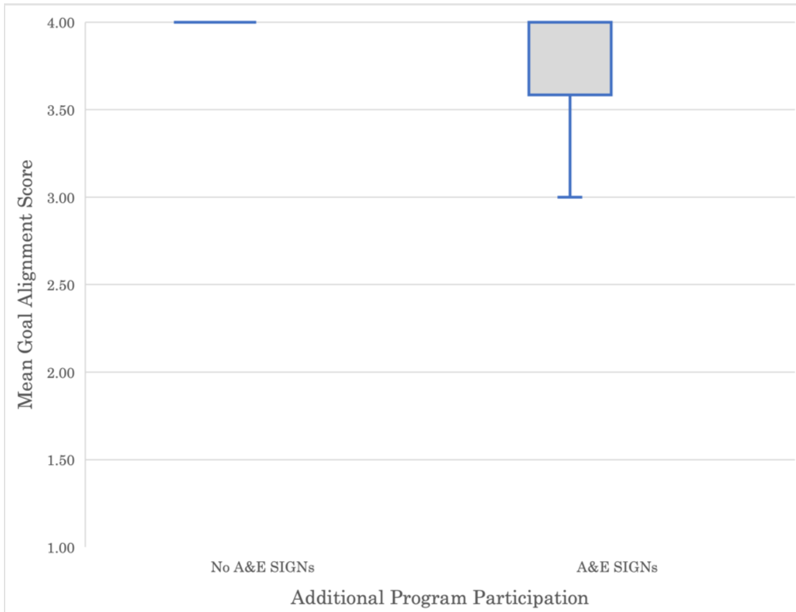

Figure 6: Mean goal alignment by additional program participation

Interviews illustrated that most of the adult participants were either formal or informal educators and had curricular goals or goals for the youth participants as a primary motivation for facilitating the Winterberry citizen science project with youth in their communities.

> *I think that teaching the kids how to gather this data, too, is very important to our village sustaining itself and the culture sustaining itself, as well as, the climate change and comparing all that data from other protocols that people do. I think that students need to be gathering this – you know, learning how to gather data because everything nowadays everywhere is data-driven. It doesn't matter if it's berries. You know, it's just data for everything, so it's just learning – you know, learning how to gather data and precise gathering of that data is so important. (Quote 1:23)*

> *Well, it's extremely convenient as a teaching tool because it's something that we can, you know, walk right out the door and involve them as your class and get berries there, but sort of ultimately teaching students about citizen science, about the project itself, and about local ecology. So, it's really just a perfect fit. (Quote 10:04)*

> *Our goal was to get more students into science and place-based education, and I'll get – also it assisted in other research projects and learning research protocols. My FFA students have other research projects that they're conducting, and this is just a very nice way to segue them into deeper research. (Quote 14:8)*

> *I think my goals are for students to have this openness to volunteer and help out. Well, I just think it's a great volunteering experience for the kids, you know this whole citizen science thing. I think that's a nice way for them to support the community. And then, I think the observation skills, having them observe what they're looking at is crucial. And then, writing that information down and monitoring, yeah, just monitoring and seeing the changes in an area that's just right there in their backyard. (Quote 18:9-10)*

> *They liked looking at the graphs of their data at the end of the year, and one of the third-grade standards is to use sheets to collect data, so we kind of played with that. We kind of did weather, and we have that documented in our Google Sheets. We did that in October, October, November, December maybe. And so yeah, they actually really liked playing with the different graphs that they, you can do on Google Sheets, so we also did that as well on the weather piece." (Quote 52:6)*

Several of the adult participants were particularly interested in youth or they themselves learning more about climate change and its impact on berries and the food supply.

> *Well, the whole idea of climate change, and the investigations are critical, and the Arctic being such a climate-sensitive environment. What do they say? It's the canary-in-the-mine type thing with regards to the health of the planet. So just getting students to understand that any data they collect in regards to changes in their environment, whether it's for climate change or against climate change or whatever, it's giving them things to critically think about and take measurements on to share with scientists, because we're on the ground and they're not." (Quote 39:6)*

> *"I like what I do. I'm a Citizen Scientist, I know I'm helping NASA and myself and my people. My goal is to get a better understanding on what's going on with our berries for our food security. How can we adapt with it? (Quote 26:11)*

> *It's perfectly aligned with what we do here, with our focus of trying to get the kids to think about – outside their door – what they can do in making observations. But I care. I personally care, and I want my kids to care. And I have them for two years, so why not care for two years at least? (Quote75:30)*

> *Well, I wanted to satisfy the research needs of the project, but beyond that, you know, just get the kids involved outside doing some research and understand, you know,*

how important it is to take accurate and legible notes in the field, and then get back to the classroom and make sure that all of the numbers added up right – just experience science. (Quote 86:7)

Well, I was interested in helping [through] Citizen Science. I believe that science isn't funded like it should be, and certainly, I mean it's the whole climate change, you know. I just think that it's more data to show us what the changes are. And everything dependent upon berries. So, I mean, it's until you start really thinking about anything you don't realize how critical it is. So, berries are very important, and I'm a birder. So, I mean animals, the birds, and I guess I didn't realize how much the animals depend upon the berries throughout the winter. So, it expanded my knowledge, and I think the more data we can get the better" (Quote 79:5)

The Winterberry focus on monitoring berry condition and abundance across Alaska appears to address both a curricular need for both formal and informal educators and at the same time interest adults in general in gaining a better understanding for themselves of the relationship between berry conditions and abundance and climate change.

Social and Cultural Importance

Adult participants reported **weak to satisfactory** social and cultural alignment, with an overall rubric score of 2.48. A Kruskal-Wallis H test determined that there were not significant differences in **social and cultural importance** by year ($\chi^2_{(2)} = .357$, $p = .836$).

*Table 7: **Social and Cultural Importance** rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	17	2.47
2018-19	29	2.41
2019-20	18	2.61
Overall	64	2.48

A Kruskal-Wallis H test also determined that there were no significant differences in **social and cultural importance** by **model type** ($\chi^2_{(2)} = 1.801$, $p = .406$).

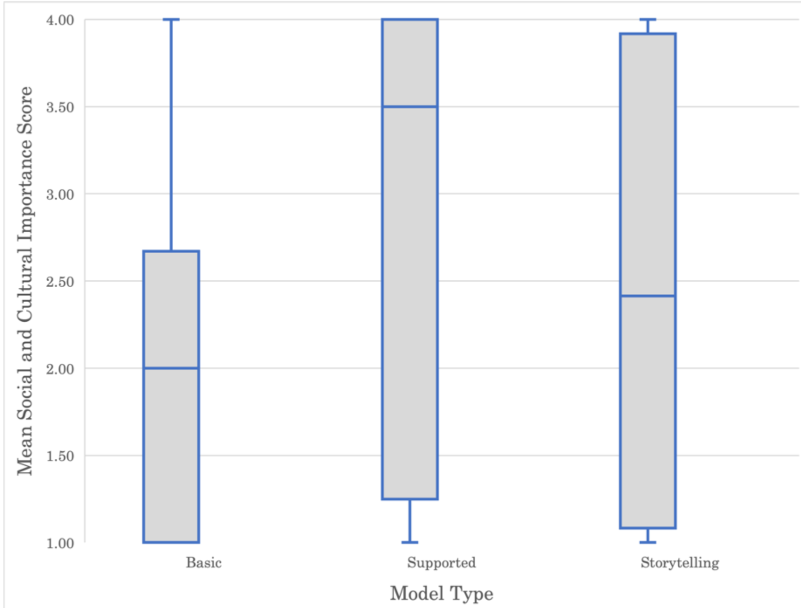

Figure 7: Mean social and cultural importance by model type

A Kruskal-Wallis H test determined that **social and cultural importance** rubric scores were significantly greater for adult participants from rural parts of the state than for adult participants from urban parts of the state ($\chi^2_{(1)} = 12.093$, $p < .001$).

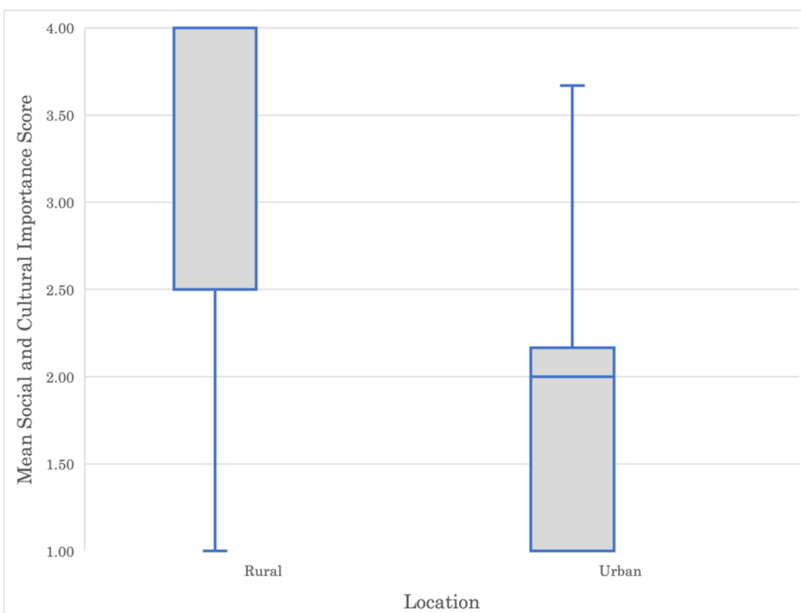

Figure 8: Mean social and cultural importance by location

A Kruskal-Wallis H test also determined that **social and cultural importance** rubric scores were significantly greater for adult participants who participated in **A&E SIGNs** in addition to Winterberry than those adult participants who only participated in a Winterberry project ($\chi^2_{(1)} = 4.546$, $p = 0.033$).

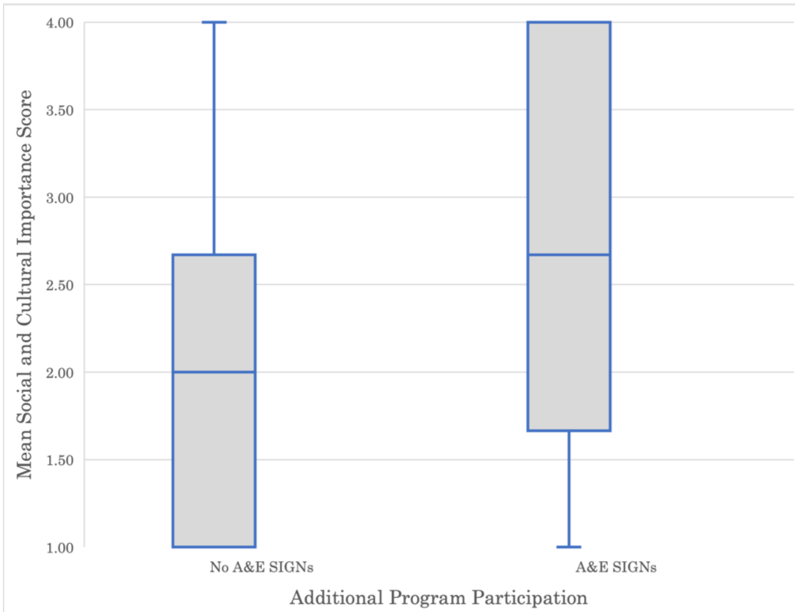

Figure 9: Mean social and cultural importance by additional program participation

Adult participants who identified social and cultural characteristics motivating their participation in the project explicitly provided a clear description of why their project is important to their local community in terms of food security, tradition, or climate change.

> *Well, berries are so important to our foods here, and – because they're a subsistence food they're – you know, people know that they're very rich nutritionally and they taste great in…fish ice cream. And people make jam out of it – delicious. And so it's, you know, vitamin C and all that other good stuff. I think that gathering this – teaching the kids how to gather, too, is very important to our village sustaining itself and the culture sustaining itself. (Quote 1:12)*

> *We bring in the cultural parts of it, too, and elder stories. I really try to integrate that, and I've done that. Last year I was pretty good about bringing in language learning to the project and then local stories about that plant to the project, which I really liked. Our story is a part of this study. That was really fun. (Quote 2:44)*

> *I'm hoping that the data and what they say is it's important to look at, what's going on in the environment so that the community can be resilient and adapt. The changes are coming. Climate – the climate is changing. Instead of being oh my goodness, I'm*

helpless here, the climate is changing, I'm gonna lose my lifestyle, I believe that these kinds of projects involve and gives ownership to the community members so that they say things are changing, I can change too. (Quote 25:49)

So that's what I really love about it. And that's something that is local here to our Native community is Native people are always learning. They're always taking information [from] the land and they're always going through a process of inquiry and something's not working with trapping or fishing, they try a different method. And so, it's just really interesting to tie it back to the local culture. (Quote 28:27) "And so on some of our community maps is actually listed local berry-picking site so that if any roads ever did come in, that that wouldn't affect the berry site. So thinking about next year down the road, that might be something that we do. I didn't really think about it at the time." (28:25) "It's going to a greater discussion than just our classrooms that we're a part of something bigger. That's I think really key. And that we can really tie it into our culture here." (28:31)

I think it has meaningful context to our students. If we can really wrap it around. We could get through this project and then wrap it into culturally how these berries are used, because they are. And their relevant even to the other animals. Maybe they're not harvested directly themselves by some, but if the animals that are important to the native diet here are dependent upon those things, I think it's real world for the kids and has a good cultural context, if we could get to that. (Quote 31:22)

For rural participants, the Winterberry citizen science project to monitor berry condition and abundance across Alaska clearly held more social and cultural importance than for urban participants. This finding was not entirely unexpected given that rural parts of the state tend to have larger Indigenous populations, who rely on berries for food security.

Valuable Contribution to Science

Adult participants reported **satisfactory to strong** alignment with the contribution to science characteristic, with an overall rubric score of 3.03. A Kruskal-Wallis H test determined that there were not significant differences in **contribution to science** by year ($\chi^2_{(2)} = 1.478$, $p = .477$).

*Table 8: **Valuable Contribution to Science** rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	17	2.94
2018-19	29	3.00
2019-20	18	3.17
Overall	64	3.03

A Kruskal-Wallis H test also determined that there were no significant differences in **contribution to science** by **model type** ($\chi^2_{(2)} = 1.643$, $p = .440$).

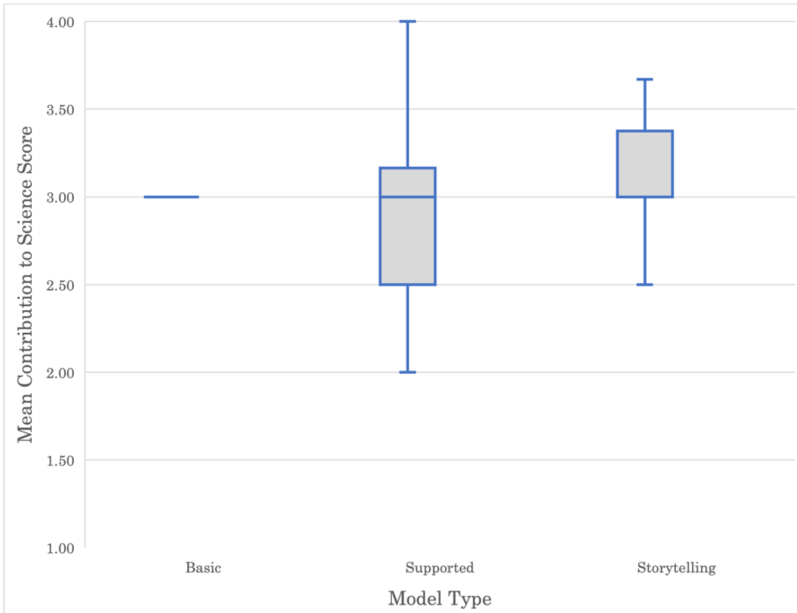

Figure 10: Mean contribution to science by model type

A Kruskal-Wallis H test also determined that there were no significant differences in **contribution to science** by **rural or urban location** ($\chi^2_{(1)} = 1.109$, $p = .292$).

Figure 11: Contribution to science by location

A Kruskal-Wallis H test also determined that there were no significant differences in **contribution to science** by whether or not the adult participant also received training through the **A&E SIGNs project** ($\chi^2_{(1)} = 0.000$, $p = .985$).

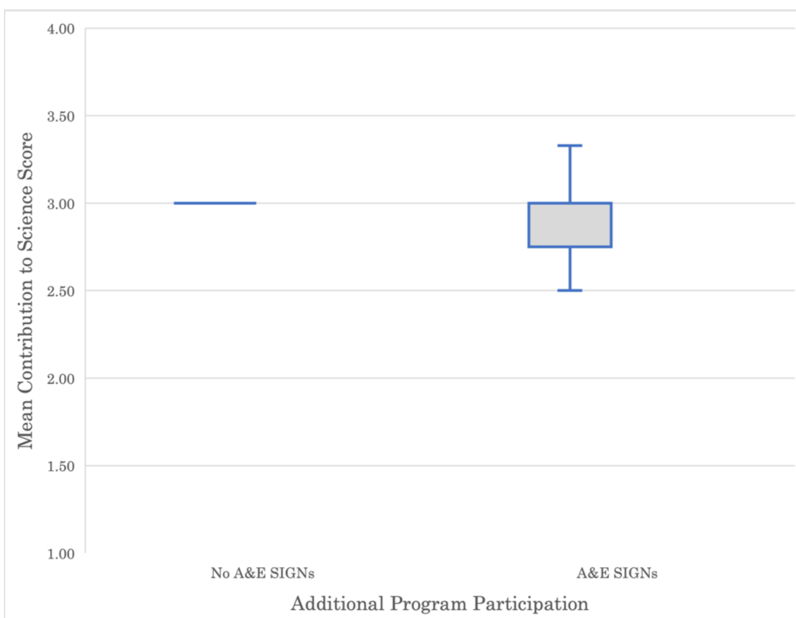

Figure 12: Mean contribution to science by additional program participation

Interview data indicates that most of the adult participants had a strong understanding of the ways in which the data they were collecting would be used by scientists. Responses like the ones below are illustrative.

> *I think the data overall is important with climate change and considering how dry it's been in certain areas of the state. It's not normally that dry. And then I think it just all goes together with other data points that scientists might look at in terms of the changes in Alaska climate. (Quote 2:32)*

> *I know that this is valuable for scientists all over and global warming and understanding what that is, any changes. Just historically in our area there's been increase in the willows in the last hundred years. I mean that's kind of widely known. But gosh, just the bigger picture of course. I think that's important. And for the students to realize also like I mentioned earlier that their data is going into the larger scientific community. It's valuable. (Quote 28:3)*

> *We'll all over Alaska their berries were also rotten because there was a lot more moisture and rainfall this year than in years past. So, we would find a lot more rotten berries. There were hardly any berries last year and then we found that to be the same throughout Alaska. So, it's been great to see that this protocol on the berry project are the same because then we can look at identifiers along the way and see what's actually changing and it's not just the localized region. It's all over. (Quote 30:13)*

> *It's our second year that we're monitoring berries here in Sitka and we're specifically looking at lowbush cranberries and crowberries here, but there are also rosehips and highbush cranberries that are being monitored elsewhere in the state because winterberries interested in looking at the differences between those four berries and their retention rate over the fall and winter. As the falls are getting warmer, the snows coming later, the hypothesis is perhaps the berries are rotting on the plant before freezing, and especially we have noticed differences already between the two different years here in Sitka. (Quote 37:1)*

> *Well, I mean I think they're studying kind of phenology of how they're changing. You know we're looking at – I mean I think that we're looking at it across the state. We're looking at temperature and whether they're rotting like before the cold comes. So, are they being eaten before fall comes and they can freeze? Are the freezing or are they rotting? (Quote 5:73)*

> *Oh, [they] will use the data. I think that they will clean up the data and publish it, and I think that, I know that several ideas for papers were in the works, the first one being more like a natural history of berries in Alaska. But I think they'll use our data*

because we are one of the further south locations to compare to like other places climate-wise, if trends were to – we're kind of like a projection, you know, for like, okay, if it gets warmer and rainier in other places, let's look at what our berries are doing and see what potentially could happen other places. (Quote 6:46)

The kids have been or the scientists have told us anyway that the data that kids have submitted seems to be very clean and therefore useful. And so I hope, my hope, and I hope that my students will know about this and I will know about this just to contribute to something bigger than themselves that eventually get published I think would be really cool. Not that my students need to publish to have that be a contribution to a publication would be huge. And I'm not sure that they're at a level of understanding yet of how important publications are in science and that could open up that conversation. (Quote 71:17)

I believe it will be used to publish trending and to see what our berries are doing. It will give a better scope; we hope it will give a better scope to see what's going across the state to see what is going on with our berries. Just to know the information may lead to other researchers or other young people wanting to go into different pathways of their careers. Also, it may encourage students with UAF to do a master's thesis just from being introduced to research at such a young age. So, what UAF will do with it I hope they will publish it. (Quote 84:14)

The Arctic Harvest-Public Participation in Scientific Research-Winterberry Citizen Science project's clear articulation of its science goals to participants helped to engage them in data collection to develop a local dataset and regional mode for understanding variability in berry phenology.

Feedback Loop

Adult participants reported **satisfactory to strong** alignment with the feedback loop between the program staff and themselves, with an overall rubric score of 3.14. A Kruskal-Wallis H test determined that there were no significant differences in **feedback loop** rubric scores by year ($\chi^2_{(2)} = 2.502$, $p = .286$).

*Table 9: **Feedback Loop** rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	17	3.29
2018-19	29	3.00
2019-20	18	3.22
Overall	64	3.14

A Kruskal-Wallis H test also determined that there were no significant differences in **feedback loop** rubric scores by **model type** ($\chi^2_{(2)} = 2.065$, $p = .356$).

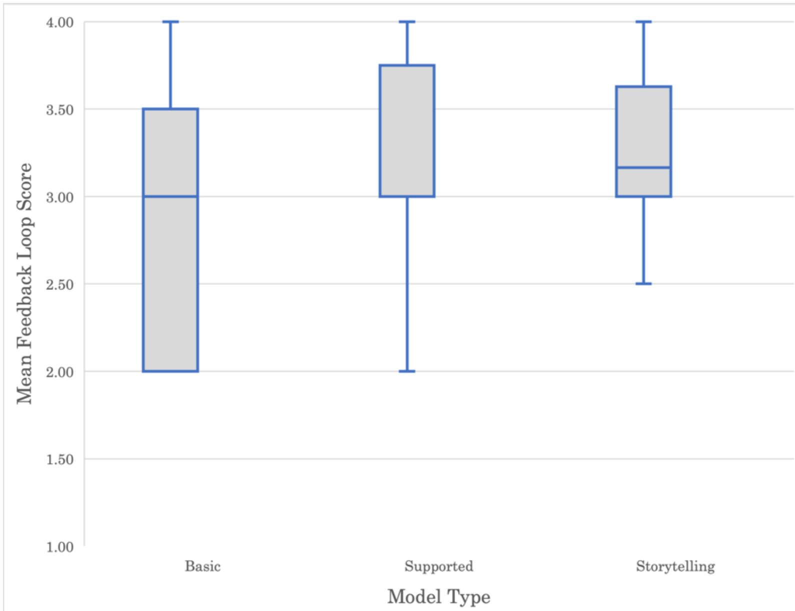

Figure 13: Mean feedback loop score by model type

A Kruskal-Wallis H test also determined that there were no significant differences in **feedback loop** rubric scores by **rural or urban location** ($\chi^2_{(1)} = .007$, $p = .933$).

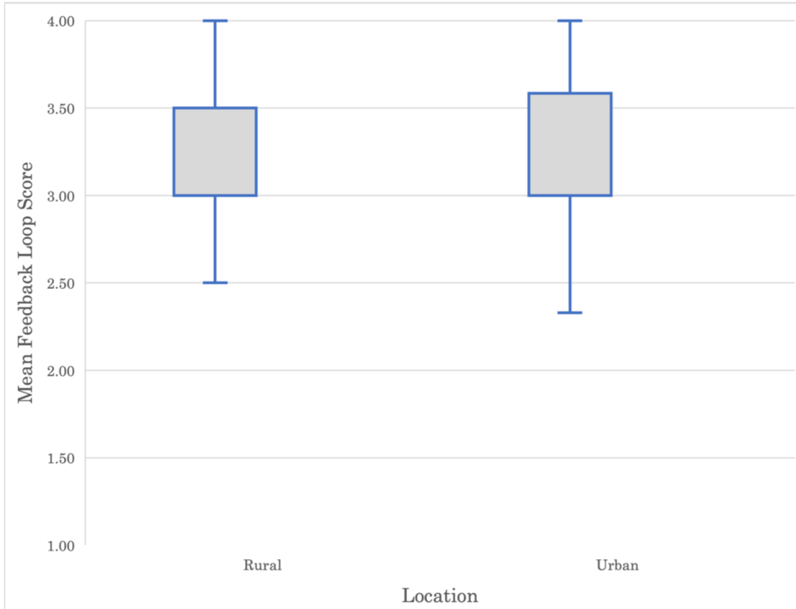

Figure 14: Mean feedback loop score by location

A Kruskal-Wallis H test also determined that there were no significant differences in **feedback loop** rubric scores by whether or not the adult participant also received training through the **A&E SIGNs project** ($\chi^2_{(1)} = 0.230$, $p = .632$).

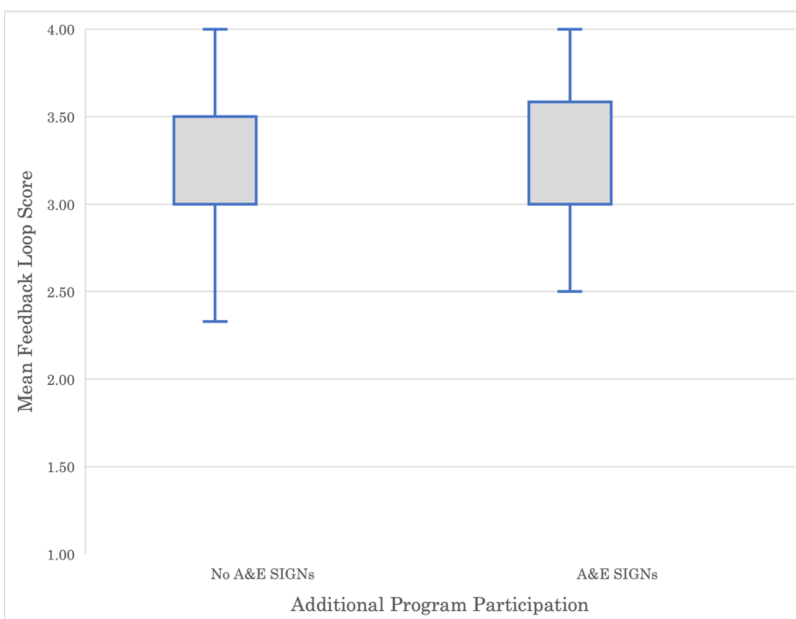

Figure 15: Mean feedback loop score by additional program participation

Interview data indicated that interactions with scientists ranged from emails and phone calls to working one-on-one with scientists to establish research sites and reviewing data with the participating youth. Following are several examples of how the feedback loop was established during the Winterberry project.

> *I have contact with them all the time. They're our partners. So, I actually was working [at Association of Interior Native Educators] and was also a participant at the workshop. So, it was in my line of work but I wanted to participate too. (Quote 26:12)*

> *…they come to my classroom. We Skype, do back and forth exchange, we facetime, we talk. My kids know Dr. [name of scientist]. She communicates with other scientists too. My students have talked to other scientists. We work closely with the NASA program with science and arrange meetings with them and so they'll call in and we'll talk to them and ask them questions. If what we need that scientist, we have study time topic that they're going to talk to us about. They tell us about data. They help us understand the data that we gathered. They show us the data that's been gathered from other places from people that's doing the same protocol. And they review our data and help us fine tune it. (Quote 30:23)*

> *Oh my gosh. An incredible amount of support. I really cannot thank them enough for how kind and patient they were throughout the entire process…and another thing that I'm very thankful for is all of the behind-the-scenes coordination that occurred with both [names of staff] as far as their coordination of travel for Alaska Forum on the Environment. Their coordination for travel for us to come up and pay a site visit to the Geophysical Institute at UAF. They've been excellent, really, really excellent. (Quote 46:32)*

> *Well, from the scientists at UAF, lots of support. I mean I had a question or the kids had a question, it was really easy to email them or call them up and ask them for clarification on things….[how often?] A couple times a month. (Quote 47:11)*

> *They were just super supportive. When I sent out an e-mail about just a couple questions, they always responded even if they were out in the field. It seemed like they were just really helpful, and they seemed to communicate well with me as well as with each other. Yeah, they just had a really good vibe in the classroom with the kids. The kids just loved having them in the classroom and also going out with them in the initial start. (Quote 48:12)*

> *[Staff name] reached out numerous times, as did [scientist name]. We had a couple of Zooms. So, UAF folks have been great about reaching out regularly. (Quote 7:21)*

[Staff name] was always super attentive, and sent emails periodically, that if I had questions, I could email her and she responded super-fast, so she was really, really helpful and I appreciated her support. And even at the fourth quarter, she called me, and then met me at school so that I could give her the last chunk of data sheets I had. So, she really went above and beyond in trying to get that stuff done. (Quote 98:13)

Our group started this back in August and they were a four-member team that was qualified for our national FFA competition of agricultural issues back in Indianapolis where 65,000 students gather. And each state is represented as a competitive team. They presented part of the [Winterberry project] and [name of scientist] worked with them on that but they brought to a higher national level within FFA and they brought more attention to Alaska and the specialty issues that are being addressed up here in Alaska and that is are berries and that is happening with our berries. So, at a national level across the Future Farmers of America they really did an outstanding job in presenting the berries in winterberry science. They also talked about their data collection and encouraged more students to get into research. (Quote 84:9)

We assumed that the supported and storytelling models would have higher feedback loop scores. That this didn't occur is a testament to the overall engagement of the science team and their support staff who clearly responded with enthusiasm to youth and adult questions, emails, and phone calls in addition to providing in-person support.

Local Community Engagement

Adult participants reported **weak** alignment with community engagement across all three years, with an overall **local community engagement** rubric score of 2.17. A Kruskal-Wallis H test determined that there were no significant differences in **local community engagement** by year ($\chi^2_{(2)} = 2.857$, $p = .240$).

*Table 10: **Local Community Engagement** rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	17	2.18
2018-19	29	1.97
2019-20	18	2.50
Overall	64	2.17

A Kruskal-Wallis H test determined there were not significant differences in **local community engagement** rubric scores by model type ($\chi^2_{(2)} = 5.394$, $p = .067$).

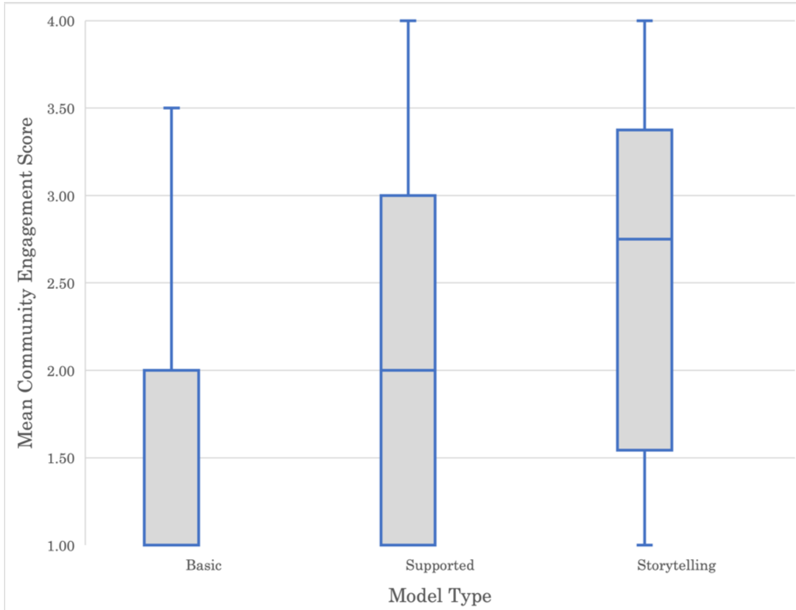

Figure 16: Mean community engagement score by model type

A Kruskal-Wallis H test determined that **local community engagement** rubric scores were significantly greater for adult participants from rural parts of the state than for adult participants from urban parts of the state ($\chi^2_{(1)}$ = 8.180, p = .004).

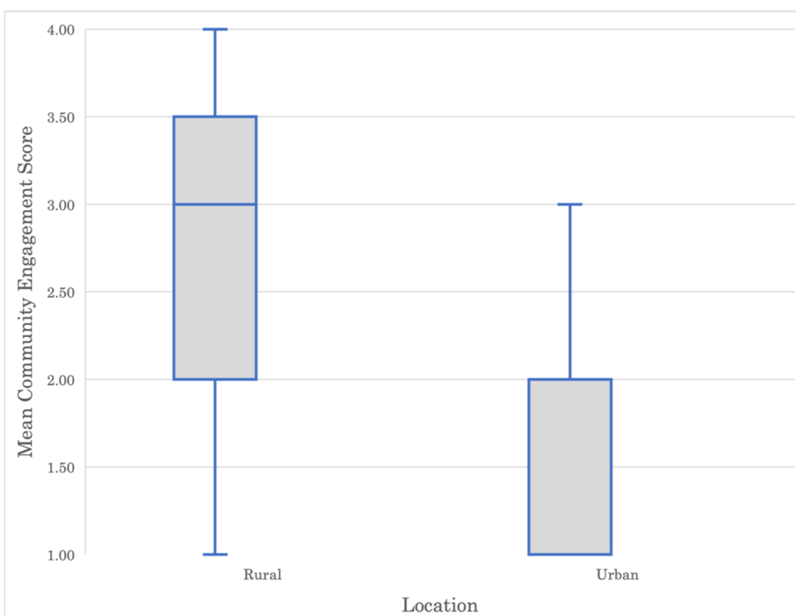

Figure 17: Mean community engagement score by location

A Kruskal-Wallis H test also determined that **local community engagement** rubric scores were significantly greater for adult participants who participated in A&E SIGNs in addition to Winterberry than those adult participants who only participated in a Winterberry project ($\chi^2_{(1)} = 4.842$, $p = 0.028$).

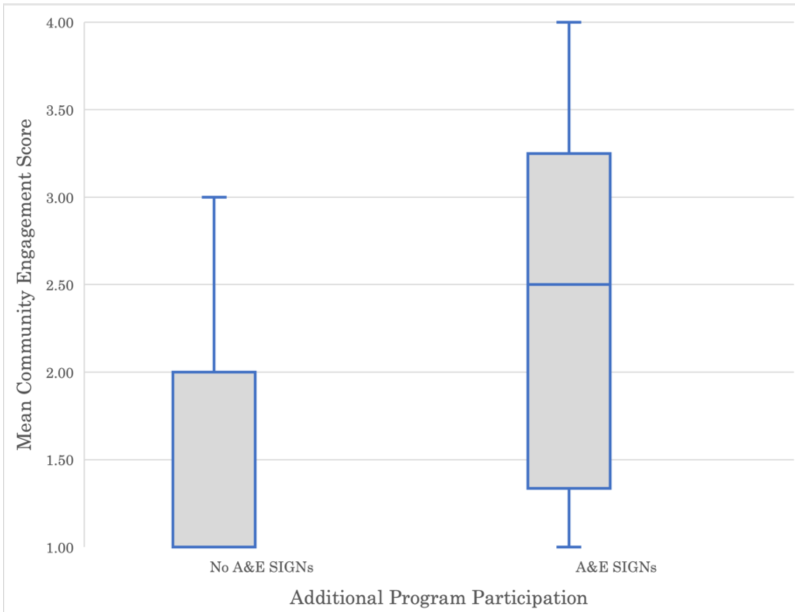

Figure 18: Mean community engagement score by additional program participation

Some adult educators engaged their local communities by bringing in Elders or local experts to help explore a community need or problem; most described their community engagement in terms of presenting their projects and findings to a larger audience, either at their school (most often to other students) or to a community group.

> *[Students took] this data that they had been collecting that they were most interested in and they turned it into analyzing the data and presented the science project to the community. And then actually out of the middle school, my students won first and second at the district level, so then they had a chance – we had a science fair here locally where I had judges and they chose the winners. And then those winners presented in front of a camera to the district and two of the middle school students actually placed in the district with a chance to go on to state. (Quote 25:15)*

> *We have after-school evenings where the parents come and see what we're doing, listen to what we're doing with science and some of our Winterberry project and we share that way. And sometimes families helped – a few families really got involved and enjoyed doing it and did it on their own [set up their own sites]. And then brought the research into the classroom. (Quote 30:24)*

> *And I also went to the Noel Wien Library with [name of scientist] and helped volunteer to kind of share – it was like a story – science and sharing at the Noel Wien Library. So, the kids came and did a mural on the berry story. So, this is kind of a little more of an accentuation of that. (Quote 32:10)*

> *"We invited the community up for some cranberry bread. The kids are showing off their data, and they were making more of those picture scenarios for them and kind of promoting – they taught the kids how to promote – I'm looking for the word here, to promote taking care, being stewards of the berry. (Quote 39:19)*

> *We had our students present twice at school board meetings. We had our students present once at a tribal council meeting, once at a community meeting. Our students also had the opportunity to present at Alaska Forum on the Environment this year. And we also have a huge community event at the end of the school year, which will be happening May 2nd I believe this year. During which time our community members are invited into our school to see areas of learning and the projects that have occurred throughout the year. So, our kids will be presenting for Exhibitions of Learning, as it's called. (Quote 46:34)*

Local engagement in rural areas is likely easier given the nature of small communities. There is also likely an interaction between the cultural importance of berries to rural Indigenous communities in Alaska and the willingness of community members to be involved in the project with the youth groups. However, that the participants in A&E SIGNs also reported higher community engagement than those who did not also participate in A&E SIGNs strongly indicates that this aspect of a citizen science project can be implemented effectively in urban areas as well with the appropriate training and support. A&E SIGNs participants were explicitly expected to engage broader community beyond the youth group in the citizen and community science project, while it was not an expectation or requirement of Winterberry. This suggests that the program expectations for participation in citizen science projects often guide the extent to which educators, who always have significant time constraints, pursue activities and engagement beyond the program.

Youth Engagement in Citizen Science Projects

Adult Perceptions of Youth Engagement

Adult participants reported **satisfactory** youth engagement, with an average youth engagement score of 3.17. A Kruskal-Wallis H test determined that there were no significant differences in **youth engagement** by year ($\chi^2_{(2)} = 1.367$, $p = .505$).

Table 11: Perceived ***Youth Engagement*** *rubric scores by program year (based on all interviews scored with the rubric)*

Year	n	Mean Rubric Score
2017-18	13	3.54
2018-19	28	3.29
2019-20	17	3.35
Overall	58	3.36

Adults interviewed described student engagement in various ways. These types of engagement all included youth participating in scientific data collection, but went far beyond in the form of discourse in the field while monitoring berries, joining conference calls with scientists while on the road for youth sports because they didn't want to miss the opportunity, data analysis, youth leadership of the project, extending the project to cooking and food preservation, and presenting the project to professional audiences. Representative quotes include:

> *Speaker #1*
> *You know, we're all standing there together knee-deep in moss and everything and mosquitoes, and so the kids are a lot more carefree in how they answer, too, so.*
> *Speaker #1*
> *Yeah. And why do you think that is?*
> *Speaker #2*
> *Our kids are just comfortable in the woods and they're comfortable about their thoughts and they don't feel threatened by saying the wrong thing. And I think that [scientist names] just encourage that type of thinking anyway in kids. (Quote 1:32)*
>
> *My highly active students made or found a way to engage. And then I had a couple outlier students that I guess were listening in via the other students 'cause they couldn't get in, so the other students patched them in, and I had no clue that I had four or five other students listening in on one student's phone. I had a sixth grader who was interested in natural resources, ag education. He was my only sixth grader, but he joined in not just for extra credit but because this is something he is interested in. Students actually decided to do their own monitoring project of rose hips just to see what was going on in their own back yard. (Quote 14:33)*

They really had a lot more involvement this year. They were the ones that put all the spreadsheets together. They reached out to [staff name] a couple of times via phone and left voicemails for her on her, you know, what her data was looking like, and they, I think, felt more comfortable with it too. Year two, there was a greater level of participation, and a greater level of self-leadership. We had two in that class that, as seventh graders, had the opportunity to stay with winterberry, and it was really, really cool to have a returning perspective from some younger students who could then assist with their peers. And that was really awesome for me to see, because it was two kids, really, that introduced all the others to it, and took the reins. And so I was there as an active support and guiding figure, but I did not do much. It was all the kids, and we also had a large group of local students that live in Nenana year-round that were really strong participants in the program this year. (Quote 17:25)

I'm super into incorporating food and wild edibles into the project because that's something we focused on anyways in the club and it was a way to get kids excited about berries and engaged with berries. So we did a lot of baking as part of the study as well. When we did berry pie charts we also made berry pies. We made berry jam and gave it to our families over Thanksgiving. We did a lot of things with berries in addition to just going out to the site and monitoring it. (Quote 37:22)

They really, really, really liked being able to have the opportunity to present their stories and their data at forums like the Forum on the Environment and community meetings and tribal meetings. I think when they had adults that were listening to the importance of what they were saying, that was really enjoyable for them. So, in some ways, going out to the data site was incredibly enjoyable because the kids got to go out. They named their plants. They felt like they were in charge of data. That was also really intimidating for them. And for some of them it was way out of their comfort zone. (Quote 46:41)

Differences in Youth Engagement by Model, Location, and Additional Program Participation

A Kruskal-Wallis H test determined that there were no significant differences in adult-reported **youth engagement** rubric scores by model type ($\chi^2_{(2)} = 4.801$, $p = .091$). However, a pairwise comparison determined that the storytelling model rubric mean was significantly greater than the basic model ($\chi^2_{(2)} = -2.049$, $p = .041$). There were not significant differences between the youth engagement means of the supported and storytelling models ($\chi^2_{(2)} = -.321$, $p = 1.000$).

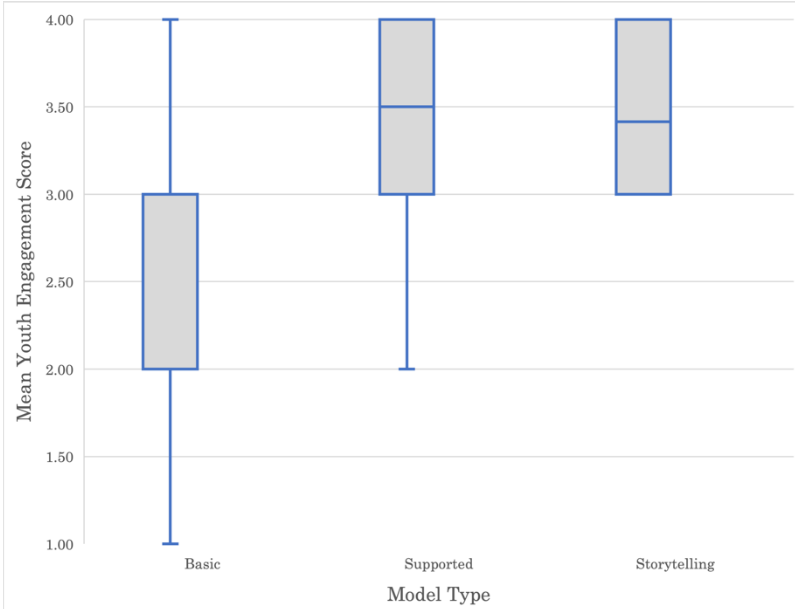

Figure 19: Mean youth engagement score by model type

A Kruskal-Wallis H test determined no significant differences **youth engagement** rubric by rural or urban location ($\chi^2_{(1)}$ = .182, p = .670).

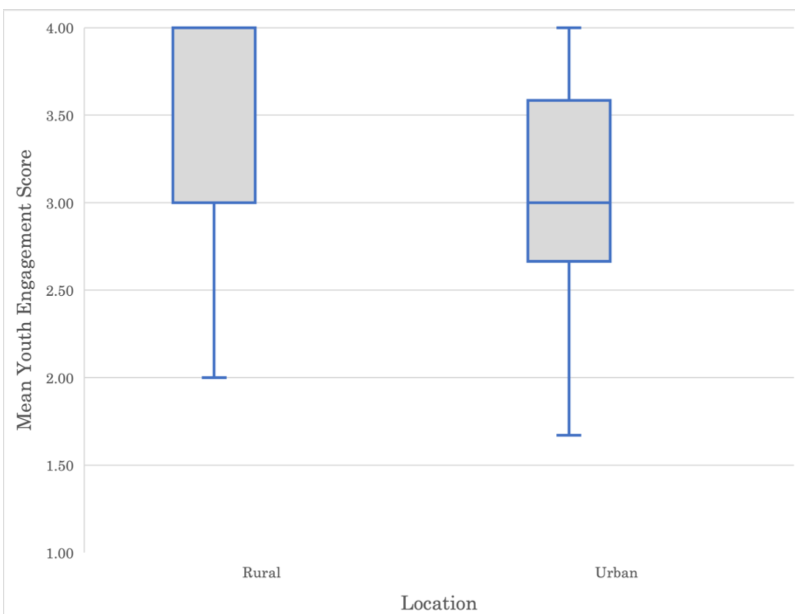

Figure 20: Mean. Youth engagement score by location

A Kruskal-Wallis H test determined **youth engagement** rubric scores were not significantly different for adult participants who participated in A&E SIGNs in addition to

Winterberry than those adult participants who only participated in a Winterberry project ($\chi^2_{(1)} = 2.004$, $p = 0.157$).

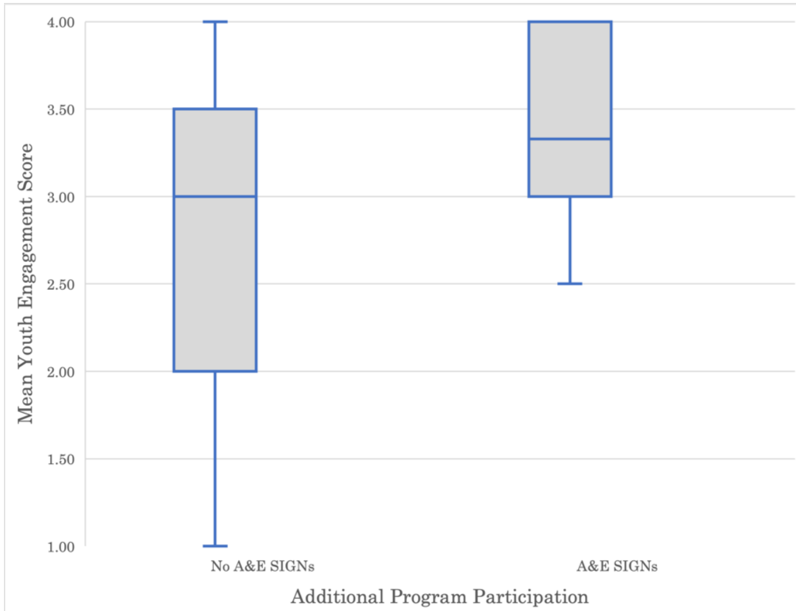

Figure 21: Mean perceived youth engagement by additional program participation

Correlations between Perceived Youth Engagement and Programmatic Characteristics

Adult reported youth engagement was significantly positively correlated with higher feedback loop rubric scores ($\tau_b = .324$, $p = .020$). as well as higher community engagement rubric scores ($\tau_b = .312$, $p = .025$). Community engagement in turn, was significantly positively correlated with higher social and cultural importance rubric scores ($\tau_b = .462$, $p < .001$) and feedback loop ($\tau_b = .317$, $p = .019$). Table xx below illustrates these correlations.

Table 12: Kendall's tau-b results of nonparametric correlations between programmatic characteristics

		Preparation	Goal Alignment	Social and Cultural Importance	Contribution to Science	Feedback Loop	Community Engagement	Youth Engagement
Preparation	Correlation Coefficient	1.000	.276	-.053	.105	.180	.120	.100
	Sig. (2-tailed)	.	.057	.688	.453	.181	.370	.467
	N	36	36	36	36	36	36	36
Goal Alignment	Correlation Coefficient	.276	1.000	-.036	.183	.336*	.015	.131
	Sig. (2-tailed)	.057	.	.807	.236	.023	.918	.387
	N	36	36	36	36	36	36	36
Social and Cultural Importance	Correlation Coefficient	-.053	-.036	1.000	.261	.317*	.462**	.240
	Sig. (2-tailed)	.688	.807	.	.065	.019	<.001	.083
	N	36	36	36	36	36	36	36
Contribution to Science	Correlation Coefficient	.105	.183	.261	1.000	.153	.274	.228
	Sig. (2-tailed)	.453	.236	.065	.	.283	.054	.118
	N	36	36	36	36	36	36	36
Feedback Loop	Correlation Coefficient	.180	.336*	.317*	.153	1.000	.217	.324*
	Sig. (2-tailed)	.181	.023	.019	.283	.	.110	.020
	N	36	36	36	36	36	36	36
Community Engagement	Correlation Coefficient	.120	.015	.462**	.274	.217	1.000	.312*
	Sig. (2-tailed)	.370	.918	<.001	.054	.110	.	.025
	N	36	36	36	36	36	36	36
Youth Engagement	Correlation Coefficient	.100	.131	.240	.228	.324*	.312*	1.000
	Sig. (2-tailed)	.467	.387	.083	.118	.020	.025	.
	N	36	36	36	36	36	36	36

Correlation is significant at the 0.05 level (2-tailed).*

Correlation is significant at the 0.01 level (2-tailed).**

Correlations between Youth Reported Outcomes and Program Characteristics

This section of the report discusses correlations between key program characteristics that should lead to increased engagement of populations underrepresented in STEM (preparation, social cultural, contribution to science, feedback loop, and community engagement) and outcomes of youth participants: enthusiasm for STEM, STEM self-efficacy, stewardship self-efficacy, critical thinking, goal alignment, meaningful impact, and communication. It is organized by the key programmatic characteristics.

Preparation

A Kendall's tau-b determined there was a significant, positive correlation between preparation rubric scores and positive pre-post change in mean youth STEM self-efficacy ($\tau_b = .146$, $p = .007$) and between preparation rubric scores and positive pre-post change in mean critical thinking ($\tau_b = .112$, $p = .039$).

Table 13: Kendall's tau-b results for preparation and youth outcomes

Youth Outcome	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	**188**	**0.146***	**0.007**
STEM Enthusiasm Change	188	0.006	0.913
Stewardship Self-Efficacy Change	188	0.084	0.122
Critical Thinking Change	**187**	**0.112***	**0.039**
Goal Alignment	188	0.016	0.782
Meaningful Impact	188	0.099	0.085
Communication	187	0.071	0.202

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Goal Alignment

A Kendall's tau-b determined there was a significant, positive correlation between goal alignment rubric scores and positive pre-post change in mean youth stewardship self-efficacy ($\tau_b = .143$, $p = .016$) and a significant, negative association between adult/teacher goal alignment rubric scores and mean youth goal alignment scores ($\tau_b = -.162$, $p = .009$).

Table 14: Kendall's tau-b results for goal alignment and youth outcomes

Youth Outcome	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	188	0.088	0.142
STEM Enthusiasm Change	188	0.083	0.177
Stewardship Self-Efficacy Change	**188**	**0.143***	**0.016**
Critical Thinking Change	187	0.022	0.718
Goal Alignment	**188**	**-0.162****	**0.009**
Meaningful Impact	188	0.053	0.401
Communication	187	-0.043	0.484

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Social and Cultural Importance

A Kendall's tau-b determined there was a significant, negative correlation between social and cultural importance rubric scores and pre-post change in mean youth STEM self-efficacy (τ_b = -.133, p = .015) and a significant, positive association between social and cultural importance rubric scores and mean youth goal alignment (τ_b = .152, p = .007).

Table 15: Kendall's tau-b results for social and cultural importance and youth outcomes

	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	**188**	**-0.133***	**0.015**
STEM Enthusiasm Change	188	0.046	0.412
Stewardship Self-Efficacy Change	188	-0.046	0.401
Critical Thinking Change	187	-0.102	0.061
Goal Alignment	**188**	**0.152****	**0.007**
Meaningful Impact	188	-0.065	0.263
Communication	187	-0.053	0.341

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Contribution to Science

A Kendall's tau-b determined there were no significant associations between contribution to science rubric scores and youth outcome means.

Table 16: Kendall's tau-b results for contribution to science and youth outcomes

	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	188	0.016	0.793
STEM Enthusiasm Change	188	0.068	0.267
Stewardship Self-Efficacy Change	188	0.102	0.086
Critical Thinking Change	187	-0.030	0.610
Goal Alignment	188	0.090	0.144
Meaningful Impact	188	0.097	0.125
Communication	187	0.042	0.496

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Feedback Loop

A Kendall's tau-b determined there were no significant associations between feedback loop rubric scores and youth outcome means.

Table 17: Kendall's tau-b results for Feedback Loop and youth outcomes

	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	188	-0.005	0.922
STEM Enthusiasm Change	188	0.045	0.420
Stewardship Self-Efficacy Change	188	0.098	0.071
Critical Thinking Change	187	-0.043	0.427
Goal Alignment	188	-0.005	0.931
Meaningful Impact	188	0.104	0.069
Communication	187	0.002	0.973

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Community Engagement

A Kendall's tau-b determined there was a significant, positive association between community engagement rubric scores and mean youth goal alignment ($\tau_b = .202$, $p < .01$); a significant, positive association between community engagement rubric scores and mean youth meaningful impact scores ($\tau_b = .202$, $p = .001$); and positive association between community engagement rubric scores and mean youth communication scores ($\tau_b = .159$, $p = .005$)

Table 18: Kendall's tau-b results for community engagement and youth outcomes

	N	Correlation Coefficient	Sig. (2-tailed)
STEM Self-Efficacy Change	188	0.062	0.263
STEM Enthusiasm Change	188	-0.020	0.725
Stewardship Self-Efficacy Change	188	-0.049	0.374
Critical Thinking Change	187	-0.006	0.919
Goal Alignment	**188**	**0.202****	**0.000**
Meaningful Impact	**188**	**0.202****	**0.001**
Communication	**187**	**0.159****	**0.005**

Correlation is significant at the 0.05 level (2-tailed).*
Correlation is significant at the 0.01 level (2-tailed).**

Discussion

Evaluation of the Winterberry Citizen Science Program demonstrated that it is possible to implement research-based characteristics of citizen science programs in a range of citizen science program types and program settings. Further, the evaluation demonstrated how these research-based characteristics contribute to youth engagement as well as to youth's increased feelings of STEM and stewardship self-efficacy and critical thinking skills. Finally, the evaluation highlighted characteristics that are essential for engaging rural Alaska youth in citizen science programs.

Across all three Winterberry models and in local and urban settings, adult participants were prepared to implement a Winterberry investigation as a facilitator with both live training and written materials (Meyer et al, 2013, Ruzic et al, 2016, Bonney et al, 2009). Better preparation was correlated with youth gains in STEM self-efficacy and critical thinking skills, highlighting the critical importance of using effective methods and materials to prepare facilitators.

Winterberry adult participants also indicated that the project goals and activities aligned with, responded to, and were relevant to their needs and interests (Bonney et al., 2009, Shirk et al., 2012; Nov, Arazy, & Anderson, 2014, Wilderman et al., 2004, Corburn, 2007, Cheng et al., 2008, and Nerbonne and Nelson, 2008, Meyer et al., 2013, Lorenz, 2016). Many of the adult participants' goals were pedagogical, which may have contributed to positive changes in youth's stewardship self-efficacy. However, we would also expect that strong goal alignment would also contribute to STEM self-efficacy and critical thinking skills, which did not occur. So, while goal alignment is important to motivate and engage adult participants, particularly in a school or educational setting, it may not be as important that youth goals align for achievement of specifically educational outcomes.

Similarly, adult participants felt strongly that they were making a valuable contribution to science (Nerbonne and Nelson, 2008, Lorenz, 2016, Ruzic et al., 2016). Yet, these feelings did not contribute to youth outcomes. While contributing to science is an important motivator for adults, this finding suggests that youth may not be as motivated to participate in a citizen science project for its contribution to science. Alternatively adult participants may not have made their project's contributions to science known to their youth participants. Either way, this is an area for further investigation to learn how youth perceive their own contribution to science in citizen science projects.

Adult participants reported a feedback loop between participants and the program's science team and program staff. The science team and program staff were available for support, to provide access to the data, and to accept participant feedback and suggestions (Ruzic et al., 2016; Evans et al., 2005). Although the Winterberry feedback loop did not contribute directly to youth outcomes, adult participants who reported a strong feedback loop perceived higher levels of youth engagement, which is an important precursor for learning (Sinatra et al, 2015).

Social and cultural importance (Chase and Levine, 2016, Falk, 2001, and Bonney, 2009) was indicated more often by rural participants. While perhaps not surprising given that rural parts of the state tend to have larger Indigenous populations, who have traditionally relied on berries for subsistence, it is nonetheless an important finding. Strong social and cultural importance contributed significantly to youth participants' reported goal alignment, suggesting that projects which can encourage a focus on social and cultural importance may motivate rural Alaska youth to participate (Bonney et al., 2009, Shirk et al., 2012; Nov, Arazy, & Anderson, 2014, Wilderman et al., 2004, Corburn, 2007, Cheng et al., 2008, and Nerbonne and Nelson, 2008, Meyer et al., 2013, Lorenz, 2016).

Adult participants in rural parts of the state were also more likely to engage the local community in their citizen science efforts by bringing in Elders or local experts to help explore a community need or problem and presenting their projects and findings to a larger audience, either at their school or to a community group. This finding is important because, higher levels of community engagement contributed significantly to youth participants' goal alignment, meaningful impact, and communication scores, which again may motivate rural Alaska youth to participate in a citizen science project (Pandya, 2012). Adult participants who reported engaging their local community also reported higher youth engagement. These types of community engagement can be encouraged through training in future citizen science projects.

Leveraging other programs also appears to have also affected the achievement of social and cultural importance and community engagement. Social and cultural importance and community engagement were reported at higher levels for participants who also participated in the A&E SIGNs project which engages educators, youth, and community members in relevant climate change investigations and stewardship projects that investigate the consequences and feedbacks of climate change both a) locally using GLOBE science measurements and b) regionally and/or globally using remotely sensed NASA data.

Recommendations

To improve the participation in and effectiveness of citizen science across diverse audiences, particularly at high-latitudes where a high proportion of communities have populations underrepresented in STEM, we recommend the following:

- Provide in-person as well as written training materials for all participants, including youth. Update training regularly to address emerging issues and to encourage ongoing participation. This recommendation is particularly important for programs with education outcomes goals.

- Continue to highlight the important citizen science contribution to the research being conducted. This recommendation is particularly important for motivating adult participants.
- Encourage science and program staff to work directly with youth participants, to encourage engagement as well as to model science careers. This recommendation is particularly important for youth engagement goals.
- Share program goals for research, community impact, and youth outcomes with participants, including youth participants to help participants align their personal and professional goals with the citizen science program.
- Encourage community engagement by providing specific training to participants, including youth participants, about ways that they can engage their community. This recommendation is particularly important for engaging rural Alaska communities and underrepresented youth.
- Design programs to explicitly focus on a social and/or cultural issue for underrepresented communities. This recommendation is especially true for engaging rural Alaska communities and underrepresented youth.

While there were not significant differences by model type for many of the characteristics of effective citizen science we studied for this evaluation, the recommendations strongly suggest a robust program like the supported and storytelling models have the potential to increase youth interest in a science, technology, engineering and math (STEM), as well as their confidence to engage in STEM school work and/or a STEM degree. Taken together, these outcomes will work to increase diverse populations in STEM fields.

Appendix A: Interview Protocol

Winterberry Citizen Science
Facilitator/Teacher Interview Protocol

Introduction

Thank you so much for agreeing to speak with us! We are interested in finding out about your experience with citizen science. There are no right or wrong answers to these questions – we are really just interested in your thoughts. If you don't understand a question, please ask me to clarify what the question means, and if you want to pass on a question, that is perfectly fine too.

Is it ok if I record our conversation so that I can remember what we said?

PROJECT CHARACTERISTICS/GOAL ALIGNMENT/ SOCIAL AND CULTURAL IMPORTANCE/ AVAILABILITY?

1. Please tell me a little bit about your Winterberry and/or Arctic and Earth Signs project(s).
    a. Describe your site(s) and what you're doing/looking at there.
    b. How old are your students? Grade levels? How many students participated?
    c. When did you start? Are you still working on the project? Will you continue next year?
    d. WHY DID YOU CHOOSE THIS PROJECT TO WORK ON WITH YOUTH IN YOUR COMMUNITY?
    e. What are your goals for this project?

PROJECT CHARACTERISTICS/PARTICIPANT ENGAGEMENT

2. Please describe how you got started with your project?
    a. Probes—did you have a scientist come to your classroom/center? was the visit in-person, online? What happened then?
3. What activities did your students participate in?
    a. Did you have a community or family night to get started with your project? What happened then?
    b. How often did these activities occur? Once a week, once a month, once a year…
4. What kind of support did you receive during the project from scientists or mentors?
5. What did your youth do with the data they collected?

a. probe: [for supported sites] Did your youth participate in a Data Discovery session? What happened during the data discovery?
b. [probe for storytelling sites] Did your youth participate in scenario stories? what happened during the scenario stories? Did the students imagine and draw or write about two different berry futures?

6. What were the most valuable aspects of your work with [name of person(s) mentioned or from the spreadsheet]?
7. [If second year] What was different about your students' or your experience this year compared to last year?

COMMUNITY ENGAGEMENT/SOCIAL NETWORK

8. How have you engaged the community in your project, if at all?
   a. Probes – presentations to community members, community member help, Elders sharing experiences, other community engagement?

PARTICIPANT ENGAGEMENT/GOAL ALIGNMENT

9. Were there any activities that your students seemed to like more or less? Describe.
10. Were there any activities that you liked more or less? Describe.

PREPARATION

11. Were there parts of this project that were particularly difficult, either for you or for the youth? (e.g., selecting a site to study, selecting individual plants, recording observations, reporting data, presenting data, analyzing data, answer questions about data).

VALUABLE CONTRIBUTION

12. How do you imagine UAF scientists will use the data?
13. Is there anything additional you would like to share about what specific activities were particularly beneficial to you as a citizen scientist? To your students?

14. That was my last question; do you have anything to add? Thank you for your time!

Finally, we also would like you to complete a short written survey. I will be emailing that to you shortly. After you finish the survey, you can enter a drawing for a $100 gift certificate.

Appendix B: Interview Coding Rubric

Topics		Criteria/Indicators
Preparation	1	problems reported with preparation (be sure to differentiate btwn prep and implementation)
	2	not addressed OR both positive and negative aspects mentioned
	3	no problems reported AND indicates ease of starting the project/ onboarding; mild evidence
	4	no problems reported AND indicates ease of starting the project/ onboarding; strong evidence
Goal Alignment	1	Doesn't report any goals
	2	Is vague about reasons for participating
	3	Goals are reported, but in coders judgement are not very specific
	4	The goals are very specific for the student age, or curricular area, or specific skill, or for a community need, or for a climate change or conservation issue or for personal reason
Social and Cultural	1	no evidence/not addressed
	2	they say it's locally important, but don't get into why
	3	tied to place/local significance described, but not really strongly tied to cultural significance
	4	strong ties to social and cultural elements of place
Contribution to Science	1	No understanding
	2	little understanding Use this code if the respondent really doesn't seem to understand how the data will be used at all
	3	some understanding Use this code if the respondent has a sense of how it will be used, but its vague

	4	strong understanding Use this code if the respondent seems to really understand how scientists will use this data and publish the results
Feedback Loop	1	No evidence of feedback loop during interview. Use this code when there is no contact between scientists/mentors, educators and students.
	2	Provides limited evidence of feedback loop during interview Use this code to describe limited contact with scientists/mentors, educators and students
	3	Provides evidence of feedback loop during interview. Use this code to describe semi-regular contact between scientists/mentors, educators, and students (presentations, to help set up site, when help was needed, etc..)
	4	Provides evidence of feedback loop during interview Use this code to describe regular contact between scientists/mentors, educators, and students (monthly, weekly)
Community Engagement	1	No community engagement
	2	ONLY participated in community events or guest speakers (e.g., Meet the Scientists) provided by program Did not presents to larger community group
	3	Brought in elders or community experts beyond what was provided by the program OR Presented project to a larger group (conference, city council, other students, family night)
	4	Implement a stewardship program AND Brought in elders or community experts beyond what was provided by the program AND Presented project to a larger group (conference, city council, other students, family night)
Student Engagement	1	students generally not into it OR none coded
	2	most students generally like it; acknowledgement that student engagement in the task was sometimes a challenge.

		Also use this code if students engaged in data collection but their enthusiasm for it was not addressed.
	3	most students really like it, and some might show agency; some acknowledgement of a few students getting distracted outside or needing encouragement to complete data entry or other tasks
	4	students self-organize around project work or pairwork or other task -- students show agency OR extreme enthusiasm

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