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Facilitator organizations enhance learning and action through citizen science: a case study of Girl Scouts' Think Like a Citizen Scientist journey on SciStarter

Haley E. Smith[a], Caren B. Cooper[a], K.C. Busch[b], Suzanne Harper[c], Amy Muslim[c], Kaleigh McKenna[c] and Darlene Cavalier[d,e]

[a]Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, North Carolina, USA; [b]Department of STEM Education, North Carolina State University, Raleigh, North Carolina, USA; [c]Girl Scouts of the USA, New York, New York, USA; [d]School for the Future of Innovation in Society, Arizona State University, Tempe, Arizona, USA; [e]SciStarter, Philadelphia, Pennsylvania, USA

ABSTRACT

Engagement in citizen science can result in participant outcomes including increased science and environmental literacy and civic action. One factor which may increase the likelihood of these outcomes is facilitation by groups such as employers, schools, or other organizations. We examined how a partnership between SciStarter and Girl Scouts of the USA facilitated participation in citizen science to shape participants' learning and civic engagement. Between July 2017 and February 2020, participants from over 200 Girl Scout troops completed the Think Like a Citizen Scientist Journey, consisting of science learning activities, participation in an environmental citizen science project on SciStarter, and a Take Action Project (TAP). Troop leaders provided open-ended descriptions of TAPs which we analyzed qualitatively. Responses provided evidence of learning outcomes spanning informal science learning goals, Girl Scout Leadership Experience outcomes, and Girl Scout STEM outcomes. Participants' TAPs overwhelmingly related to science and environmental topics (81%) and the majority sought to educate and inspire others (66%), reaching audiences of peers, adults, the general public, and civic leaders. This program demonstrates the potential for facilitator organizations to leverage existing citizen science projects to promote learning outcomes, civic science education, and community action with participants as young as 4–5 years old.

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Introduction

Benefits of citizen science for scientific research

The phenomenon of public participation in scientific research, or citizen science (CS), involves members of the public in various stages of the scientific process, including formulating research questions, making observations, and analyzing and interpreting data (Crowdsourcing and Citizen Science Act (CCSA) 2017; Haklay et al. 2021; Shirk et al. 2012). CS has made notable contributions to scientific research, especially in environmental fields such as ecology, natural resource

CONTACT Haley E. Smith hesmith2@ncsu.edu Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC 27695, USA.

management, and conservation biology – particularly through the public's ability to collect and analyze data on much greater spatial and temporal scales than professional researchers alone (Bonney et al. 2014; Chandler et al. 2017; Cooper, Shirk, and Zuckerberg 2014; Fraisl et al. 2022; Miller-Rushing, Primack, and Bonney 2012).

Both adults and youth can make valuable contributions to scientific research through participation in CS. For example, a 2017 study of students, teachers, and corporate volunteers collecting marine debris data for a CS project in Australia demonstrated that the quality and efficiency of data collection by youth rivaled that of data collected by adults, including professional researchers (van der Velde et al. 2017). Regardless of the age of participants, the scientific outcomes of a CS project are often dependent upon the suitability of the research question being addressed by a CS approach (typically related to the level of expertise and/or the types of equipment required for data collection and analysis), the quality of protocols and training available to participants, quality control performed on the data collected, and the availability of feedback and communications between participants and project scientists (Bonney et al. 2009; McKinley et al. 2017).

Benefits of CS for participants

In addition to its contributions to science, other key outcomes of CS include participant learning and civic action (Ballard, Dixon, and Harris 2017; Turrini et al. 2018). Particularly for the environmental field, in the face of global challenges such as climate change, air and water quality impairment, and habitat and biodiversity loss, it has never been more important to empower the public with the knowledge to recognize environmental challenges and the ability to help address those challenges (Ballard, Dixon, and Harris 2017; Schultz 2011; Wals et al. 2014). Especially for youth, instilling knowledge and environmental science agency through CS participation can be critical to paving the way to future actions which can benefit the complex socio-ecological systems of which they are a part (Ballard, Dixon, and Harris 2017; Tidball and Krasny 2010).

CS is in many ways uniquely situated to promote science learning, given its inherently scientific context, the unique nature of participation, and existing infrastructures that support learning (National Academies of Sciences, Engineering, and Medicine [NASEM], 2018). Commonly cited CS learning outcomes include the potential to enhance scientific literacy and content knowledge (Bonney et al. 2016; Jordan et al. 2011). However, science learning can also be understood in a broader sense to include precursors to knowledge gain, such as interest, affective connections to science (e.g. science identity and self-efficacy), and the application of knowledge and skills through the practice of science (NASEM, 2018; National Research Council [NRC], 2009). These interrelated facets of learning are captured by the six strands of Learning Science in Informal Environments (LSIE) proposed by the National Research Council: (1) sparking excitement and interest, (2) understanding scientific content and knowledge, (3) engaging in scientific reasoning, (4) reflecting on science, (5) engaging in scientific practices, and (6) identifying as a science learner (NRC, 2009) (Appendix A). CS has the potential to achieve each of these outcomes, and the intended learning outcomes of many CS programs align well with the LSIE strands, as demonstrated by Phillips et al. (2018).

Another key outcome of CS is the potential to influence civic action (Ballard, Dixon, and Harris 2017; Turrini et al. 2018). While CS participation can itself be seen as a form of civic action – working collaboratively to address questions with important implications for society – CS can also pave the way to further civic participation as a form of civic science education. Levy, Oliveira, and Harris (2021) defined civic science education as 'educational experiences that support individuals' ability to understand, explore, and take informed action on public issues related to science' (1054). In the context of environmental CS projects, the epitome of participant outcomes is often seen as participants going beyond engaging in CS to adopt other pro-environmental behaviors, such as teaching others about environmental topics, improving or managing habitat, and voting or lobbying to influence environmental policies (Haywood, Parrish, and Dolliver 2016; Lewandowski and Oberhauser 2017; McKinley et al. 2017; Phillips et al. 2018). While voting may not be an option for youth, many examples exist of impactful youth civic environmental action associated with participatory learning experiences, including: students adopting long-term pro-environmental attitudes and behaviors and promoting inter-generational learning after participating in an environmental service-learning program in Mexico (Schneller 2008); youth participants in a disaster risk-reduction program in the Philippines influencing community action through the use of participatory video (Haynes and Tanner 2015); and students in North Carolina, USA influencing concern and policy support related to marine debris among community leaders and adults following a year-long marine debris-related curriculum (Hartley et al. 2021). This final example also demonstrates the value of CS as a potential pathway to cultivating community science literacy, or the collective and distributed capacity of a community to apply scientific knowledge and tools to address issues of priority to the community (including environmental challenges) (Gibson et al. 2022; NASEM, 2016; NASEM, 2018).

Designing CS to promote participant outcomes

While such isolated examples of learning and action following CS participation exist across the literature, there remains a limited understanding among both CS practitioners and theoreticians about how participant experiences can be designed to better foster desired learning and action outcomes (Peter et al. 2021). As demonstrated by a recent study of Chilean school children sampling plastic marine debris, participation in a CS project alone may not be sufficient to achieve such outcomes, and complementary learning experiences may be necessary (Wichmann et al. 2022). Furthermore, research on pro-environmental behaviors has repeatedly demonstrated that learning and knowledge gains do not necessarily translate directly into actions or behavioral change (Kollmuss and Agyeman 2002; Nelson, Ira, and Merenlender 2022; Wals et al. 2014), though they can certainly contribute (Varela-Candamio, Novo-Corti, and García-Álvarez 2018). Therefore, considering specific contexts and conditions that may facilitate both learning and action is critical to developing a better understanding of how to effectively design and execute CS programming to achieve desired participant outcomes.

One unique context that warrants closer examination is CS participation that is facilitated by groups external to the project leadership or administration, such as an employer, school, community organization, library, or other entity. Such *facilitator organizations* have no influence on project design but enable participation by individuals who may not otherwise engage in CS. These organizations also have the potential to enhance learning and other outcomes of CS by contextualizing participation within their program designs to support learning experiences.

The concept of facilitator organizations in citizen science (and the participatory sciences more broadly) has been referred to as 'third-party organizations' who recruit, train, and otherwise manage CS volunteers (Sharova 2020), 'enablers' who facilitate interactions between scientists and participants (Salmon et al. 2021), and 'intermediary units' who support citizen-driven research projects (Gresle et al. 2021). The facilitator organization role also bears some similarities to the idea of 'learning brokers' in environmental education, where an individual (often a parent), supports another individual's (often a child's) learning by connecting them to a learning opportunity or experience (Barron et al. 2009). However, it is worth noting that we here emphasize the role of a larger program, organization, or entity when describing facilitator organizations, rather than the impact of a single individual on another's learning. We choose to use the term 'facilitator organization' in identifying these parties as unique players in the CS 'ecosystem' (Allf et al. 2022), as we feel it best captures their role in fostering participation, supporting learning, and facilitating the achievement of desired outcomes. Consideration of these facilitators' roles is an important step for building a more holistic and volunteer-centric understanding of CS participation outside the context of individual projects (Allf et al. 2022).

Many facilitator organizations bring their own organizational goals to the table, often along with pre-existing program structures to achieve these outcomes. When these goals align with those of a CS project or the practice of CS as a whole, the facilitator organization may choose to employ CS in their programming. Yet adoption of CS by facilitator organizations to achieve these common goals has the potential not only to fulfill existing organizational and CS project goals, but also to achieve synergistic outcomes promoting participant learning and action through structured programming and learning supports (Ballard, Dixon, and Harris 2017; Wichmann et al. 2022).

While a variety of learning outcomes have been associated with CS participation and experiences, most research to date has focused on only a small subset of these outcomes at a time, primarily among adults, and often in the context of discrete CS projects. For example, many studies have explored changes (or lack thereof) in project-relevant content knowledge (Branchini et al. 2015; Forrester et al. 2017; Greving et al. 2022; Jordan et al. 2011; Price and Lee 2013; among others). Others have addressed the development of scientific literacy and understanding of the processes or nature of science through participation in a CS project, with evidence again mixed (Bonney et al. 2016; Jones et al. 2017; Jordan et al. 2011; Price and Lee 2013).

Another segment of research has explored more affective learning outcomes, including evidence for the development of interest and engagement in science and environmental topics through participation in CS, particularly in formal educational contexts where participation is less likely to be inherently interest-driven (Schneiderhan-Opel and Bogner 2020; Smith et al. 2021; Toomey and Domroese 2013; Vitone et al. 2016). Some studies have also shown that participation in CS helps cultivate a sense of self-efficacy or agency related to science and the environment in youth (Ballard, Dixon, and Harris 2017; Hiller 2012), college students (Smith et al. 2021), and adults (Haywood, Parrish, and Dolliver 2016). Another small but growing set of literature has begun to explore the development of science identity through participation in CS (Ballard, Harris, and Dixon 2018; He et al. 2019; Williams, Hall, and O'Connell 2021), again with differing outcomes noted.

A final area of the literature has focused on attitudinal and behavioral outcomes from CS participation, with some studies demonstrating modest changes in attitudes towards science, the environment, or a project-specific subject (Bruckermann et al. 2021; Chase and Levine 2018; Greving et al. 2022; Santori et al. 2021; Toomey and Domroese 2013), while others reported little to no changes in attitudes (e.g. Forrester et al. 2017). One difficulty often encountered in these studies is that CS participants typically have pre-existing positive attitudes towards science and the environment. Similarly, studies of behavior changes and action following CS participation have demonstrated mixed results, perhaps related to high pre-existing engagement in such behaviors among participants (Forrester et al. 2017; Haywood, Parrish, and Dolliver 2016; Jordan et al. 2011; Santori et al. 2021; Toomey and Domroese 2013).

Regardless of the types of outcomes being considered, there is a growing understanding among the CS literature that these outcomes don't simply happen as a result of participation in CS and require intentional design and structured learning supports to be achieved (Bela et al. 2016; Bonney et al. 2016; NASEM, 2018; Peter et al. 2021; Roche et al. 2020; Wichmann et al. 2022; among others). There is, therefore, a great need for research examining the contexts and factors which facilitate these varied participant outcomes.

Research aims

To this end, the current study explores the unique context of facilitated CS and seeks to answer the following questions:

1. How and to what extent do facilitator organizations expand possible CS learning outcomes?
2. In what ways do facilitator organizations extend and support civic science education and civic action through CS experiences?

We address these questions through a case study that demonstrates the potential for structured participation in CS *via* a facilitator organization to fulfill expected project and programmatic goals and promote a broad spectrum of participant outcomes. Specifically, we investigate the potential for a facilitator organization to extend community science literacy and civic science education through community action as encouraged by the Girl Scouts' Take Action Project. We conclude with a research agenda to pursue a better understanding of the roles of facilitator organizations within the CS ecosystem.

Methods

Study context

The paper reports on a case study (Yin 2009) of CS participation supported by a facilitator organization. The context for this case study is the Think Like a Citizen Scientist Journey (hereafter referred to as 'the Journey'), a partnership between Girl Scouts of the USA (the facilitator organization) and SciStarter.org (an online platform which provided planning support, resources, and other infrastructure critical to the implementation of the Journey). Girl Scouts of the USA (GSUSA) is an organization dedicated to leadership development for K-12 girls that focuses on making positive change in the world while building skills in the following areas: STEM, Outdoors, Life Skills, and Entrepreneurship (GSUSA, 2022a). GSUSA supports girls in acquiring STEM and other skills by completing individual activities to earn 'badges' and more in-depth experiences called 'journeys', where girls can earn awards for digging deeper into content and making a difference in their communities. Girl Scout Journeys are scaffolded learning experiences guided by a curriculum which encourages girls to build on what they learned from earning a badge by completing a Take Action Project (TAP) in their community. SciStarter is an online CS hub connecting participants to thousands of CS projects worldwide. SciStarter partners with many facilitator organizations such as Girl Scouts and provides critical infrastructure to enable CS programming, including the design of learning pathways, project curation, launching pages (or 'microsites'), and progress tracking. SciStarter's digital infrastructure enables research and evaluation such as this case study through data tracking, resource repositories for uploaded content, and the integration of questionnaires and embedded assessment tools across the site.

The Journey was co-created by GSUSA and SciStarter and piloted in 2017 with the goal of encouraging Girl Scouts to engage in citizen science to support STEM learning. The Journey's pilot phase targeted girls in grades K-5 (Girl Scout levels 'Daisy' (grades K-1, ages 4–7), 'Brownie' (grades 2–3, ages 6–9), and 'Junior' (grades 4–5, ages 8–11)) and initially featured 11 curated CS projects (Appendix B). These projects were recommended by SciStarter in alignment with Girl Scout's requested criteria (outdoors, simple or no specialized instruments, suitable for a variety of age-groups, project scientists willing to provide welcome and thank you videos, and engagement of SciStarter affiliates that could enable digital tracking of participation). Girls could choose projects by going to a SciStarter landing page specifically designed for the Journey. This page, hereafter referred to as 'the microsite', expanded over time to feature up to 20 projects. During the Journey, girls earned an initial award for completing program content consisting of (1) a series of age-appropriate STEM learning activities; and (2) making a SciStarter account and participating in a citizen science project through the microsite. Girls earned a second award for completing (3) a TAP in their community (Figure 1).

Figure 1. Image depicting the three scaffolded steps or phases of the Girl Scouts' Think Like a Citizen Scientist Journey.

The stated outcomes for the Journey were for girls to: (1) 'Explore how scientists do research and create solutions to some of the most important problems faced by people, animals, and the environment'; (2) 'practice making scientific observations and collecting data'; (3) 'participate in a citizen science project'; and (4) 'do a Take Action project to address an issue in [their] community' (GSUSA, n.d.a, 1).

During the pilot phase, Journeys were generally completed by Girl Scout troops working together as a group. During the first step of the Journey (Figure 1), girls completed age-appropriate, preparatory STEM activities, which varied by age level and included practicing skills such as observation, prediction, data collection and analysis, etc. After completing these activities, girls then participated in a CS project on SciStarter. Projects were selected from the curated list of age-appropriate projects featured on the SciStarter microsite (Appendix B).

The final step to fulfill the Journey curriculum was for girls to complete a TAP. The goal of a TAP is to 'address an issue by tackling the factors that cause or contribute to it' (GSUSA, 2022b, Activity Details section). As opposed to a Community Service Project which might make a one-time impact, TAPs are intended to enact a long-term change that 'addresses a root cause of an issue' (GSUSA, 2022b, Table 1) and is 'sustainable'. Suggested ways of making a sustainable change include: '1. Make your solution permanent, 2. Educate and inspire others to be part of the change, and 3. Change a rule, regulation, or law' (GSUSA, 2022b, Activity Details section). While these TAPs can be standalone, inclusion in the Journey provides a pathway for girls to build on what they have learned and done throughout the rest of the Journey curriculum when developing a project. However, the nature of the project was ultimately up to the girls and their project leaders.

Data collection and preparation

After completing all Journey components (preparatory activities, CS project, TAP), GS troop leaders were asked to mark the Journey as complete on SciStarter and fill out a brief survey comprised of three open-ended questions to describe their troop's TAP: (1) What problem did you want to solve with your Take Action project?, (2) What was your solution?, and (3) How did you make your solution sustainable? (For example: Did you educate and inspire others to follow your lead? Did you create something permanent? Did you get a rule or a law changed?). SciStarter then provided the research team with records of each Journey, including participation dates, participant age ranges, CS project chosen, and responses to the open-ended survey, exported in SQLITE format. This data was acquired in accordance with approval under NC State University Institutional Review Board protocol #12200 and was deemed exempt.

We performed initial data merging and cleaning in RStudio using R version 4.1.3 (R Core Team 2022). We merged Journey dates, participant ages, CS project, TAP responses, and other related data by Journey number to create a single entry for each Journey, beginning with 456 entries. After removing all duplicate Journeys and uncompleted Journeys (never marked as 'complete' on SciStarter), we were left with 286 entries.

While the Journey later expanded to include all GS levels (K-12 or GS levels 'Daisy' through 'Ambassador'), older girls outside of the initial K-5 pilot age range often completed their Journeys independently or in smaller groups. Additionally, the onset of the COVID-19 pandemic around March of 2020 led to Girl Scout troops not being able to meet in person and younger girls also completing Journeys alone or in smaller groups. To ensure greater consistency across the Journeys, we retained for analysis only Journeys completed by Girl Scout troops with pilot grade levels K-5 *and* those completed before March 1st, 2020, resulting in 253 entries.

Following initial data cleaning and export, the coders (HS and LT) read through open-ended responses and manually removed entries where respondents only wrote brief responses such as 'NA' or 'yes' or mistakenly described their participation in a CS project as part of Step 2 of the Journey instead of their TAP. This resulted in a total of 245 completed Journeys with responses for analysis.

Table 1. Question 1 codes representing expected learning outcomes (see Appendix A for code definitions, sample quotes, and additional details).

Code Abbreviation	Full Name & Description aligned to LSIE strands and GSUSA outcomes
Strand 1	LSIE Strand 1 - Sparking Excitement and Interest
Strand 2	LSIE Strand 2 - Understanding Scientific Content and Knowledge
Strand 3	LSIE Strand 3 - Engaging in Scientific Reasoning
Strand 4	LSIE Strand 4 - Reflecting on Science
Strand 5	LSIE Strand 5 - Engaging in Scientific Practices
Strand 6	LSIE Strand 6 - Identifying as a science learner
GSLE1	GS Leadership Experience Outcome 1 - Develop a strong sense of self
GSLE2	GS Leadership Experience Outcome 2 - Display positive values
GSLE3	GS Leadership Experience Outcome 3 - Seek challenges and learn from setbacks
GSLE4	GS Leadership Experience Outcome 4 - Form and maintain healthy relationships
GSLE5	GS Leadership Experience Outcome 5 - Identify and solve problems in the community
GS STEM1	GS STEM Outcome 1 - STEM Interest
GS STEM2	GS STEM Outcome 2 - STEM Confidence
GS STEM3	GS STEM Outcome 3 - STEM Competence
GS STEM4	GS STEM Outcome 4 - STEM Value

Analysis

We performed manual qualitative analysis of the open-ended survey responses guided by the following analytic questions:

1. Are troops who complete the Journey achieving expected learning outcomes (informal science learning, Girl Scout Leadership Experience (GSLE) outcomes, and Girl Scout STEM outcomes?
2. Are troops' TAPs related to the science and environmental themes addressed throughout the Journey?
3. In what ways are troops 'taking action' through their TAPs?

We used a combination of deductive and inductive coding with a constant comparative method (Merriam and Tisdell 2015). To address our first analytic question, we deductively coded responses to the three open-ended questions, using 15 *a priori* codes developed from: (1) the six strands of Learning Science in Informal Environments (LSIE); (2) the five GSLE outcomes and (3) the four Girl Scout STEM outcomes (Table 1). As is common in STEM programming, the explicitly stated goals of the Think Like a Citizen Scientist Journey put a primary emphasis on traditional science content, skill, and process learning rather than affective, behavioral, and cognitive correlates to learning (NASEM, 2018). These stated outcomes aligned well with many of the LSIE strands, and in turn with many of the overarching goals for CS programming more broadly. The codes we chose therefore capture both the typical learning outcomes expected to occur through CS experiences (as encompassed in the LSIE strands) and specific organizational goals of the Girl Scouts as a facilitator organization (Leadership and STEM Leadership goals). For a complete codebook, sample quotes, and detailed explanation of alignment between codes and intended outcomes, see Appendix A.

To answer question 2, we used inductive coding of open-ended responses cross-referenced with the name of the CS project type to develop in vivo codes representing the ways in which girls' TAPs were related to science and environmental themes (or whether they were unrelated) (Table 2). For question 3, we further examined the types of actions performed in projects which were related to science and environmental themes. We used inductive coding of open-ended responses to develop in vivo codes characterizing the nature of the actions taken (Table 3). We classified projects which were not related to science and environmental topics as 'unrelated' and did not code them further.

In investigating answers to these initial questions, it became clear that 'educating and inspiring others' was an overwhelmingly common action taken by girls on their Journey. Therefore, we also sought to answer the following question:

4. What audiences are girls engaging about scientific and environmental topics?

We used inductive coding of responses to the three open-ended questions to develop codes characterizing the girls' audiences for projects related to science and environmental topics (Table 4). Again, we classified projects which were unrelated to science and environmental topics as 'unrelated' and did not code them further.

For questions 2–4, the initial list of codes was developed by a single university-affiliated member of the research team, but with an option of 'other' included. To establish inter-rater reliability, a second member of the research team affiliated with the Girl Scouts of the USA worked with the first member to agree upon code definitions. These two individuals then independently coded 59 responses (24% coverage of all responses) for analytic questions 1–4. The 59 responses were selected to represent a broad array of codes. Percent agreement was calculated across these 59 responses and was 84% overall (Miles, Huberman, and Saldaña 2018).

Table 2. List of question 2 codes characterizing relevance of girls' Take Action Projects to science and environmental themes.

Code	Sample Quotes
Participated in another citizen science project	'The girls chose to do another Citizen Scientist Observation Project. They chose the Nature's Notebook. The girls walked around the wooded area by our meeting space and collect data on the birds in the area'.
Encouraged others to participate in citizen science	'Citizen Science projects are fun and help the scientific community, but our friends and family don't know about citizen science. We made a video to share with family and friends. We explained what citizen science is and how to get involved. In our video we also shared what project we did & how much fun it was! We encouraged others to take on a citizen science project too!'
Related to an environmental theme	'We wanted to protect our ocean from plastic trash that hurts wildlife by teaching our friends to stop using single use plastics (like straws, plastic bags, and water bottles). We created a game called "Beach Cleanup" that teaches about not using plastics and caring for our ocean in a fun way'.
Related to citizen science project subject	A troop that completed ANT-vasion said: 'We really enjoyed learning how natural ant repellents are safe and effective! We wanted to share our findings with others, so that they may try them out where they may need ant control. We made an educational video showing how we did the experiment, and the results. We obtained permission to post it to our own Girl Scout Troop…YouTube channel'.
Related to science literacy	'We wanted to provide more opportunities for kids in our area to learn about STEM. We assisted in building and donating a STEM backpack for the Frisco Library available to all kids in our area'.
Not related to science or the environment	'The Troop wanted to help the residents of the nursing home by providing small throw blankets to help keep them warm. The residents needed the small throw blankets because the larger blankets get caught in the wheels of their wheel chairs. The Troop provided one small throw blanket to each resident of the nursing home (60 blankets)'.

Based on this high percent agreement which indicated code stability, the first member of the research team completed coding for the remaining 186 responses.

After coding was completed, the coded data was then imported back into R to create summary statistics to address each of these questions 1–4.

Results

Across the 245 completed journeys that we analyzed, there were participants from 231 GS troops representing 90 different councils across the US. This included participants from 43 states and Washington DC, as well as one GS troop from the USA Girl Scouts Overseas Program. Of the 231 GS troops, 130 were single-level troops, meaning all girls were roughly of the same age or grade and fell into a single GS level - Daisy ($n=53$ GS troops), Brownie ($n=41$), and Junior ($n=49$). The remaining 101 GS troops were multi-level troops with 2 or more GS levels represented.

Troops participated in 11 different CS projects in the journeys we analyzed, although 90% of troops chose among just 5 popular projects: Ant Picnic (70 journeys), Stream Selfie (59), Project Squirrel (49), GLOBE Observer: Clouds (22), and Globe at Night (20) (Appendix B).

Expected learning outcomes

Analysis of learning outcomes in accordance with analytic question 1 revealed that all 15 possible learning outcomes were represented at least once (Figure 2). Notably, the three most common outcomes spanned the three code categories of GSLE Outcomes, LSIE Strands, and GS STEM Outcomes, and reflected girls' ability to address problems in their communities, understand scientific content and knowledge, and develop STEM confidence.

GSLE Outcome 5: Identify and Solve Problems in the Community was the most common outcome, occurring 355 times (48% out of a possible 735 responses: 245 journeys × 3 responses per Journey). This outcome was often apparent in descriptions of the problem and solution

Table 3. List of question 3 codes characterizing the types of actions performed through Take Action Projects.

Code	
Educate and Inspire Others	A troop that completed Globe at Night said: 'We wanted to teach others about the stars and constellations. Also about lights out times to view the stars. Our troop made 5 informational posters that are on display in several local schools, at our local library, and we're displayed at our cookie booths'. 'Not enough people are aware of Citizen Science…[We made] a presentation and handouts for the public that explains Citizen Science and encourages others to engage in projects'.
Improve environment or habitat	'The girls wanted to create areas that would attract 'good' native bugs and insects. The girls planned and planted raised garden beds at the local YMCA'
Participate in more citizen science	'We wanted to contribute to another citizen science project. We chose Project Squirrel'.
Take civic action	'The girls would like to limit the amount of school supply waste by recycling used and worn out items that are being thrown in the trash. We will partner with Crayola and other companies to place recycling bins through out the school for markers, crayons, and paper and send them to be repurposed. By partnering with the school district they will be implementing this program every year by educating the teachers and reminding students of the location and purposes of the bins'.
Promote science literacy	'There were many students in our schools that didn't know much about science and couldn't find any age appropriate books to read about science. We decided to raise money and buy science books to donate to our school library'.
Project unrelated to science or environmental theme	'The Hedgehog…at [a local] Nature Center keeps getting [sic] wearing out his sleep sacks. The girls sewed 8 new sleep sacks, using techniques from their research into making hedgehog bags'.

Table 4. List of question 4 codes characterizing the audiences engaged through Take Action Projects.

Code
Peers
Adults
General Public
Civic Leaders
Unspecified Audience
Project unrelated to science or environmental theme

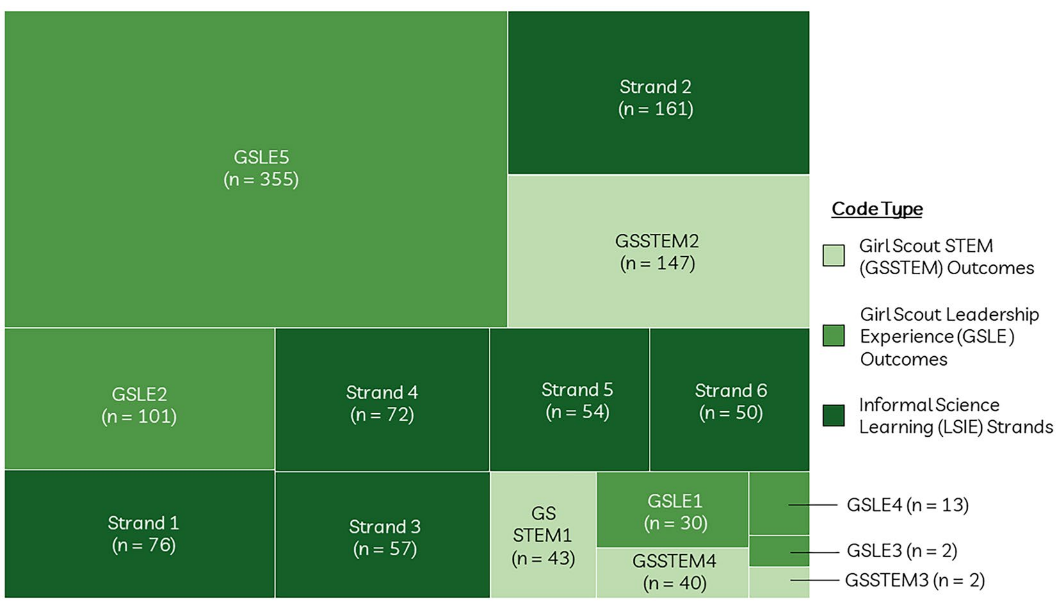

Figure 2. Treemap depicting comparative frequencies of occurrence of each code for analytic question 1.

addressed through a TAP. For example, one Girl Scout troop leader presented the following problem and solution:

> The girls would like to limit the amount of school supply waste by recycling used and worn out items that are being thrown in the trash. We will partner with Crayola and other companies to place recycling bins through out [sic] the school for markers, crayons, and paper and send them to be repurposed.

The next most common outcome was LSIE Strand 2: Understanding Scientific Content and Knowledge (161 occurrences, 22% of responses). In demonstrating an understanding of scientific content and knowledge, girls sometimes shared project-relevant content they learned during participation in their chosen citizen science project, for example: 'The girls wanted to inform the public about light pollution after completing the Stars at Night'.

They also often shared information about the process of participating in citizen science and what they learned through that process. For example, the leader of a Girl Scout troop that participated in the Ant Picnic project stated: 'The girls talked with their classmates about science and being Citizen Scientist [sic]. They showed them their posters on the different foods ants like to eat and what they were not crazy about'.

However, many troops also explored new science and environmental topics through their TAPs, as evident in the report by the leader of a troop who completed the Stream Selfie citizen science project:

> Bat populations are facing difficulty. Bats need clean water and a place to roost and raise young. The troop researched bat boxes and built 12 boxes to be donated to state parks as well as the area where our citizen science project took place.

The last of the most common three codes was Girl Scout STEM Outcome 2: STEM Confidence (147 occurrences, 20% of responses). This was typically characterized by girls demonstrating their understanding of the scientific processes they engaged in to others. For example, one troop leader stated: 'The Daisies told many people what they did and shared how important it is to collect data and interpret results'.

Relevance to science and the environment

In addressing analytic question 2, six codes were inductively developed to characterize the relevance of a TAP to science and environmental themes (Figure 3). While girls had the option to solve any problem in the community for their TAPs, most (81%) chose to take an action related to science or the environment. Projects involved activities both related and unrelated to the original CS project completed in Step 1, participating in another CS project or encouraging others to do so, and addressing access to resources for cultivating science literacy in the community.

Some projects encompassed more than one code, and therefore percentages represented in Figure 3 are non-exclusive, except for the 19% of projects which were not related to science or the environment. For example, some troops completed a TAP directly related to the citizen science project they participated in (31%), which also was related to an environmental theme. Many troops who contributed to Stream Selfie chose to follow up with a stream clean-up and/or additional water testing:

> We went to the stream observed and recorded the clarity of the water. We cleaned up what little litter we found. We then reported the issues of skin irritation and signs of pesticide and fertilizer runoff we found…to city officials and others in our neighborhood.

Other troops completed a project related to an environmental theme or issue, but unrelated to the citizen science project they completed. For example, one troop who participated in the

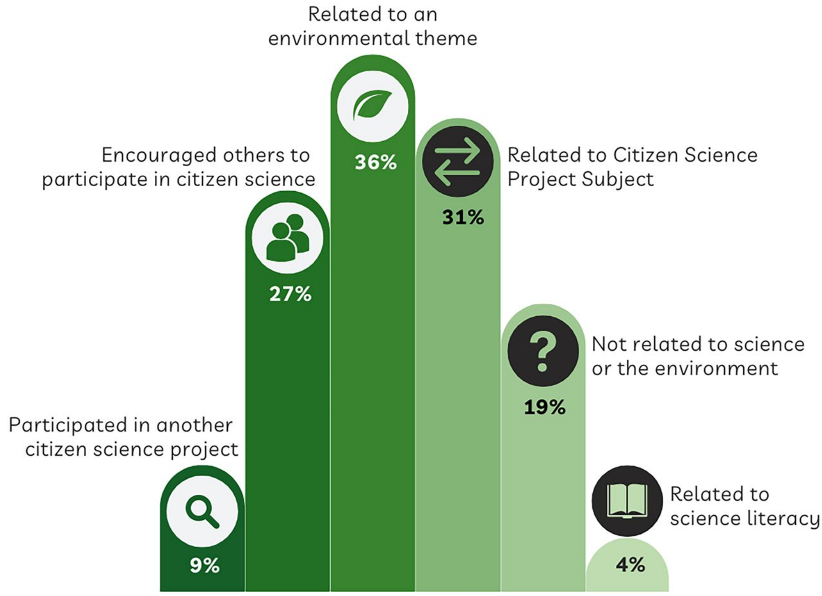

Figure 3. Bar graph depicting how Take Action Projects related to science and the environment. Categories are non-exclusive with the exception of 'not related…'; percentages therefore add up to more than 100%. Percentages are rounded to the nearest percent.

Globe at Night project – a project focused on recording light pollution (Appendix B) – completed a TAP related to water conservation:

> Our Girl Scout Troop wanted to help educate family, friends and the community on how easy it is to recycle rainwater for use in gardens and landscaping. Our Troop made a small-scale model of a home with a downspout and a rainwater collection barrel out of cardstock, a straw and a small solo cup. Each Girl Scout will then show their family, friends and community what they made and, hopefully, start a conversation on how easy it is to recycle rainwater for use in the garden.

Several others took action by either participating in another CS project themselves, or encouraging others to do so. While less frequent, a notable handful of troops chose to complete TAPs related to science literacy. For example, after their experience completing the journey, one troop leader stated:

> We wanted other kids to know how much [fun] science could be and easy ways they could enjoy science. [They] made a flyer with different tv shows, web sites and books that are STEM related and are fun to to [sic] watch, play and read.

Types of action

After addressing analytic question 2, we did not seek to further characterize TAPs which were unrelated to science and environmental topics. We therefore excluded those 47 projects from the remaining analyses. To address analytic question 3, five codes were inductively developed to characterize the types of actions taken during the remaining 198 projects (Figure 4). Again, these codes were non-exclusive, meaning a single project may involve more than one type of action. For example, many troop leaders reported their troop's choice to improve habitat or participate in another citizen science project, but also incorporated 'educating and inspiring others' into their project by getting others to participate with them or telling others about what they did and how they could participate in the future. One troop who participated in

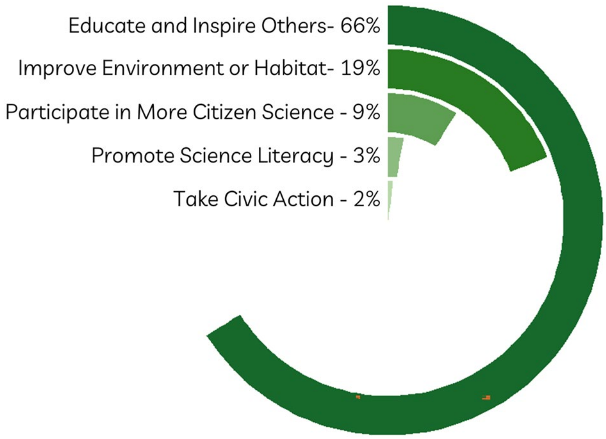

Figure 4. Circular bar graph illustrating the percentages of Take Action Projects in which girls took each coded type of action. Percentages are rounded to the nearest percent. Projects unrelated to science and environmental topics are not included. All categories are non-exclusive, therefore percentages add up to more than 100%.

Project Squirrel chose to participate in a second project (Stream Selfie), host a stream cleanup, and educate others about clean water:

> Trash near streams impacts our drinking water. We cleaned up all the trash we saw and also contributed data to Stream Selfie. We contributed data to help the scientists with their efforts and will continue to educate others on how everyone can help scientists with data and aldo [sic] how important it is to keep our waters clean.

A small but notable subset of troops took civic action to achieve long-term solutions to the problems they identified. For example, one individual Girl Scout addressed the following challenge:

> We do not have a recycling bin on our Scout House. I met with two members of the city's recycling commission to ask their help in asking the city to put in a recycling bin. They helped me write a presentation to present to the city staff. I will teach our troop what to put into the bin and what not to put into the bin.

Audiences engaged

As seen in Figure 4, 'Educating and Inspiring Others' was the most common type of action girls performed during their TAPs, occurring in 74% of projects related to science and environmental topics. Among projects that *were* related to science and the environment (81%, Figure 3), we further examined the types of audiences girls engaged on these topics in pursuit of analytic question 4. We identified 4 main audience categories: peers, adults, the general public, and civic leaders, with additional codes for 'unspecified' audiences and 'unrelated' projects. With the exception of 'unrelated', these categories are again non-exclusive, as girls often spoke to more than one type of audience.

Of the 151 TAPs which sought to 'educate and inspire others', *peers* (including other Girl Scouts, siblings, classmates, and friends) were the most frequently engaged audience ($n=85$), with the *general public* ($n=39$) and *adults* (teachers, parents, etc.; $n=37$) being fairly common as well (Figure 5). A smaller number of troops ($n=9$) approached civic leaders about enacting change in their communities. Many respondents also simply wrote that they 'educated others', thus the audience was categorized as 'unspecified' ($n=66$).

Examples of projects with audiences spanning multiple categories include ones who engaged their families (parents and siblings, or adults and peers):

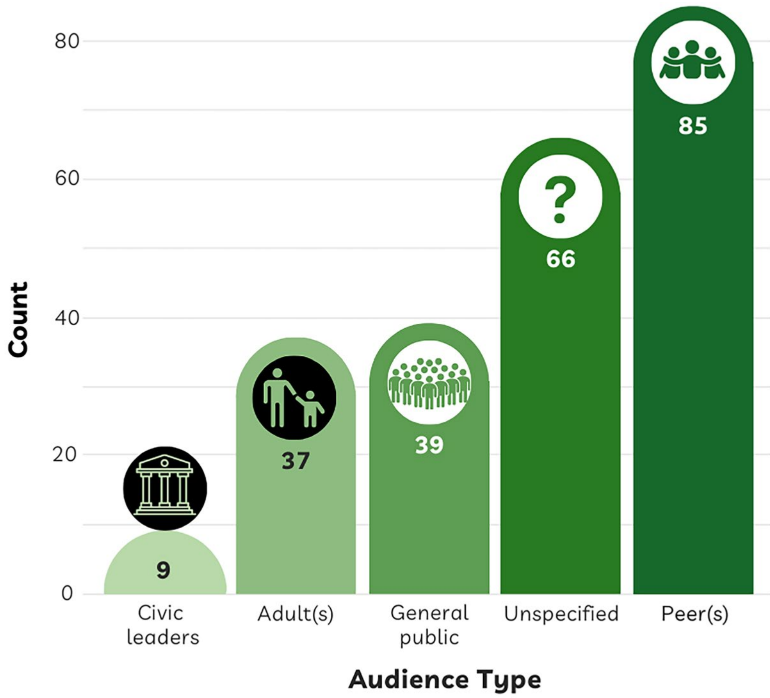

Figure 5. Bar graph demonstrating the frequency with which girls engaged different audiences through their Take Action Projects. Projects unrelated to science and environmental topics are not included. All categories are non-exclusive, therefore percentages add up to more than 100%.

> Every scout made a clean water pledge and decided on one action she and her family can do to reduce water pollution (ie do not litter). Each scout intends to make a permanent change and include her household members in the pledge;

other Girl Scouts, teachers, and classmates (peers and adults):

> We passed out flyers [about fun STEM activities] to our fellow girls [sic] scouts. We also brought flyers to our schools and gave them to our teachers so that they could give them out to the other kids in our classes;

and members of the school community and local community more broadly (peers, adults, and general public):

> [Our Troop] wanted to educate their school and local community about how they could use SciStarter to engage in citizen scientist projects. The Brownies in [Troop Number] designed a flyer that was distributed to everyone in their k-8 school about how to join citizen scientist projects using SciStarter…They are also trying to get the information printed in the local newspaper.

Discussion

Expanding CS learning outcomes through facilitation

The structure provided by the facilitated curriculum of the Think Like a Citizen Scientist Journey and SciStarter platform demonstrated great potential to support varied forms of learning. Our analysis identified a wide array of cognitive, affective, and behavioral outcomes among participants. By completing the three scaffolded Journey steps, girls implicitly made progress towards at least three of the expected learning outcomes (Table 1). The science learning activities in step 1 of the Journey included practicing observation and data collection and therefore facilitated achieving LSIE Strand 3: Engaging in Scientific Reasoning, while step 2 – participating in a CS Project – fulfilled LSIE Strand 5: Engaging in Scientific Practices (NASEM, 2018). Completing a TAP in step 3 fulfilled GLSE Outcome 5: Identify and solve problems in the community (GSUSA, 2017).

While a more targeted quantitative assessment of learning outcomes during the first two steps of the Journey may have allowed measuring changes in knowledge and certain affective and behavioral components to learning, our analysis of learning here helps to address the dearth of literature qualitatively exploring outcomes of participation in CS learning experiences (Phillips et al. 2019). The open-ended nature of responses allowed troops to reflect and identify the salient aspects of learning from their Journey.

Our analysis revealed that not only these three implicit outcomes but all 15 possible learning outcomes were present, including the development of content knowledge and science literacy as well as affective and behavioral outcomes such as science identity, STEM confidence, and taking actions to address scientific and environmental challenges (Figure 2; Appendix A). While our analysis centered on the TAP phase of the Journey, it was evident from troop leaders' responses that the scaffolded and facilitated nature of this learning experience was self-reinforcing, with troops building on the science learning which occurred in steps 1 and 2 of the Journey during the TAP phase. Such intentional learning supports are one key element of facilitated CS which may help to better foster a variety of learning outcomes.

Extension of learning and supporting civic science education

We found Levy et al.'s (2021) typology of civic science education (CSE) provided a helpful framework for understanding the different forms of civic science engagement which occurred through the GS Journey (Table 5). This typology places participation in most CS projects in the *exploratory* stage of CSE, which 'involves the collection and analysis of data on science-related civic issues' (Levy et al. 2021, 1057). As discussed above, steps 1 and 2 of the Journey provided opportunities to achieve these types of skill- and process-focused science learning.

The third step of the Journey – the TAP – proved to be a unique feature of this facilitated CS experience which paved the way for extensions of learning beyond the typical focus on scientific skills, content knowledge, and process knowledge. The TAP served as a bridge to propel girls from the *exploratory* category of CSE to the *purposefully active* category, defined by Levy et al. (2021) as 'experiences that involve raising awareness, advocating, organizing others, designing solutions, and/or purposefully participating in efforts to address science-related public matters' (1057). Experiences such as these are critical foundations to prepare youth to be more engaged in civic issues related to science and the environment in the future (Ballard et al. 2017; Tidball & Krasny, 2010).

There were no explicitly stated learning outcomes for the TAP step of the Journey; the goal was simply to 'Do a Take Action Project to address an issue in your community' (GSUSA, n.d.a., 1). Perhaps due to the broad guidelines for this step of the Journey, the TAP therefore created the potential for many unintended learning outcomes. In particular, the emphasis on action paved the way to the types of behavioral outcomes often only hoped for in CS and environmental programming more broadly (Haywood et al. 2016; Lewandowski & Oberhauser, 2017; McKinley et al. 2017; Phillips et al. 2018).

While the Journey curriculum provided examples of ways to connect a TAP to the previous steps in the Journey, the topic of the TAP was ultimately left open to the discretion of each

Table 5. Activities from the Girl Scouts' (GS) Think Like a Citizen Scientist Journey mapped onto Levy et al.'s (2021) typology of civic science education (CSE).

Levy et al. (2021) CSE Category	Levy et al. (2021) Definition	Relevant GS Journey Activities
Foundational	'CSE experiences that involve exposure to, discussion of, and/or peer interactions around science-related public matters, with a focus on the development of related knowledge, skills, and values'.	Interactions with various audiences through efforts to educate and inspire others provided foundational CSE experiences to these audiences.
Exploratory	'CSE experiences that involve asking questions and collecting and/or analyzing data and/or evidence related to science-related public matters'.	Participating in a citizen science project provided exploratory CSE experiences for GS participants and those who participated with them.
Purposefully Active	'CSE experiences that involve raising awareness, advocating, organizing others, designing solutions, and/or purposefully participating in efforts to address science-related public matters'.	Enacting a Take Action Project (including sharing or discussing science and/or environmental topics; reaching out to a civic leader; improving the environment or creating habitat; encouraging others to participate in citizen science, etc.) provided GS troop members with purposefully active CSE experiences.

girl or GS troop. Despite this, 81% of troops still chose to address a problem related to a science or environmental topic. Among this 81% (198 projects), a high proportion (66%) involved efforts to educate and inspire others. This process of sharing findings and information with others who can act upon it – particularly with civic leaders – could itself be considered a form of civic environmental action (Haywood et al. 2016). Furthermore, the act of demonstrating expertise and sharing findings has been shown to reinforce learning and boost youth CS participants' environmental science agency, therefore promoting their confidence in taking future civic environmental action (Ballard et al. 2017). These opportunities therefore likely supported the development of STEM confidence and science identity captured in some open-ended responses.

Such efforts to educate and inspire others also had the potential to further the learning impacts of the Journey by providing *foundational* CSE to the girls' audiences, characterized by 'exposure to, discussion of, and/or peer interactions around science-related public matters…' (Levy et al. 2021, 1057). Given their engagement of outside audiences and the breadth of scientific skills and both science and environmental content knowledge girls were exposed to throughout the Journey, there was great potential for the diffusion of knowledge through the girls' social networks and broader audiences. This phenomenon has been described previously in relation to CS participation, including the spreading of environmental knowledge and skills by CS participants in a 2014 country-wide study in India (Johnson et al. 2014). The authors identified a three-step process of dissemination wherein individuals – typically those with pre-existing interest and concern for environmental issues – seek out opportunities to participate in CS; develop a degree of expertise and self-efficacy on related issues through this participation; and in turn engage in advocacy by encouraging members of their social networks to participate, educating members of the public on related topics, or pursuing a related career or educational path. In the case of the Girl Scout Journey, we see that even young individuals who may be newly exposed to environmental and scientific topics of societal importance are able to spread knowledge and inspire actions through their social networks.

GS troops accomplished this *via* both peer-to-peer and inter-generational learning through their efforts to educate their peers, the public, and adults in their lives. Previous research has demonstrated the potential for peer-to-peer learning to encourage environmental action among youth (de Vreede et al. 2014). Additionally, youth-led action on environmental issues has been shown to influence concern and policy support among adults, including civic leaders and members of the public outside their immediate family (Hartley et al. 2021). In all its forms, the ways in which the Journey facilitated the sharing of knowledge and outlets for engaging in CS and science more broadly makes it an excellent example of the potential for CS participation to foster community science literacy, an area of emerging interest in CS and STEM education research (Gibson et al. 2022; NASEM, 2016; NASEM, 2018).

Limitations and future research

We know that girls who completed the Journey were exposed to a variety of science and environmental topics, participated in a CS project, and took community action. Yet, while we observed extensive evidence of fulfilled learning outcomes among troop leader responses to our open-ended questions, we were not able to directly or quantitatively measure girls' learning within the scope of the current work. Additionally, although girls and their GS troop leaders documented extensive efforts to 'educate and inspire others', we did not have the ability to quantify the impact on their audiences. Finally, while we only saw evidence of direct engagement with civic leaders in nine Journeys, we expect that older troops may have a greater capacity for such engagement, as a few open-ended responses specifically noted that due to the girls' ages (roughly 5–11), their ability to change a rule or a law (one of the suggested ways of making a TAP 'sustainable') was limited. Wichmann et al. (2022) recently noted the influence of age on behavioral outcomes of CS participation, with increasing participant age positively affecting students' ascription of harm for plastic marine debris (PMD), but negatively affecting their perceived behavioral control, awareness of consequences, ascription of responsibility, and self-reported behaviors surrounding PMD. Future research could examine and compare outcomes across the extended age range for the Journey (grades K-12) and similar programs and could aim for a more quantitative assessment of learning outcomes and civic engagement, perhaps working in partnership with older girls to measure impacts of their TAPs.

This case study demonstrates the potential for a facilitator organization to promote learning outcomes and civic action through a CS learning experience. Beyond this single instance of facilitated citizen science, there is still much to be learned about the roles these organizations play in the CS ecosystem, including what their motivations are for engaging with CS and the types of common outcomes these organizations can achieve in pursuit of their own goals and those of science learning more broadly (multi-project participation, pro-environmental behaviors, etc.). For example, in the case presented here, the GSUSA focus on hands-on learning and STEM education made CS programming a good fit for achieving their organizational goals, while the Girl Scouts' emphasis on STEM leadership and existing programs to promote learning and action provided important structures to support and extend learning outcomes from CS participation. Examination of a greater variety of facilitator organizations will help inform future program management by further elucidating the contexts and features that can best promote desired outcomes. One contextual piece which also may be of interest is examining the role of specific individuals within a facilitator organization in supporting participant learning outcomes. We emphasized earlier that we were interested in the role of the organization as a whole, but it is worth noting that key individuals (such as Girl Scout troop leaders) may still have a critical role as learning brokers in a CS experience (Barron et al. 2009).

A final area of future research with broad implications for the CS community at large is the potential for facilitator organizations to foster greater inclusion of individuals from groups that may have been historically under-represented in CS and the STEM sphere more broadly. CS has roots in efforts to democratize science (Bonney et al. 2016), yet current participant demographics poorly reflect such aspirations (Allf et al. 2022; Mahmoudi et al. 2022), leading to recent calls to make CS more inclusive and aligned with community interests (Cooper et al. 2021; Pandya, 2012). While demographics have not been a large focus of this case study, and specific demographics of participating girls were not available, it is worth emphasizing the geographic diversity of participants from across the US, including rural and urban areas in 43 states and DC. This geographic diversity likely also reflects a diversity of economic, social, political, and other backgrounds which would be worth exploring further. By fostering participation of individuals who may not otherwise self-select to participate in CS, facilitator organizations like the Girl Scouts and others – such as employers, formal and informal educational institutions, and community groups – could have an important role to play in enhancing inclusion in CS.

Conclusion

This case study of the Girl Scouts' Think Like a Citizen Scientist Journey on SciStarter demonstrates the potential for facilitator organizations to promote learning outcomes that might arise from participation in citizen science and associated learning activities. In particular, the structured progression of activities from content-and-skills based learning to action-based outcomes facilitated an extremely diverse array of cognitive, affective, and behavioral outcomes being reported, including the acquisition of STEM content knowledge and skills, development of science confidence and identity, and the adoption of civic action and advocacy behaviors. Furthermore, this case provided a unique example of how pairing CS with community engagement activities can foster peer-to-peer learning, intergenerational learning, increasing levels of civic science education, and civic action related to science and the environment, paving the way to increased community science and environmental literacy. Future research related to the role of facilitator organizations in CS should focus on developing a better understanding of the motivations of these organizations in employing CS, the specific contexts and organizational features which promote successful outcomes, and the role facilitator organizations play in enhancing inclusion in CS.

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ORCID

Haley E. Smith http://orcid.org/0000-0003-3027-884X
Caren B. Cooper http://orcid.org/0000-0001-6263-8892
K.C. Busch http://orcid.org/0000-0002-4549-5401
Suzanne Harper http://orcid.org/0000-0002-4642-8585
Darlene Cavalier http://orcid.org/0000-0002-6886-3289

References

Allf, B. C., C. B. Cooper, L. R. Larson, R. R. Dunn, S. E. Futch, M. S. Sharova, and D. Cavalier. 2022. "Citizen Science as an Ecosystem of Engagement: Implications for Learning and Broadening Participation." *Bioscience* 72 (7): 651–663. https://doi.org/10.1093/biosci/biac035

Ballard, H. L., C. G. H. Dixon, and E. M. Harris. 2017. "Youth-Focused Citizen Science: Examining the Role of Environmental Science Learning and Agency for Conservation." *Biological Conservation* 208: 65–75. https://doi.org/10.1016/j.biocon.2016.05.024

Ballard, H. L., E. M. Harris, and C. G. H. Dixon. 2018. Science Identity and Agency in Community and Citizen Science: Evidence and Potential. Commissioned by the National Academies of Science, Engineering, and Medicine. https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_189606.pdf

Barron, B., C. K. Martin, L. Takeuchi, and R. Fithian. 2009. "Parents as Learning Partners in the Development of Technological Fluency." *International Journal of Learning and Media* 1 (2): 55–77. https://doi.org/10.1162/ijlm.2009.0021

Bela, G., T. Peltola, J. C. Young, B. Balázs, I. Arpin, G. Pataki, J. Hauck, et al. 2016. "Learning and the Transformative Potential of Citizen Science." *Conservation Biology: The Journal of the Society for Conservation Biology* 30 (5): 990–999. https://doi.org/10.1111/cobi.12762

Bonney, R., C. B. Cooper, J. Dickinson, S. Kelling, T. Phillips, K. V. Rosenberg, and J. Shirk. 2009. "Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy." *BioScience* 59 (11): 977–984. https://doi.org/10.1525/bio.2009.59.11.9

Bonney, R., J. L. Shirk, T. B. Phillips, A. Wiggins, H. L. Ballard, A. J. Miller-Rushing, and J. K. Parrish. 2014. "Next Steps for Citizen Science." *Science (New York, N.Y.)* 343 (6178): 1436–1437. https://doi.org/10.1126/science.1251554

Bonney, R., T. B. Phillips, H. L. Ballard, and J. W. Enck. 2016. "Can Citizen Science Enhance Public Understanding of Science?" *Public Understanding of Science (Bristol, England)* 25 (1): 2–16. https://doi.org/10.1177/0963662515607406

Branchini, S., M. Meschini, C. Covi, C. Piccinetti, F. Zaccanti, and S. Goffredo. 2015. "Participating in a Citizen Science Monitoring Program: Implications for Environmental Education." *PLoS One* 10 (7): e0131812. https://doi.org/10.1371/journal.pone.0131812

Bruckermann, Till, Hannah Greving, Anke Schumann, Milena Stillfried, Konstantin Börner, Sophia E. Kimmig, Robert Hagen, Miriam Brandt, and Ute Harms. 2021. "To Know about Science is to Love It? Unraveling Cause-Effect Relationships between Knowledge and Attitudes toward Science in Citizen Science on Urban Wildlife Ecology." *Journal of Research in Science Teaching* 58 (8): 1179–1202. https://doi.org/10.1002/tea.21697

Chandler, M., L. See, K. Copas, A. M. Z. Bonde, B. C., B. López, F. Danielsen, J. K. Legind, et al. 2017. "Contribution of Citizen Science towards International Biodiversity Monitoring." *Biological Conservation* 213 (B): 280–294. https://doi.org/10.1016/j.biocon.2016.09.004

Chase, S. K., and A. Levine. 2018. "Citizen Science: Exploring the Potential of Natural Resource Monitoring Programs to Influence Environmental Attitudes and Behaviors." *Conservation Letters* 11 (2): e12382. https://doi.org/10.1111/conl.12382

Cooper, C. B., C. L. Hawn, L. R. Larson, J. K. Parrish, G. Bowser, D. Cavalier, R. R. Dunn, et al. 2021. "Inclusion in Citizen Science: The Conundrum of Rebranding." *Science* 372 (6549): 1386–1388. DOI: https://doi.org/10.1126/science.abi6487

Cooper, C. B., J. Shirk, and B. Zuckerberg. 2014. "The Invisible Presence of Citizen Science in Global Research: Migratory Birds and Climate Change." *PLoS One* 9 (9): e106508. https://doi.org/10.1371/journal.pone.0106508

Crowdsourcing and Citizen Science Act (CCSA). 2017. "Public Law 114–329." Title IV, § 402.

de Vreede, C., A. Warner, and R. Pitter. 2014. "Facilitating Youth to Take Sustainability Actions: The Potential of Peer Education." *The Journal of Environmental Education* 45 (1): 37–56. https://doi.org/10.1080/00958964.2013.805710

Forrester, T. D., M. Baker, R. Costello, R. Kays, A. W. Parsons, and W. J. McShea. 2017. "Creating Advocates for Mammal Conservation through Citizen Science." *Biological Conservation* 208: 98–105. https://doi.org/10.1016/j.biocon.2016.06.025

Fraisl, D., G. Hager, B. Bedessem, M. Gold, P.-Y. Hsing, F. Danielsen, C. B. Hitchcock, et al. 2022. "Citizen Science in Environmental and Ecological Sciences." *Nature Reviews: Methods Primers* 2 (64): 1–20. https://doi.org/10.1038/s43586-022-00144-4

Gibson, Lauren M., K. C. Busch, Kathryn T. Stevenson, Bethany B. Cutts, Elizabeth A. DeMattia, Olivia M. Aguilar, Nicole M. Ardoin, et al. 2022. "What is Community-Level Environmental Literacy, and How Can we Measure It? A Report of a Convening to Conceptualize and Operationalize CLEL." *Environmental Education Research* 28 (10): 1423–1451. https://doi.org/10.1080/13504622.2022.2067325

Girl Scouts of the USA (GSUSA). n.d.a. *Girl Scout Juniors Think like a Citizen Scientist Leadership Journey*. Internal GSUSA document: Unpublished.

Girl Scouts of the USA (GSUSA). n.d.b. 2023. Four ways Girl Scouts builds girl leaders in STEM. Retrieved January 6, from https://www.girlscouts.org/content/dam/girlscouts-gsusa/forms-and-documents/about-girl-scouts/research/GSRI_four-ways-Girl-Scouts-builds-girl-leaders-in-STEM_0417.pdf

Girl Scouts of the USA (GSUSA). 2017. 5 Ways Girl Scouts builds girl leaders. Retrieved August 18, 2022, from https://my-stage.girlscouts.org/content/dam/girlscouts-gsusa/forms-and-documents/about-girl-scouts/research/GSUSA_Five-Ways-Girl-Scouts-Builds-Girl-Leaders_2017.pdf

Girl Scouts of the USA (GSUSA). 2022a. 2022. from The Girl Scout Leadership Experience: Girl scouts. Retrieved August 1, https://www.girlscouts.org/en/discover/about-us/what-girl-scouts-do/leadership-experience.html

Girl Scouts of the USA (GSUSA). 2022b. Understanding take action activity: Girl scouts. Retrieved August 11, 2022, from https://www.girlscouts.org/en/activities-for-girls/juniors/take-action-activity.html

Gresle, A.-S., E. Urias, R. Scandurra, B. Balázs, I. Jimeno, L. de la Torre Ávila, and M. J. Pinazo. 2021. "Citizen-Driven Participatory Research Conducted through Knowledge Intermediary Units. A Thematic Synthesis of the Literature on "Science Shops." *Journal of Science Communication* 20 (05): A02. https://doi.org/10.22323/2.20050202

Greving, Hannah, Till Bruckermann, Anke Schumann, Tanja M. Straka, Daniel Lewanzik, Silke L. Voigt-Heucke, Lara Marggraf, et al. 2022. "Improving Attitudes and Knowledge in a Citizen Science Project about Urban Bat Ecology." *Ecology and Society* 27 (2): 24. https://doi.org/10.5751/ES-13272-270224

Haklay, M., D. Fraisl, B. G. Tzovaras, S. Hecker, M. Gold, G. Hager, L. Ceccaroni, et al. 2021. "Contours of Citizen Science: A Vignette Study." *Royal Society Open Science* 8 (8): 202108. https://doi.org/10.1098/rsos.202108

Hartley, J. M., K. T. Stevenson, M. N. Peterson, E. A. DeMattia, S. Paliotti, and T. J. Fairbairn. 2021. "Youth Can Promote Marine Debris Concern and Policy Support among Local Voters and Political Officials." *Frontiers in Political Science* 3 (2021): 1–11. https://doi.org/10.3389/fpos.2021.662886

Haynes, K., and T. M. Tanner. 2015. "Empowering Young People and Strengthening Resilience: Youth-Centred Participatory Video as a Tool for Climate Change Adaptation and Disaster Risk Reduction." *Children's Geographies* 13 (3): 357–371. https://doi.org/10.1080/14733285.2013.848599

Haywood, B. K., J. K. Parrish, and J. Dolliver. 2016. "Place-Based and Data-Rich Citizen Science as a Precursor for Conservation Action." *Conservation Biology: The Journal of the Society for Conservation Biology* 30 (3): 476–486. https://doi.org/10.1111/cobi.12702

He, Y., J. K. Parrish, S. Rowe, and T. Jones. 2019. "Evolving Interest and Sense of Self in an Environmental Citizen Science Program." *Ecology and Society* 24 (2): 33. https://doi.org/10.5751/ES-10956-240233

Hiller, S. E. 2012. "The Impact of a Citizen Science Program on Student Achievement and Motivation: A Social Cognitive Career Perspective." Thesis (PhD). George Mason University

Johnson, M. F., C. Hannah, L. Acton, R. Popovici, K. K. Karanth, and E. Weinthal. 2014. "Network Environmentalism: Citizen Scientists as Agents for Environmental Advocacy." *Global Environmental Change* 29 (2014): 235–245. https://doi.org/10.1016/j.gloenvcha.2014.10.006

Jones, M. G., E. N. Corin, T. Andre, G. M. Childers, and V. Stevens. 2017. "Factors Contributing to Lifelong Science Learning: Amateur Astronomers and Birders." *Journal of Research in Science Teaching* 54 (3): 412–433. https://doi.org/10.1002/tea.21371

Jordan, R. C., S. A. Gray, D. V. Howe, W. R. Brooks, and J. G. Ehrenfeld. 2011. "Knowledge Gain and Behavioral Change in Citizen-Science Programs." *Conservation Biology: The Journal of the Society for Conservation Biology* 25 (6): 1148–1154. https://doi.org/10.1111/j.1523-1739.2011.01745.x

Kollmuss, A., and J. Agyeman. 2002. "Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to Pro-Environmental Behavior?" *Environmental Education Research* 8 (3): 239–260. https://doi.org/10.1080/13504620220145401

Levy, B. L. M., A. W. Oliveira, and C. B. Harris. 2021. "The Potential of "Civic Science Education": Theory, Research, Practice, and Uncertainties." *Science Education* 105 (6): 1053–1075. https://doi.org/10.1002/sce.21678

Lewandowski, E., and K. Oberhauser. 2017. "Butterfly Citizen Scientists in the United States Increase Their Engagement in Conservation." *Biological Conservation* 208: 106–112. https://doi.org/10.1016/j.biocon.2015.07.029

Mahmoudi, D., C. L. Hawn, E. Henry, D. Perkins, C. B. Cooper, and S. Wilson. 2022. "Mapping for Whom? Communities of Color and the Citizen Science Gap." *ACME: An International Journal for Critical Geographies* 21 (4): 372–388.

McKinley, D. C., A. J. Miller-Rushing, H. L. Ballard, R. Bonney, H. Brown, S. C. Cook-Patton, D. M. Evans, et al. 2017. "Citizen Science Can Improve Conservation Science, Natural Resource Management, and Environmental Protection." *Biological Conservation* 208: 15–28. https://doi.org/10.1016/j.biocon.2016.05.015

Merriam, S. B., and E. J. Tisdell. 2015. *Qualitative Research: A Guide to Design and Implementation* (4th ed.). San Francisco, CA: John Wiley & Sons.

Miles, M. B., A. M. Huberman, and J. Saldaña. 2018. *Qualitative Data Analysis: A Methods Sourcebook* (4th ed.). Los Angeles, CA: Sage Publications.

Miller-Rushing, A., R. Primack, and R. Bonney. 2012. "The History of Public Participation in Ecological Research." *Frontiers in Ecology and the Environment* 10 (6): 285–290. https://doi.org/10.1890/110278

National Research Council (NRC). 2009. *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington, DC: National Academies Press. https://doi.org/10.17226/12190

National Academies of Sciences, Engineering, and Medicine (NASEM). 2016. *Science Literacy: Concepts, Contexts, and Consequences*. Washington, DC: The National Academies Press. https://doi.org/10.17226/23595

National Academies of Sciences, Engineering, and Medicine (NASEM). 2018. *Learning through Citizen Science*. Washington, DC: National Academies Press. https://doi.org/10.17226/25183

Nelson, S., G. Ira, and A. M. Merenlender. 2022. "Adult Climate Change Education Advances Learning, Self-Efficacy, and Agency for Community-Scale Stewardship." *Sustainability* 14 (3): 1804. https://doi.org/10.3390/su14031804

Pandya, R. E. 2012. "A Framework for Engaging Diverse Communities in Citizen Science in the US." *Frontiers in Ecology and the Environment* 10 (6): 314–317. https://doi.org/10.1890/120007

Peter, Maria, Tim Diekötter, Tim Höffler, and Kerstin Kremer. 2021. "Biodiversity Citizen Science: Outcomes for the Participating Citizens." *People and Nature* 3 (2): 294–311. https://doi.org/10.1002/pan3.10193

Phillips, T. B., H. L. Ballard, B. V. Lewenstein, and R. Bonney. 2019. "Engagement in Science through Citizen Science: Moving beyond Data Collection." *Science Education* 103 (3): 665–690. https://doi.org/10.1002/sce.21501

Phillips, T., N. Porticella, M. Constas, and R. Bonney. 2018. "A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science." *Citizen Science: Theory and Practice* 3 (2): 3. https://doi.org/10.5334/cstp.126

Price, C. A., and H. Lee. 2013. "Changes in Participants' Scientific Attitudes and Epistemological Beliefs during an Astronomical Citizen Science Project." *Journal of Research in Science Teaching* 50 (7): 773–801. https://doi.org/10.1002/tea.21090

R Core Team. 2022. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. URL https://www.R-project.org/.

Roche, J., L. Bell, C. Galvão, Y. N. Golumbic, L. Kloetzer, N. Knoben, M. Laakso, et al. 2020. "Citizen Science, Education, and Learning: Challenges and Opportunities." *Frontiers in Sociology* 5: 613814. https://doi.org/10.3389/fsoc.2020.613814

Salmon, R. A., S. Rammell, M. T. Emeny, and S. Hartley. 2021. "Citizens, Scientists, and Enablers: A Tripartite Model for Citizen Science Projects." *Diversity* 13 (7): 309. https://doi.org/10.3390/d13070309

Santori, C., R. J. Keith, C. M. Whittington, M. B. Thompson, J. U. Van Dyke, and R. Spencer. 2021. "Changes in Participant Behaviour and Attitudes Are Associated with Knowledge and Skills Gained by Using a Turtle Conservation Science App." *People and Nature* 3 (1): 66–76. https://doi.org/10.1002/pan3.10184

Schneller, A. J. 2008. "Environmental Service Learning: Outcomes of Innovative Pedagogy in Baja California Sur, Mexico." *Environmental Education Research* 14 (3): 291–307. https://doi.org/10.1080/13504620802192418

Schneiderhan-Opel, J., and F. X. Bogner. 2020. "How Fascination for Biology is Associated with Students' Learning in a Biodiversity Citizen Science Project." *Studies in Educational Evaluation* 66: 100892. https://doi.org/10.1016/j.stueduc.2020.100892

Schultz, P. W. 2011. "Conservation Means Behavior." *Conservation Biology: The Journal of the Society for Conservation Biology* 25 (6): 1080–1083. https://doi.org/10.1111/j.1523-1739.2011.01766.x

Sharova, M. 2020. "Next Steps in Shared Management of Citizen Scientists: Understanding Project Owner Perspectives and Volunteer Connections to Science." Master's thesis. [University Name], United States.

Shirk, J. L., H. L. Ballard, C. C. Wilderman, T. Phillips, A. Wiggins, R. Jordan, E. McCallie, et al. 2012. "Public Participation in Scientific Research." *Ecology and Society* 17 (2): 29. https://doi.org/10.5751/ES-04705-170229

Smith, H., B. Allf, L. Larson, S. Futch, L. Lundgren, L. Pacifici, and C. Cooper. 2021. "Leveraging Citizen Science in a College Classroom to Build Interest and Efficacy for Science and the Environment." *Citizen Science: Theory and Practice* 6 (1): 29. https://doi.org/10.5334/cstp.434

Tidball, K. G., and M. E. Krasny. 2010. "Urban Environmental Education from a Social-Ecological Perspective: Conceptual Framework for Civic Ecology Education." *Cities and the Environment* 3 (1): 1–20. Article 11. https://doi.org/10.15365/cate.31112010

Toomey, A. H., and M. C. Domroese. 2013. "Can Citizen Science Lead to Positive Conservation Attitudes and Behaviors?" *Human Ecology Review* 20 (1): 50–62, 67.

Turrini, T., D. Dorler, A. Richter, F. Heigl, and A. Bonn. 2018. "The Threefold Potential of Environmental Citizen science - Generating Knowledge, Creating Learning Opportunities and Enabling Civic Participation." *Biological Conservation* 225 (2018): 176–186. https://doi.org/10.1016/j.biocon.2018.03.024

Varela-Candamio, L., I. Novo-Corti, and M. T. García-Álvarez. 2018. "The Importance of Environmental Education in the Determinants of Green Behavior: A Meta-Analysis Approach." *Journal of Cleaner Production* 170 (2018): 1565–1578. https://doi.org/10.1016/j.jclepro.2017.09.214

van der Velde, T., D. A. Milton, T. J. Lawson, C. Wilcox, M. Lansdell, G. Davis, G. Perkins, and B. D. Hardesty. 2017. "Comparison of Marine Debris Data Collected by Researchers and Citizen Scientists: Is Citizen Science Data Worth the Effort?" *Biological Conservation* 208: 127–138. https://doi.org/10.1016/j.biocon.2016.05.025

Vitone, T., K. Stofer, M. S. Steininger, J. Hulcr, R. Dunn, and A. Lucky. 2016. "School of Ants Goes to College: Integrating Citizen Science into the General Education Classroom Increases Engagement with Science." *Journal of Science Communication* 15 (01): A03. https://doi.org/10.22323/2.15010203

Wals, A. E. J., M. Brody, J. Dillon, and R. B. Stevenson. 2014. "Convergence between Science and Environmental Education." *Science (New York, N.Y.)* 344 (6184): 583–584. DOI: https://www.jstor.org/stable/24743862. https://doi.org/10.1126/science.1250515

Wichmann, C., D. Fischer, S. M. Geiger, D. Honorato-Zimmer, K. Knickmeier, K. Kruse, A. Sundermann, and M. Thiel. 2022. "Promoting Pro-Environmental Behavior through Citizen Science? A Case Study with Chilean Schoolchildren on Marine Plastic Pollution." *Marine Policy* 141 (105035): 105035. https://doi.org/10.1016/j.marpol.2022.105035

Williams, K. A., T. E. Hall, and K. O'Connell. 2021. "Classroom-Based Citizen Science: Impacts on Students' Science Identity, Nature Connectedness, and Curricular Knowledge." *Environmental Education Research* 27 (7): 1037–1053. https://doi.org/10.1080/13504622.2021.1927990

Yin, R. K. 2009. *Case Study Research: Design and Methods* (4th ed.). Los Angeles, CA: Sage Publications.

Appendix A. Analytic question 1 codebook.

List of *a priori* codes used for manual deductive coding of analytic question 1, accompanied by their formal definitions from NRC (2009)[a], GSUSA (2017)[b], and GSUSA (n.d.b)[c]. This table also describes alignment between the selected codes and the stated learning goals of the Think Like a Citizen Scientist Journey (GSUSA, n.d.a)[d] where applicable, as well as representative quotes for each code.

Code	Full Name & Description	Formal Definition [a, b, c]	Alignment with Intended GSUSA Journey Outcomes [d]	Representative Sample Quote
Strand 1	LSIE Strand 1 - Sparking Excitement and Interest	Learners experience excitement, interest, and motivation to learn about phenomena in the natural, physical, constructed, and social worlds.	**Outcome 1:** 'Explore how scientists do research and create solutions to some of the most important problems faced by people, animals, and the environment'.	'We wanted other kids to know how much [fun] science could be and easy ways they could enjoy science'.
Strand 2	LSIE Strand 2 - Understanding Scientific Content and Knowledge	Learners come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science (including both technical content and broader social, political, and cultural contexts of science).	**Outcome 1:** 'Explore how scientists do research and create solutions to some of the most important problems faced by people, animals, and the environment'.	'The girls wanted to inform the public about light pollution after completing the Stars at Night'.
Strand 3	LSIE Strand 3 - Engaging in Scientific Reasoning	Learners manipulate, test, explore, predict, question, observe, and make sense of the natural, physical, constructed, and social worlds.	**Outcome 2:** 'Practice making scientific observations and collecting data'.	'We helped gather data for project squirrel, visited a wetland, and a forest preserve, observed and learned about a lot of plant and animal species, talked about conservation, invasive species, pollination and the monarch butterfly (we played pollinators with silk flowers and paper butterflies, and then laid our eggs on the monarch's host plant, milkweed)'.
Strand 4	LSIE Strand 4 - Reflecting on Science	Learners reflect on science as a way of knowing: on processes, concepts, and institutions of science; and on their own process of learning about phenomena.	**Outcome 1:** 'Explore how scientists do research and create solutions to some of the most important problems faced by people, animals, and the environment'.	'We shared with our friends and family how we contributed to science by doing observations and recording data on the squirrels we saw'.
Strand 5	LSIE Strand 5 - Engaging in Scientific Practices	Learners participate in scientific activities and learning practices with others, using scientific language and tools, and engaging in collective activities.	**Outcome 3:** 'Participate in a citizen science project'.	'We joined up with the National Park Service at Great Smoky Mountains National Park to work the Citizen Scientist project "Solar Eclipse 2017: Life Responds." We looked at animal behavior 30 min before totality, during totality, and 30 min after totality, then sent our data to scientists so they can study it'.
Strand 6	LSIE Strand 6 - Identifying as a science learner	Learners think about themselves as science learners—that is, as ones who CAN learn science—and develop an identity as someone who knows about, uses, and sometimes contributes to science.		'We wanted others to know what a citizen scientist was and how people of all ages could be one'.

Code	Full Name & Description	Formal Definition [a, b, c]	Alignment with Intended GSUSA Journey Outcomes [d]	Representative Sample Quote
GSLE1	GS Leadership Goal 1 - Develop a strong sense of self	Girls have confidence in themselves and their abilities, and form positive identities.		'The girls talked with their classmates about science and being Citizen Scientist [sic]. They showed them their posters on the different foods ants like to eat and what they were not crazy about'.
GSLE2	GS Leadership Goal 2 - Display positive values	Girls act ethically, honestly, and responsibly, and show concern for others.		'We spent an afternoon picking up litter along street [sic] as we traveled to and from a stream setting an example and making an impact'.
GSLE3	GS Leadership Goal 3 - Seek challenges and learn from setbacks	Girls take appropriate risks, try things even if they might fail, and learn from mistakes.		'Educated friends and family on how and why to conduct fun science experiments, even when you don't get expected results!'
GSLE4	GS Leadership Goal 4 - Form and maintain healthy relationships	Girls develop and maintain healthy relationships by communicating their feelings directly and resolving conflicts constructively.		'The girls worked with another troop doing this experiment. They wanted to do more things with other Girl Scout troops'.
GSLE5	GS Leadership Goal 5 - Identify and solve problems in the community	Girls desire to contribute to the world in purposeful and meaningful ways, learn how to identify problems in the community, and create 'action plans' to solve them.	**Outcome 4:** 'Do a Take Action project to address an issue in your community'.	**Problem:** 'The girls would like to limit the amount of school supply waste by recycling recycling used and worn out items that are being thrown in the trash'. **Solution:** 'We will partner with Crayola and other companies to place recycling bins through out the school for markers, crayons, and paper and send them to be repurposed'.
GS STEM1	GS STEM Leadership Goal 1 - STEM Interest	Girls are excited about STEM subjects and want to learn more about them.		'We did a [sic] education video for people on how to become a citizen scientist and the cool things you can do as a scientist'.
GS STEM2	GS STEM Leadership Goal 2 - STEM Confidence	Girls have confidence in their STEM skills and abilities.		'The Daisies told many people what they did and shared how important it is to collect data and interpret results'.
GS STEM3	GS STEM Leadership Goal 3 - STEM Competence	Girls think scientifically to solve problems.	**Outcome 2:** 'Practice making scientific observations and collecting data'.	'By participating in the USA National Phenology Network's Nature's Notebook we were able to collect data about plants and animals in our community and upload it to their organization through a downloaded application'.
GS STEM4	GS STEM Leadership Goal 4 - STEM Value	Girls learn the importance and relevance of STEM to people and society.	**Outcome 1:** 'Explore how scientists do research and create solutions to some of the most important problems faced by people, animals, and the environment'.	'Educate family and friends on importance of science and observations around us'.

Appendix B. Citizen science projects featured on Girl Scouts microsite on SciStarter.

Project Name and Sponsoring Organization	Times Completed	Dates Featured on GS Microsite	Purpose, Goal, and/or Task
Ant Picnic by Your Wild Life	70	2018 – present (Fall 2022)	'Inform scientists about global food preferences of ants. Create a picnic for ants, wait an hour, record number of ants'.
ANT-vasion by the Backyard Biodiversity Project	9	2018 – 2020	'To get the ants out of your home without harmful chemicals! Test out a natural deterrent to see if it keeps the ants away!'
Girl Scouts SciStarter Project on iNaturalist by iNaturalist	1	2020 – present	'Share the biodiversity that you and your troops explore'.
Globe at Night by NSF's NOIRLab	20	2018 – present	'With Globe at Night, citizen scientists match the appearance of a constellation they see with 7 star maps of progressively fainter stars. They then submit their choice of star map online with their date, time and location to help create a light pollution map worldwide'.
GLOBE Observer: Clouds by NASA and The GLOBE Program	22	2018 – present	'GLOBE Observer is an international citizen science initiative to understand our global environment. Your observations help scientists track changes in clouds in support of climate research. Scientists also use your data to verify NASA satellite data. And by submitting your observations, you can help students of all ages do real scientific research as part of the GLOBE Program'.
GLOBE Observer: Trees by NASA and The GLOBE Program	2	2019 – present	'Observe trees to understand changes in biomass and effects on the carbon cycle'.
ISeeChange by ISeeChange	3	2018 – present	'We're making a record of climate change impacts. What you see change in your backyard, neighborhood, and city is important to our understanding of how climate change and weather affect our communities. Your observations and insights can help scientists, engineers and local organizations advocate for and create solutions to climate challenges'.
Nature's Notebook by the USA National Phenology Network	9	2018 – present	'Observe, share seasonal changes in plants and animals'.
Project Squirrel by Project Squirrel	49	2018 – present	'Help scientists better understand tree squirrel ecology'.
Stream Selfie by the Izaak Walton League of America	59	2018 – present	'Map streams across the country and start testing the waters. Simply snap a pic of your local stream and share it!'
ZomBee Watch by the Natural History Museum of Los Angeles County	1	2018 - present	'Learn where in North America bees are infected by Zombie Flies. Collect honey bees; report easy-to-spot signs of infection'.