Elevating Citizen Science Through an Evaluation Rubric

December 2022

Team Members:
Eliza Dion
Aidan Kaufman
Calvin Page
James Ralph

Partner:
Port Phillip EcoCentre

Advisors:
Professor Holly Ault
Professor Stephen McCauley

Abstract

Citizen science is the engagement of citizens in scientific research. The Port Phillip EcoCentre, in Melbourne, Australia, uses this practice to promote sustainability and connect individuals to their environment. In 2017, the EcoCentre developed an evaluation rubric to assist citizen science practitioners with improving the design of their projects. This project improved upon the EcoCentre's rubric and provided an avenue to promote it to citizen science practitioners. Through an in depth literature review, interviews with prominent citizen scientists, and collaboration with EcoCentre staff, informed updates to the EcoCentre's citizen science rubric and delivery of an interactive promotional workshop were successfully accomplished. These achievements work towards improving the effectiveness and impact of environmental citizen science, ultimately leading to a cleaner, healthier planet.

Revitalizing a Standard to Evaluate Citizen Science

Environmental citizen science is one of the most innovative ways that the practice of science has progressed to become more inclusive over the past generation. It enables educating the community on scientific issues by eliciting their participation in research. These volunteers allow for the collection of large-scale datasets that are otherwise unattainable to a conventional scientist. The utilization of citizen science allows organizations to engage, enrich, and educate communities in an interactive and productive manner. With organizations such as the European Union and United Nations adopting this method of data collection and community engagement, citizen science has been brought to the world stage. However, some conventional scientists question the credibility of volunteer-generated datasets, leading to many of these datasets not being used to their fullest potential.[1] Despite this, thousands of active citizen science projects are run across the world, collecting vital data that have the potential to benefit many scientific fields while engaging communities to take ownership and action against the problems faced.

For decades, Australian organizations have improved the significance of citizen science. Organizations, governmental and private, use citizen science for scientific, community, and educational projects. One example is the Commonwealth Scientific and Industrial Research Organisation (CSIRO), an Australian government organization responsible for scientific research and funding organizations such as the Australian Citizen Science Association (ACSA). The ACSA works to increase community participation and the utilization of citizen science. Through the help of organizations like CSIRO and ACSA, Australia has hundreds of active citizen science projects with hundreds of thousands of participants.[2] Organizations across Australia continue to develop and evolve citizen science.

One leader in the field is the Port Phillip EcoCentre, located in St. Kilda, Victoria. The EcoCentre manages active citizen science programs and partners with other organizations to "promote environmental sustainability and community action."[3] To accomplish this, the EcoCentre conducts a variety of programs available to schools, communities, and corporate volunteers to help tell the story about the problems the environment faces over time. For example, the EcoCentre helped coordinate the Drain Detectives program (Figure 1), resulting in volunteers taking 341 reports on drain water conditions over two years in five different locations.[4] These reports assisted EPA Victoria with testing low-cost citizen science based drain water monitoring.[5]

Figure 1: A volunteer conducts sampling for the EcoCentre's drain detectives program.[6]

In 2017, the EcoCentre collaborated with a team of students from Worcester Polytechnic Institute (WPI), and formulated a citizen science evaluation rubric to improve the effectiveness of citizen science programs. This rubric allows citizen scientist practitioners to gain insight on the design of their project by prompting them to think critically about their project. The three main aspects of a citizen science project that the rubric focused on were scientific contribution, recruitment and retention, and spreading awareness. This rubric faces inadequate usage despite its potential to improve the design of citizen science projects due to gaps in the rubric's content, and an uninviting format.

The goal of this project was to increase the Port Phillip EcoCentre's contribution to the field of citizen science by expanding its positive influence on external citizen science projects. The team revised the EcoCentre's rubric and developed a workshop to promote the rubric's use to citizen science practitioners. To accomplish this, the team researched different citizen science program design resources and interviewed representatives from prominent citizen science organizations to learn about important topics which the former rubric did not cover. To create the workshop, the group researched workshop design practices and collaborated with EcoCentre educators. These contributions allow citizen science projects to have more harmonized data and a streamlined design process. These positive impacts on citizen science would allow the field to garner more credibility with the government and other scientific funding bodies, increase the influence of citizen science on decision makers and the general public, and expand the reach and depth of these projects, all to work towards the common goal of a healthier environment.

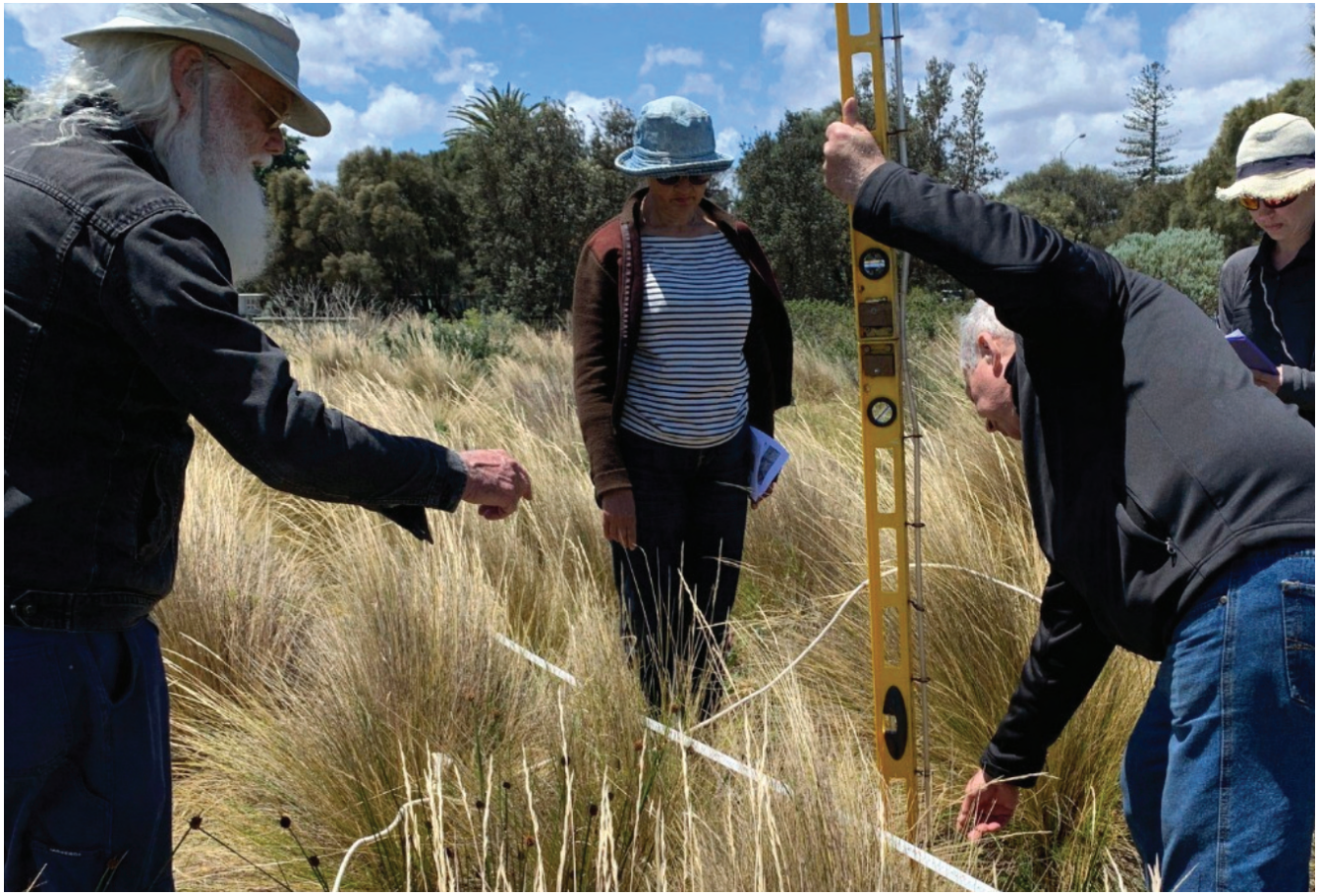


Figure 2: The Port Phillip EcoCentre conducting a citizen science project.[7]

The Current State of Citizen Science

Citizen science is the practice of public engagement in scientific research. In citizen science projects, members of the general public are involved in data collection, analysis, and reporting. The projects encourage participants to be a part of data-gathering networks in order to make advancements in a number of scientific fields, though this report focuses on environmental citizen science. Although citizen scientists are typically not professional scientists, they share like-minded characteristics within citizen science such as being curious and motivated to make a difference. These citizen scientists benefit from their participation by experiencing field work and gaining knowledge about the studies they participate in, and become increasingly more aware of the problems that their communities face.

Citizen science provides opportunities to conduct new research projects

Citizen science, as a tool, is increasingly utilized for its many benefits and advantages over more traditional scientific methods. This is demonstrated by iNaturalist, a popular citizen science platform, growing from under two hundred thousand participants to over two million participants in the past six years (Figure 3).[8] By relying on a larger participant base, citizen science projects with high participation rates are effective at raising awareness about issues, collecting large amounts of data from varying sites, monitoring sites over extended periods of time, connecting people to their community, and offering participants a close look at local environmental concerns. Additionally, local participants provide a pool of relevant geographic and cultural knowledge to ensure a project is conducted responsibly and respectfully on the lands where it is conducted.

In 2015, the UN created seventeen sustainable development goals for creating a more eco-friendly civilization. These goals address issues such as poverty, inequality, climate, environmental degradation, prosperity, and peace and justice.[9] An evaluation of trends from large amounts of data from all around Europe was necessary to iterate upon and evaluate these goals. The UN decided to rely on citizen scientists to collect photographic data as well as answer surveys to gather both qualitative and quantitative data. Their use of citizen science not only allows for the construction of large datasets, but also for continual long-term data collection. By doing this, observable trends can be seen in real-time rather than on an annual or semi-annual basis.

This trend of governments utilizing citizen science as a form to understand problems and create new policies was shown again by the European Union when in 2015 they issued a detailed work program with calls that address policy objectives. The European Union stated: "Just as the internet and globalization have profoundly changed the way we do business, interact socially, consume culture or buy goods, they are now profoundly impacting how we do research and science … Just as people offer spare rooms via Airbnb, why shouldn't they be allowed to offer spare brain power via citizen science?"[10] In another example, the New South Wales Environmental Protection Association

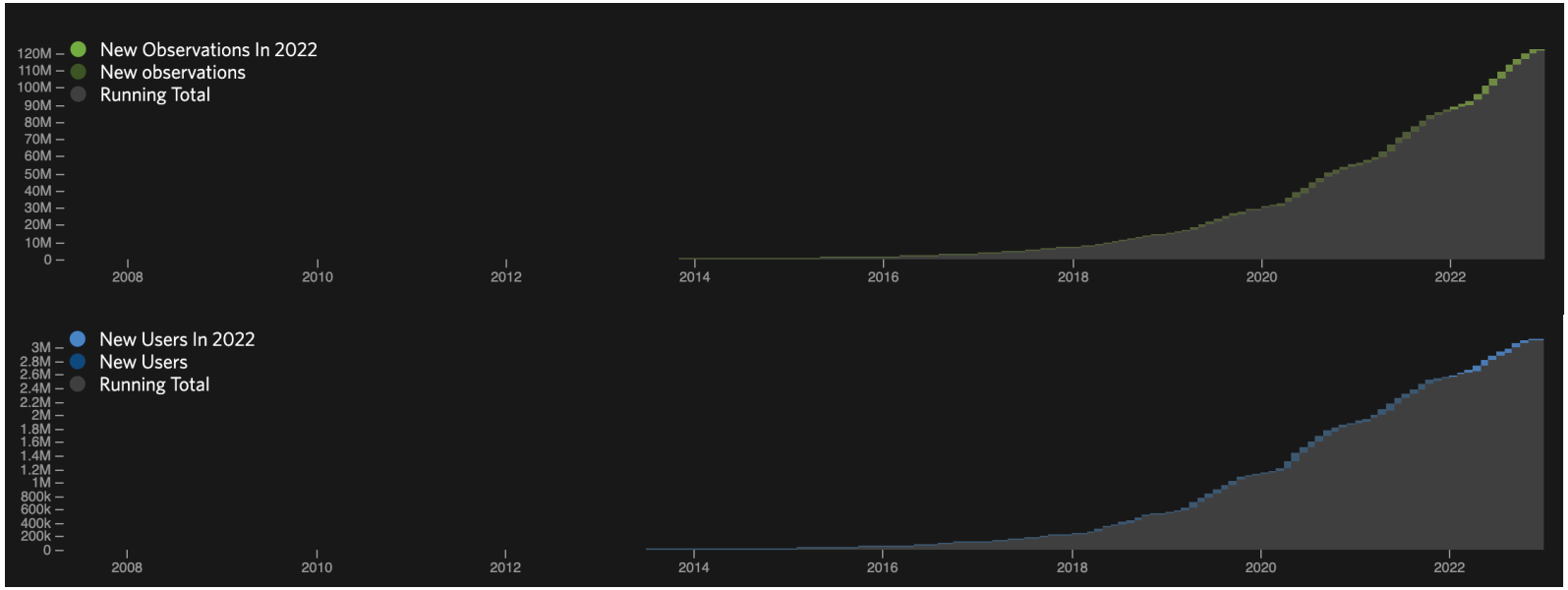


Figure 3: Growth of users and observations in iNaturalist, a popular citizen science platform, since 2008.[8]

utilized citizen science to collect millions of datum points on the amount and type of plastic pollutants in the ocean. From this data, the EPA had the ability to categorize the areas and types of pollutants washing ashore (Figure 4) and reallocate their resources to specifically target probable pollutants in their likely locations.[9] These powerful impacts of citizen science explain the increase in both the number of projects taking place and amount of funding.

Items	Strength of interaction*	Management zones		
		North	Central	South
Balloons	H	M	H	H
Fishing line	H	M	M	H
Fishing traps and pots	H	-	H	-
Foam packaging	M	-	M	L
Food packaging	M	L	L	-
Hard plastic remnants	H	H	M	M
Plastic bag	H	M	H	M
Plastic drink packaging	M	L	L	-
Plastic food lids	L	L	L	-
Plastic rope (and fragments)	H	H	M	H
Soft plastic remnants	H	M	H	M
Microplastics #	H	H	H	H

Figure 4: Categorization of the areas and types of pollutants on the east coast of Australia.[9]

Real-world experience provided by citizen science encourages local action on environmental issues. As anyone is able to participate in citizen science, the expansion of a program is less limited than traditional science programs. Communities involved in citizen science are equipped with an engaged population, connection to their land, and information about their environment. These tools enable a community to thoughtfully take action on environmental concerns previously infeasible to tackle on a local scale.

Lack of institutional standardization in data quality and dissemination limit citizen science's benefits

While citizen science has potential to provide valuable contributions to scientific discovery, there are challenges that limit both its current effectiveness and efficacy. With citizen science often holding a grassroots structure, there are not as many resources available to help ensure quality and a sense of harmony between projects compared to traditional scientific research. Scientific standards and institutional regulation for traditional scientific research ensure not only quality data, but also scientific importance and reproducible results. Analogous resources are not available to citizen science organizations to the same extent. This lack of standardization leads to barriers that limit community-based organizations from gaining funding for their citizen science programs. These issues all impact the management of a citizen science project and its quality control methods. As stated in the article Citizen science, public policy,

> ***Although professional scientists are not immune from quality transgressions, methodological rigor is central to their training and professional advancement, and formal mechanisms exist for holding professional scientists accountable for the quality of their work. Volunteers, on the other hand, may not experience similar external pressures to ensure research integrity and may prioritize other aspects of their participation. Also, there may be fewer opportunities for professional scientists to address knowledge gaps and otherwise act as a check on quality if their involvement in projects is minimal.[1]***

A lack of mechanisms to hold citizen scientists accountable creates disorganization in their data and creates obstacles to achieving scientific research and policy change goals. This makes it challenging to build on previous projects and make strong arguments.

Another limiting factor citizen science faces is the communication of these results to different audiences. Of the published papers stemming from citizen science projects, 70 percent mention no benefits or negative impacts from their results.[11] This displays a lack of understanding about research conducted and poor foresight from the organizers of the studies. Of the published papers with listed benefits, most only discuss potential benefits. This takes away from the validity of the paper as there are no concrete results that can be used to implement ideas as well as making donors, communities, and governments unsure of whether the research done will translate into the real world and whether the data collected is reliable.[11]

Government support is key to citizen science programs' success

The Australian government takes advantage of the use of citizen science for scientific research. In 2014, the Australian Citizen Science Association (ACSA) was founded to support the country's expanding field of citizen science.[12] The Australian government is in favor of citizen science because it raises community awareness and interest in science while also providing opportunities for the development of new skills and social connections.

To encourage further use of citizen science, the Australian government allocates grant money to a number of organizations to distribute grants to individual citizen science projects. Typically, there is an application process that allows for the most eligible projects to receive grants. Some of these organizations that distribute grant money are the Australian Citizen Science Association (ACSA), the Commonwealth of Scientific and Industrial Research Organization (CSIRO), and the National Health and Medical Research Council (NHMRC)(Figure 5).

While the government supports these programs financially, citizen science projects provide the government with information that influences change and decision-making. In the state of Victoria, citizen science is continuously integrated into monitoring systems that are used in policy development and public reporting.[13] Citizen science projects conducted in Australia contribute heavily to marine and coastal environment management. For example, a project funded by the Victorian Government's Port Phillip Bay Fund conducted surveys of plastic resin pellets in Port Phillip Bay.

Figure 5: The flow of money from government grants to citizen science programs. Government grants help citizen science projects get over common roadblocks which pushes them one step closer to success.

To figure out where these resin pellets came from, stormwater drain traps were installed in the city's nearby plastics factories. The Environmental Protection Authority, a government agency, conducted site inspections at these factories which resulted in mitigation strategies implemented which ultimately led to a decrease in pellet loss.[14] Therefore, citizen science projects provide valuable information to the government that informs ways to better protect the environment in the state of Victoria.

Port Phillip EcoCentre: A Leader in Citizen Science

The Port Phillip EcoCentre is a non-profit organization located on the Port Phillip Bay in Melbourne, Australia. Its goal is to help promote environmental sustainability and community activism. The original concept for the EcoCentre was created in 1998 by the city of Port Phillip but has now become independent, community organized, and acts as a regional organizer for numerous environmental management efforts. The EcoCentre has been central to citizen science progression as "since 1999, the Port Phillip EcoCentre has delivered education, programs, and services to more than 19,000 participants annually."[15] This outreach to both local and international communities shows the importance of the EcoCentre, the outreach they have, and the crucial role they play in the progression of citizen science.

"Since 1999, the Port Phillip EcoCentre has delivered education, programs, and services to more than 19,000 participants annually"
-Port Phillip Council

<u>The EcoCentre has established itself as an expert in citizen science program design</u>

The Port Phillip EcoCentre and its many affiliates provide education and community awareness through outreach programs conducted consistently throughout the year. Through activities ranging from the Port Phillip Baykeeper and Deep Time Walks to Corporate Volunteering and Multicultural Bay Ambassadors, the EcoCentre targets a wide-ranging audience.[16] Through their outreach, the EcoCentre has been widely recognized for its contribution to citizen science and environmental management. In 2020-2021 the EcoCentre and its affiliates won a number of awards.[17] This recognition increased the EcoCentre's credibility within Australia.

Port Phillip EcoCentre's future plans consist of continuing to foster new partnerships and create new, innovative programs, as shown by their creation of the Baykeeper Program Framework (Figure 6).[18] This framework's goal is to build knowledge, foster connection to the environment, build networks, and influence communities by utilizing inventive solutions to overcome hurdles that the Port Phillip community faces.

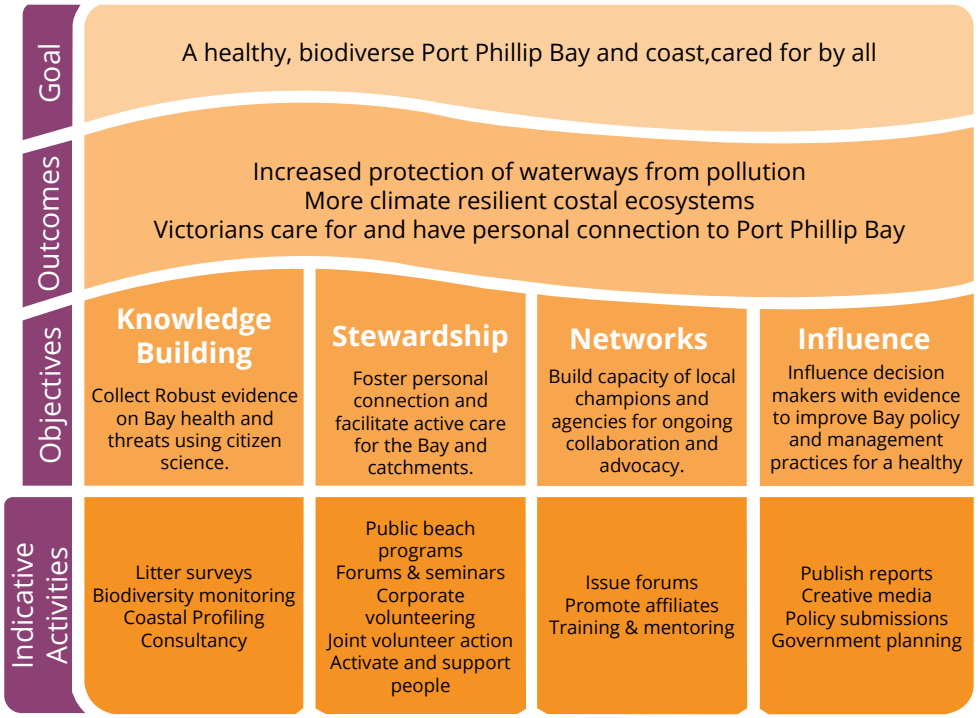


Figure 6: Port Phillip EcoCentre's Baykeeper Program Framework.[18]

Citizen Science Evaluation Rubric: A Newly Emerging Tool Limited by Minimal Use

Citizen science project practitioners have a small variety of resources to reference to guide project design. The Port Phillip EcoCentre created a citizen science evaluation rubric in 2017.[19] Additionally, a group of researchers published a similar rubric in the academic journal BioScience (hereon referred to as the BioScience rubric) [20], and the United States Environmental Protection Agency and New South Wales state government released citizen science guidelines. These resources all provide massive potential to enable citizen science practitioners to run excellent citizen science programs.

Existing citizen science frameworks and toolkits are used to assist program design

The New South Wales government created a citizen science hub project guide (Figure 7) to maximize the success and impact of citizen science projects. The project guide focuses on designing a project by splitting a project's design into a number of subsections. These subsections include community promotion and engagement, creating a project plan with regards to budgeting and funding, and collection and analysis of data.[21]

Likewise, the United States Environmental Protection Agency created a citizen science handbook that discusses a quality assurance project plan to help citizen scientists plan successful projects that produce high quality data in hopes of using the data to influence government decisions. The handbook includes a series of templates and other resources that outline different aspects of citizen science projects. Some of these include sampling design, data collection methods, data management, analytical methods, and reporting. This handbook is intended to be used to design projects that are scientifically rigorous.[22]

Figure 7: NSW's Citizen Science Hub Project Guide.[21]

Using the EcoCentre's rubric to evaluate a program

In 2017, the Port Phillip EcoCentre collaborated with a student team from Worcester Polytechnic Institute to create an evaluation rubric.[19] The rubric focuses on a program's fundamental outcome goals and evaluates the performance of each. This is achieved by breaking the high level goals of a given program into three elements, then breaking each of these elements into smaller subelements. The elements and their subelements can be seen in Table 1. Every subelement has an accompanying description to eliminate ambiguity. Subelements are scored a number between 0 and 3 based on performance. Every subelement offers a description for each of the four possible scores.

To start an evaluation, a project reviewer must score a project twice. First, they score the project on its intended target scores. Then, the program is scored on its current performance. These scores allow a project reviewer to identify shortcomings in each subelement of the project. The rubric then requires the reviewer to write down ways to improve each subelement. Improvements are prioritized and an implementation plan is developed. The assessment is iterative in nature, so this process should be repeated throughout the duration of a project.

By assigning target scores to each goal, this rubric is dynamic, allowing it to be more effective at assessing a wide range of projects with varying goals. Outcomes, rather than processes, are the only concern, allowing project managers freedom to prescribe methods in ways that they see fit.

Table 1: EcoCentre rubric elements and subelements. The elements of a project can be seen bolded in column 1 while the subelements for each element are placed in column 2.[19]

EcoCentre Rubric Elements and Subelements	
Elements	**Subelements**
Scientific Contribution	Project Objective
	Project Quality
	Data Analysis
	Project Robustness
Volunteer Recruitment/Retention	Volunteer Sourcing
	Volunteer Motivation
	Time/Effort Investment
	Returns
Communication	Content
	Project Story
	Communications Delivery

Using the BioScience rubric to evaluate a program

While the EcoCentre and WPI students were developing a citizen science rubric in Australia, a team of scientists in San Diego, CA, USA were independently developing their own rubric.[20] This rubric, published in BioScience, takes an alternative focus on evaluating citizen science projects. Methods, data accessibility, and the scientific rigor catch the spotlight. Community involvement is noted but far from center stage. Rubric elements are scored on a scale from 1 (needs considerable improvement) to 10 (no improvements required). Table 2 depicts every element and subelement in this rubric.

These rubrics face scarce usage, limiting their ability to cause positive impact

Despite the potential of citizen science evaluation rubrics, they suffer from a lack of dissemination and usage. Though the BioScience rubric has been publicly available for five years at the time of writing, there exists a minimal number of allusions to this rubric's use in literature. A forward search was able to identify a couple dozen papers that reference it. While these papers discuss the use of citizen science, they do not discuss any situation where the rubric is used, and therefore offer little insight to the process of using the rubric.[23,24] Meanwhile, only two organizations are known to use the EcoCentre rubric. This lack of adoption provides a clear opportunity to capitalize on the untapped potential of citizen science evaluation tools.

Table 2: BioScience rubric elements and subelements. The elements of a project can be seen bolded in column 1 while the subelements for each element are placed in column 2.[20]

BioScience Rubric Elements and Subelements	
Elements	**Subelements**
Stakeholder collaboration and program resources	Stakeholders
	Resources
	Volunteers
Goals and objectives	Goals
	Objectives
Methods: Design and implementation of monitoring	Current understanding and conceptual model
	Sample and protocol design
	Training and managing volunteers
Data entry, storage, analysis, and synthesis	Organization and management of data
	Quality assurance and information integrity
	Data analysis and interpretation
Reporting and dissemination	Communication planning
	Outreach implementation and reporting
Outcome assessment and program review	Evaluating outcomes: Science, learning and engagement
	Program review: Self study and/or external review

Methods for Updating and Disseminating the Rubric

This project was intended to improve upon the Port Phillip EcoCentre's citizen science evaluation rubric, and the rubric's promotion among citizen science practitioners, to allow citizen science projects to more effectively contribute to environmentalism. To achieve this, the scope of the project was split into three main objectives:

- Understand the design process of citizen science programs and how these programs influence community awareness, scientific discovery, and policy change
- Update the citizen science evaluation rubric based on engagement with citizen science experts and resources
- Develop and pilot a workshop to promote the rubric's uptake

These objectives were completed through a series of methods that build on each other to yield a well-rounded rubric and workshop.

1. Understand the design process of citizen science programs and how these programs influence community awareness, scientific discovery, and policy change

One of the main goals of this project was to identify the extent to which citizen science is being used to influence community awareness and policy change in Australia. To do this, organizations that had been impactful with their citizen science programs in the past were identified by leveraging the EcoCentre's vast network of citizen science organizations. A series of semi-structured interviews with leaders of prominent citizen science organizations were conducted to achieve this objective. A central goal was to determine how citizen science programs collect trustworthy datasets and how they communicate their findings to different audiences to influence social perceptions. The interviews also provided the opportunity to identify specific organizations' shortcomings and where there may be room to improve. This allowed for the comparison of organizations' methods and the identification of influential strategies.

Prevalent commonalities that informed the development of key findings included specific data collection practices, strong communication strategies, and participant sourcing plans. Leveraging an analysis of existing evaluation and project development tools in the context of conducted interviews further informed the formation of key findings. These key findings outlined a clear path to address the most pressing topics within the rubric.

Figure 8: Interviews with Suzanne Ryan and Cate Clark (middle left), Ella Ryan (top right), and Ben Hudson (bottom right).

2. Update the citizen science evaluation rubric

It has been five years since the original EcoCentre rubric was created. Throughout this timeframe, environmental citizen science has evolved and become more prevalent and more influential. New resources have been introduced into citizen science, bringing new strategies to aid citizen science organizations in the design and execution of their projects. There is benefit to incorporating new resources' knowledge into the EcoCentre's citizen science rubric. Updating the content contained within the EcoCentre rubric came in the form of integrating key findings from the interviews and other citizen science resources. Simultaneously, suggestions from EcoCentre staff led to updates focused on the appearance and usability of the rubric. Three iterative rounds of appearance and usability updates focused on simplicity of wording and user friendliness.

To begin the process of updating the rubric, key findings from the research with experts were used as a basis to form Implementation Plans (available in the supplemental materials). Each Implementation Plan outlines a brief description of its purpose, specific steps to execute this change, benefits and drawbacks of this method of execution versus alternatives, and the sources that informed this change. Once the Implementation Plans were finalized, the rubric itself needed to be altered. To allow the EcoCentre to iterate upon the rubric in the future, it was reconstructed using Adobe Illustrator. Illustrator was the program of choice due to prior expertise within the team, its compatibility with the software suites that the EcoCentre has access to, and its compatibility with the EcoCentre's desired PDF file format. Once the rubric had been finalized, it was ready for the upcoming workshop.

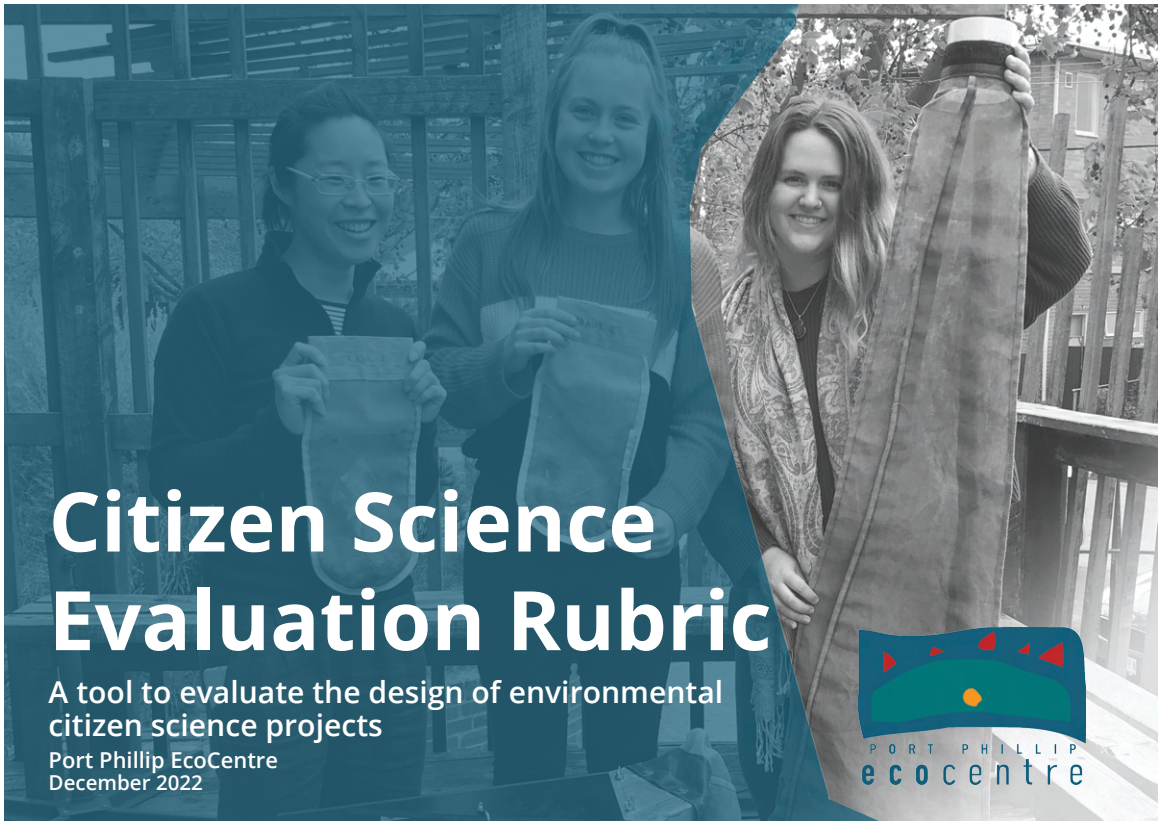


Figure 9: Title page of the updated rubric.

3. Develop and pilot a promotional workshop for the rubric

In addition to updating the rubric, an avenue to distribute the rubric would be necessary to maximize its impact. This need was fulfilled in the form of a workshop that would inspire participants to make their own citizen science programs, encourage further use of the rubric by participants, and make participants comfortable with using the rubric. This workshop was designed for external use in context such as a citizen science related conference.

Consultations with April Seymore and Betsabe Otiz, the EcoCentre's experts in education and communication, provided insights on effective workshop design. Additionally, the structure of the workshop was based on the FIDO (Feelings, Information, Decisions, Outcomes) metaprocess, a proven structure for delivering information that appeals to emotions in hopes of achieving desired outcomes. The FIDO process (Figure 10), created by Bob Dick, guides an educator through designing a learning plan. A learning plan's desired outcomes are first defined. Then, the decisions participants must make to achieve these outcomes are determined. Finally, the information participants must learn to be able to make these decisions is decided. From there, the workshop is designed to create positive feelings and remove negative feelings to "allow the interchange of information, which if useful and understood, help those present to make more effective decisions."[25] A FIDO Workshop Design Roadmap (available in the supplemental materials) was produced to guide the workshop's design.

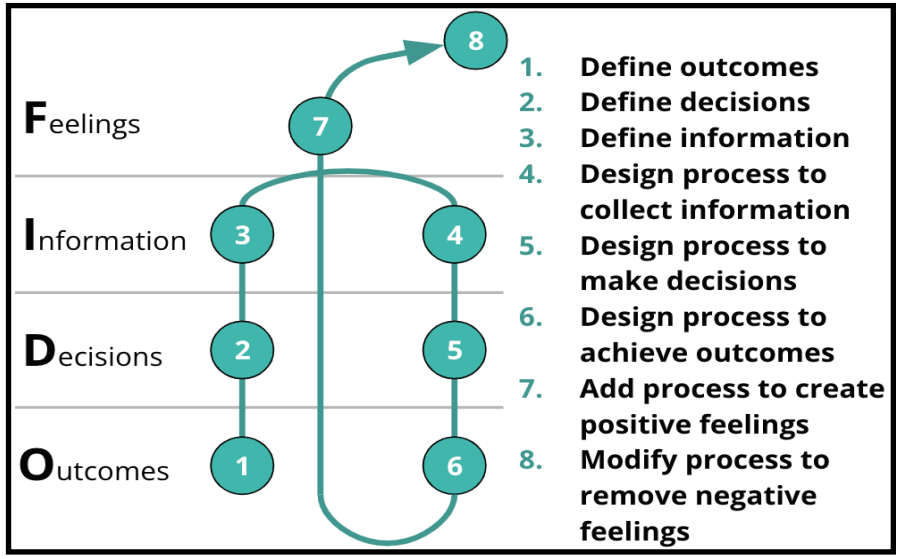


Figure 10: Diagram of the FIDO metaprocess. [25]

Feedback from the workshop was sought out through three different means. Two dedicated facilitators observed audience participation, logistical concerns, and time constraints. A debrief directly following the workshop allowed participants to discuss their thoughts and briefly brainstorm how to improve the workshop. Finally, an anonymous feedback survey at the end of the workshop provided metrics about participant satisfaction.

Figure 11: James Ralph (left) and Eliza Dion (right) deliver the pilot workshop.

Key Findings and Updates to the Rubric

Analysis of interviews and citizen science materials provided valuable insights that informed changes to the rubric. The key findings are described below, along with the specific changes to the rubric that were informed by each of the findings. In addition to content updates influenced by findings from literature review and interviews, the new rubric features improved formatting and usability. Staff from the EcoCentre expressed an interest in improving the rubric's ease of use by addressing concerns about its complicated workflow and prominence of concise scientific terminology. This focus on user experience led to formatting and language updates while shedding light on the importance of not increasing the rubric's complexity in content updates. These key findings influenced four main changes to the rubric:

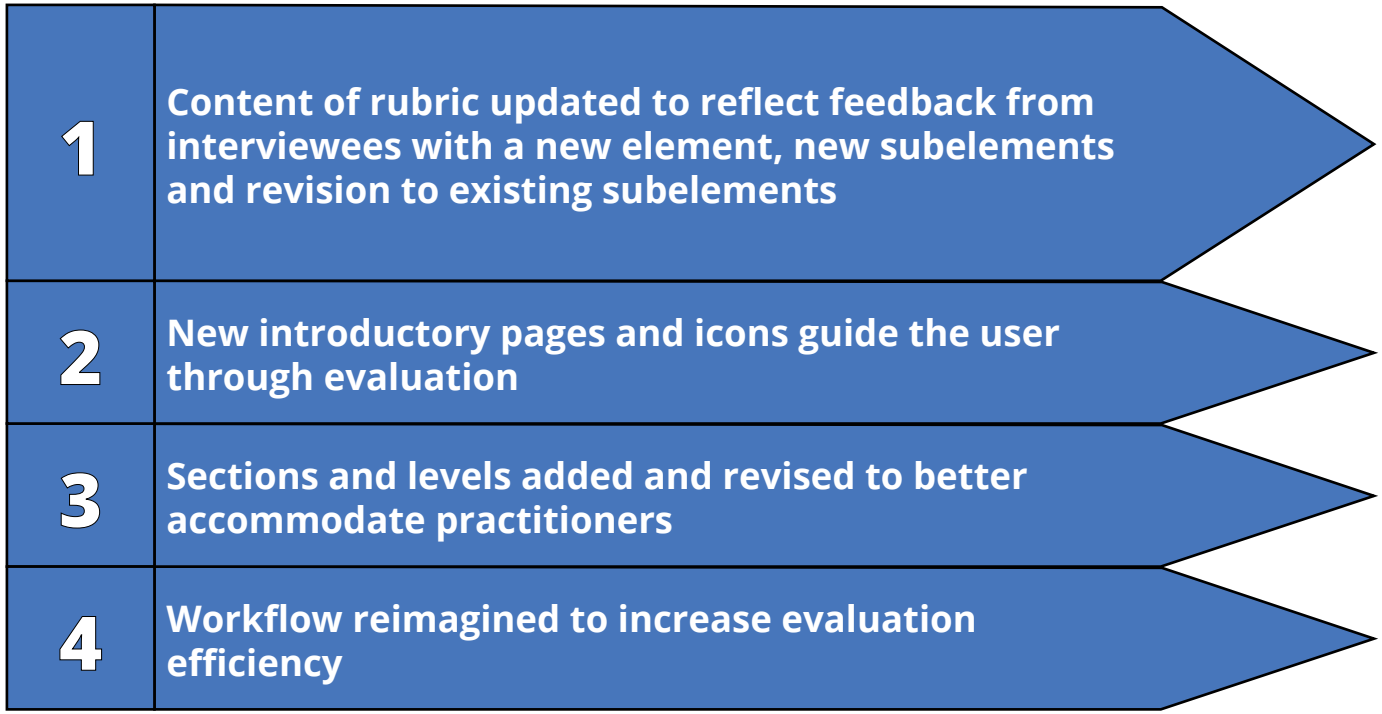


Figure 12: Primary changes to the rubric informed by findings.

Content Changes:

Well-defined project scopes increase impact and prevent missed opportunities

Key finding: Throughout discussions with citizen science experts at the EcoCentre and interviews, it became apparent that many organizations struggle with defining objectives for their citizen science projects. Many projects exhibit a narrow scope that limits their impact. Some projects monitor a local ecosystem without expanding their goals to make scientific impact. Meanwhile, other projects collect valuable scientific data but miss the opportunity to engage participants with the environment.

Change to rubric: This opportunity for improvement led to the creation of the *Project Scope and Deliverables* element. This element is broken into three subelements that encompass the high level scope of a project: *Project Objectives, Delegation of Roles, and Managing Partnerships*. *Project Objectives* prompts the user to answer the guiding question: "How is/are the scientific method(s) defined?" *Delegation of Roles* asks the user "Who else will need to be involved in the project?" and "Is there cross-participation by people in different aspects of the project?" These questions guide the user to expand their view of the citizen science projects they are either participating in or conducting, and question areas of their project where the fundamental ideas may be flawed or incomplete. The final subelement, *Managing Partnerships*, guides the user to evaluate whether or not their partnerships are benefiting the project.

Thoughtfully managing partnerships leads to better collaborators and funding

Key finding: A common trend that both citizen scientists and citizen science toolkits reiterate is the importance of strategic partnerships. The Citizen Science Project Guide, developed by the New South Wales (NSW) Sharing and Enabling Environmental Data (SEED) initiative, states that "[d]iscussing [a] project with local and state government agencies and not-for-profit environmental groups can help refine the project's aims and identify how the data may be used more broadly."[21] Additionally, quality partnerships enable relatively smaller, more local efforts such as Shepparton RiverConnect to make an impact. Alison White, RiverConnect's Project Officer, explained that her "organization is based entirely on partnerships" that help gather data and recruit participants. Patrick Bonney of the Australian Citizen Science Association voiced his support for thoughtful partnerships, though he articulated that mindfully including connections is important because too many participating organizations may hinder the efficiency of a program. Thoughtfully networking will increase a citizen science program's chance of succeeding.

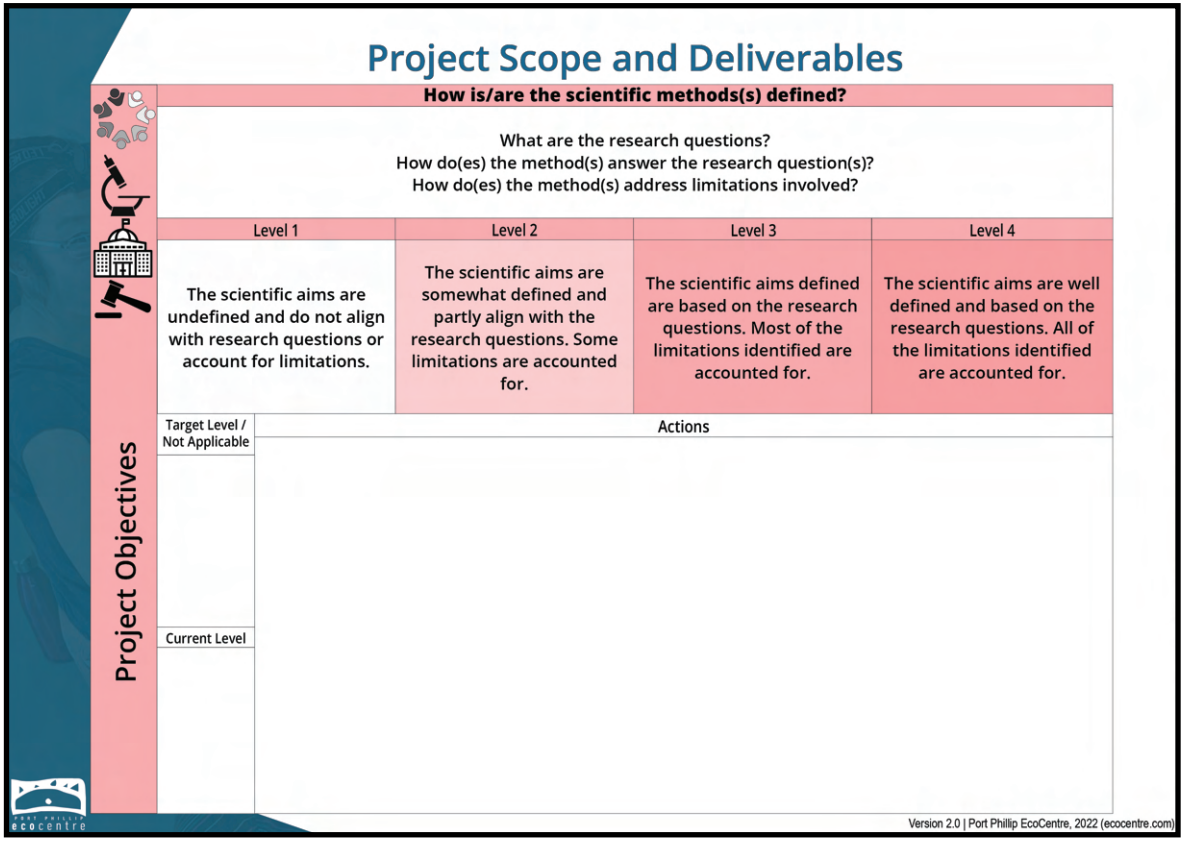


Figure 13: *Project Objectives* Subelement.

Change to the rubric: The rubric now reflects the importance of partnerships with the addition of the *Managing Partnerships* subelement (Figure 13). This subelement asks the primary leading question of "How are partnerships built and maintained?" It addresses Bonney's concerns by prompting the question: "How does the partnership affect efficiency?" This subelement falls under the new *Project Scope and Deliverables* element because it deals with the high-level setup of a project.

Precision in communication is essential to the usability of citizen science data

Key finding: In a world where misinformation is rampant and hasty conclusions are commonplace, it is important for science to stay laser focused on precise communication. The EcoCentre's Baykeeper, Neil Blake, explained a not uncommon occurrence where otherwise robust and accomplished citizen science projects may falter: precision in communication. When a program disseminates its findings, it must be clear and exact. Otherwise, its findings may appear to contradict results from other projects. This is the

fundamental idea behind harmonious data: distinct datasets that have similar goals. If a microplastics beach survey does not specify its findings as applying to only microplastics, it may be confused with a macroplastics beach survey despite covering two separate fields of plastic pollution
(Figure 14).

Change to the rubric: A newly added guiding question encourages citizen science practitioners using the rubric to be conscious of this common pitfall in communication. This question falls under the *Communication Methods* subelement in the *Communication* element due to its acute focus on the dissemination of project findings. This question, "Are the exact data collection methods communicated? (E.g. Specifying collection of macroplastics vs microplastics)?", ensures that program evaluation critically considers how the communication of results may interact with other similar studies. This guiding question will encourage citizen science practitioners to more precisely communicate their findings.

<u>Analysis of biases increases the validity of data</u>

Key finding: Considering bias is extremely important when analyzing the data collected during any scientific project, including citizen science. It is important to acknowledge any project elements that could introduce bias to data. The Port Phillip Baykeeper Neil Blake discussed a time when he unconsciously introduced bias to a dataset. During a mollusk shell survey, he chose a location spot underneath a pier as it was easily identifiable and convenient to meet. After the survey was conducted, he realized that the data was flawed because the mollusk biodiversity near a pier is more concentrated than other sections of the beach. As a result, the data could not be used as it skewed the overall data set. Stepping back from a project to look for certain elements that could introduce bias increases the scientific validity of the data. If the biases are recognized and explicitly stated, larger datasets and metastudies can account for these biases to ensure these projects are not skewed.

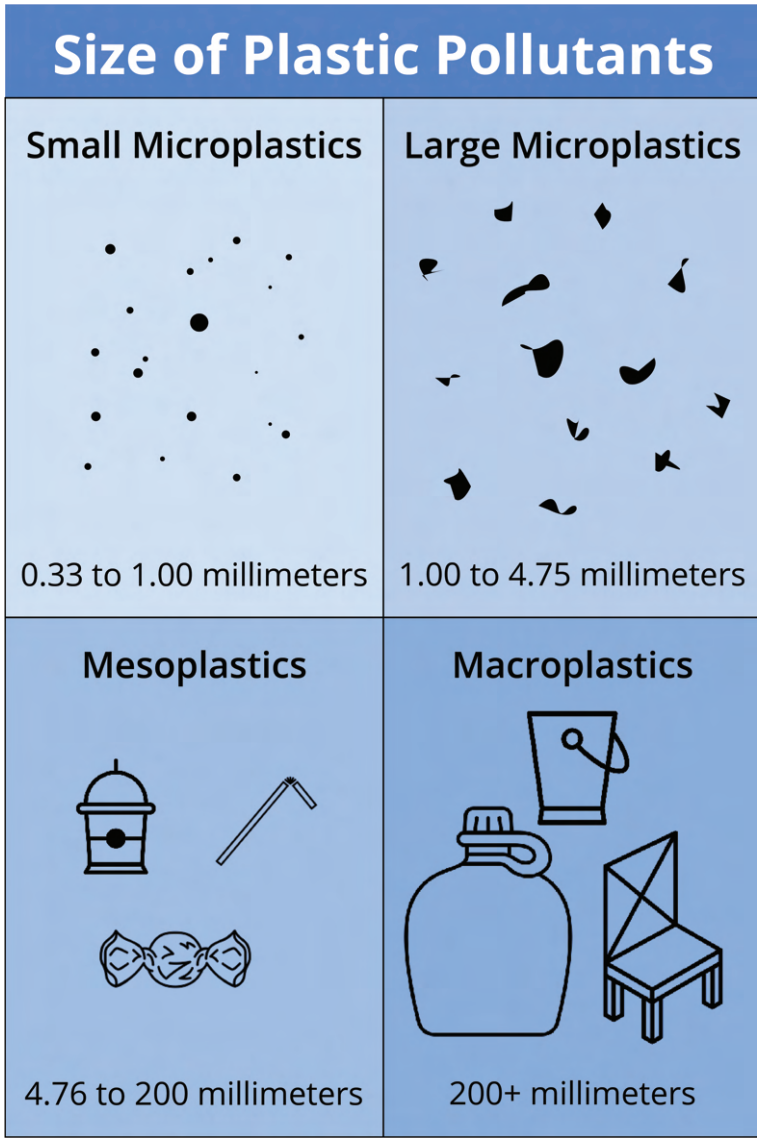


Figure 14: Plastics survey results must specify the type of plastics collected.[26]

Change to the rubric: The strategy of recognizing bias was added to the rubric in the *Project Quality* subelement by prompting the question: "Are methods designed to minimize bias?" If the methods are designed to reduce bias, the project will produce more high quality data. This question does not delve into how to minimize bias as the rubric is intended to primarily point practitioners in the right direction rather than teach citizen science.

Subelement supplemental descriptions are unclear

Key finding: Anna Ridgway provided a lot of valuable insight on the rubric as her organization had utilized the rubric in the past. One recommendation pertained to the supplemental descriptions which explain the subelements to the user. Ridgway stated that these descriptions are "highly subjective and highly flawed." Ridgway's reasoning for this was that the individuals who wrote the descriptions "[came] from a position of assumption that whoever's running the project is doing it as a particular kind of scientific project." By making this assumption, the rubric is no longer inclusive to all types of citizen science organizations as not all of the descriptions apply to their type of organization.

Change to the rubric: To make the rubric more inclusive, the supplemental descriptions for the subelements were revised to make the rubric useful to all types of environmental organizations. The new descriptions are more general which allows all organizations to use the rubric easily. Primarily, the language of the descriptions was changed to be more inclusive and understandable to anybody using the rubric. For example, the original *Project Robustness* subelement included a lot of scientific language that may not be understood by all audiences such as the word "disseminated." Therefore, it was changed to a much simpler language, along with many other sections, to increase the rubric's inclusivity.

Documentation of data quality leads to more transparent and credible projects

Key finding: Documentation is an instrumental tool to increase a project's longevity. The United States EPA's Citizen Science Quality Assurance and Documentation Handbook states that "[c]ollecting data for a big project is fun and valuable but to make conclusions from the data, you need to carefully document these activities." This valuable insight addresses an absence in the EcoCentre's 2017 rubric. Documentation tracks the activities of a program such that methods can be understood and assessed in the future. It also helps ensure the validity and scope of data when a past project is questioned.

Change to the rubric: The *Documentation* subelement (Figure 15) now addresses the need for a focus on documentation. This subelement falls under the *Scientific Contribution* element due to its nature of documenting the scientific methods and data handling of a project. This subelement asks guiding questions such as "How is documentation stored?" and "Is decision making well documented?" to ensure that a project practitioner thinks critically about not just what is documented, but how the documentation itself is accessed in the future. This new subelement ensures projects consider their documentation in an effort to increase project longevity.

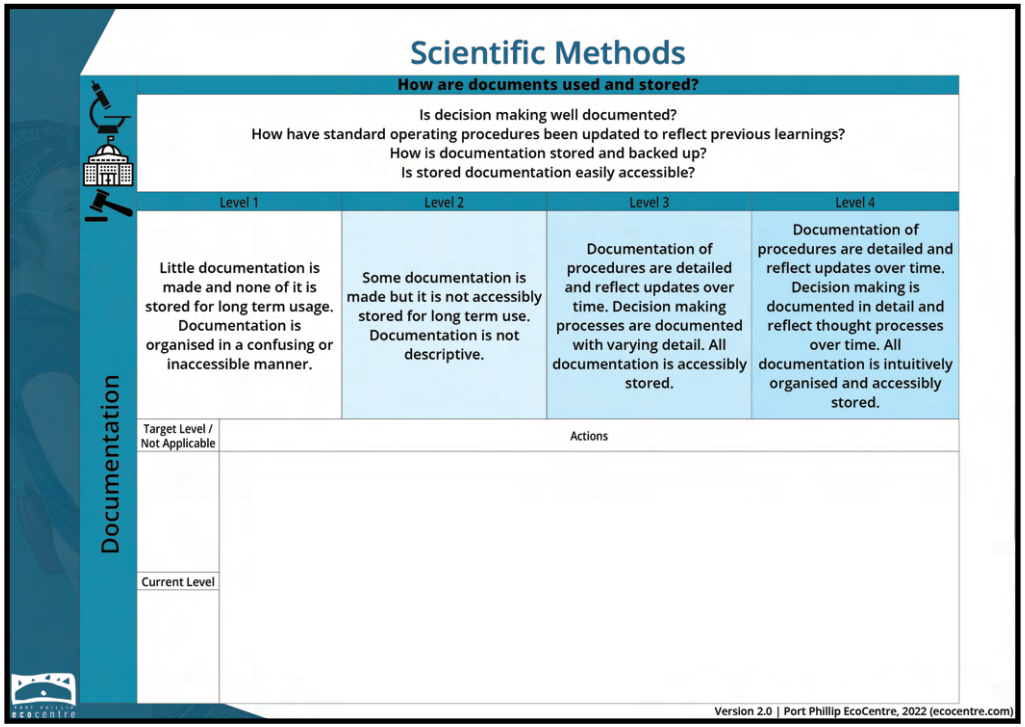


Figure 15: *Documentation* Subelement.

Achieving long term participant engagement strengthens volunteers' connection to organizations

Key finding: Many organizations struggle with their volunteer retention rates. For example, Mr. Bonney, from the ACSA, stated that he sees organizations struggle with what he calls the "fly in fly out" volunteer mindset. This means that volunteers participate in one or two projects but never return or gain a deeper connection to their environment. On the other hand, there are examples of organizations that do not struggle with their volunteer retention rates due to their engagement tactics.

One of the most prominent engagement tactics observed was social media. Nine out of the eleven interviewees noted the use of social media in their organizations to engage their volunteers by posting project updates. When volunteers see the impact they make, it encourages them to continue to volunteer. By posting progress updates, volunteers continually feel like they are contributing to science, creating a bigger sense of attachment between the volunteer and the organization's success. A study looking into the effect of communication on volunteer identification and retention found that "[e]ven though the social media postings are externally oriented, they have a beneficial impact on members of an organization due to their educational and connective value."[27]

Another way to build and retain participant interest is by acknowledging participant contributions. The New South Wales "Citizen Science Project Guide" emphasizes the need for recognizing contributions. The toolkit states that this can be done through methods such as newsletters, certificates, presentations, and experience opportunities. Recognizing and rewarding participants' efforts increases the likelihood of sustained and repeated participation.[21] Similarly, a study done by Claremont Graduate University in relation to the association between felt volunteer respect and volunteer retention stated: "Volunteers feeling more respect from others were more likely to continue volunteering than their counterparts. This is in line with social exchange theory: When volunteers do not perceive sufficient social rewards from volunteering, the continuation of volunteering may not justify the costs."[28]

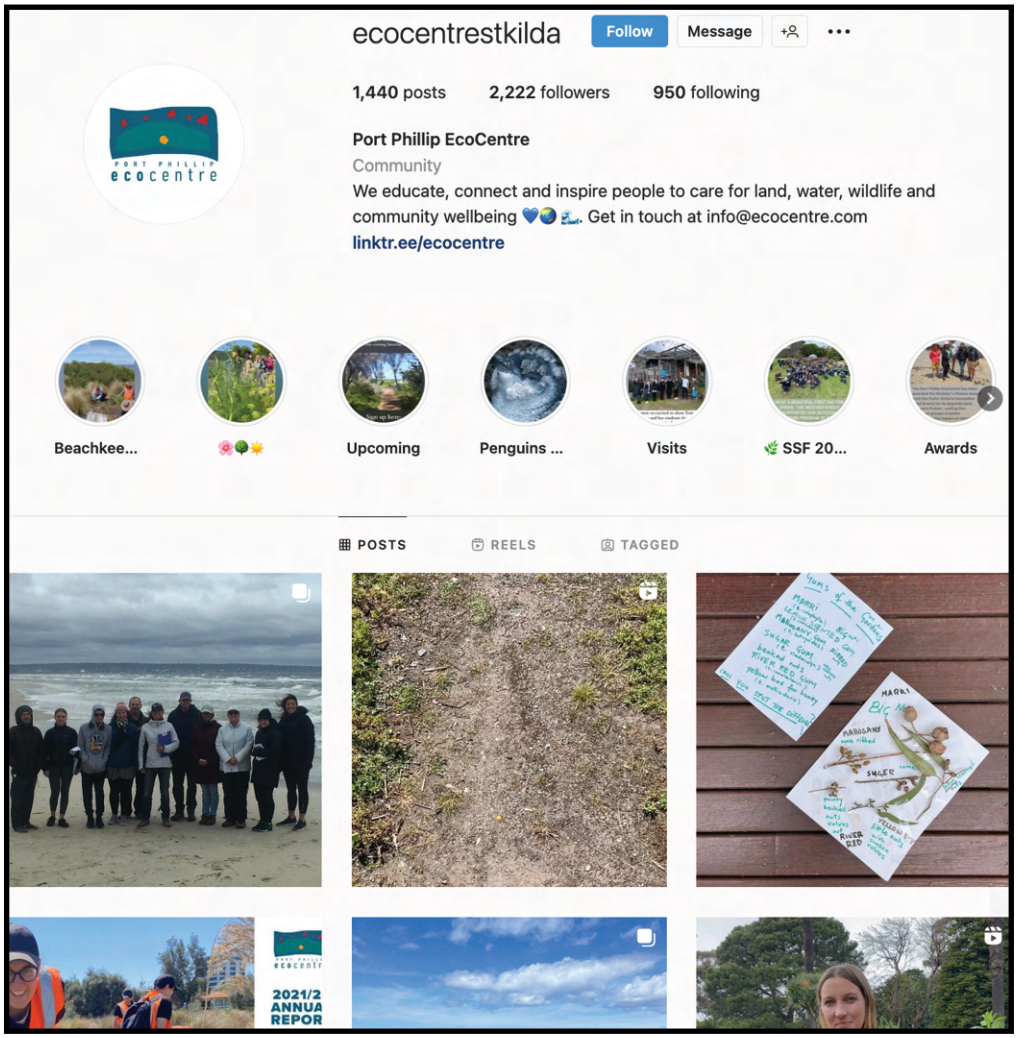


Figure 16: The EcoCentre uses social media to increase engagement with volunteers.[7]

Change to the rubric: Participant engagement presents itself in two different sections of the updated rubric. The *Communication Methods* subelement includes the addition of the questions: “Are regular updates about the project sent to participants?” and “Is consistent communication kept with volunteers and the wider community for the duration of the project?” These guiding questions emphasize the need for participant engagement and increasing volunteer retention rates by maintaining constant communication with the volunteers. Next, in the *Returns* subelement, within the *Participant Recruitment and Retention element*, asks the guiding question: “Are participant contributions acknowledged?” reflects the evidence gathered from the New South Wales “Citizen Science Project Guide” relative to rewarding participants for their contributions.

Regular quality checks increase the likelihood of generating useful datasets

Key finding: Seven out of eleven organizations represented in interviews do not use regular quality checks. Every organization requires training for their volunteers to participate in the collection of data but there are no quality checks after training. Ben Hudson from Melbourne WaterWatch explained that his organization conducts regular and random quality checks to ensure the volunteers are adhering to data collection requirements. Neil Blake from the EcoCentre explained that having a supervisor on-site at the project, if possible, can greatly improve data quality. In 2021 the Tangaroa Blue Foundation partnered with the University of New South Wales to conduct a study on the marine debris pattern on the coast of Australia. When conducting the study the researchers from the university found that nearly a third of the data that had been collected over thousands of clean-ups and data collection events was scientifically invalid due to a number of reasons and this data had to be filtered out.[9] This example of data quality checks demonstrates why it is so important. Data used for scientific validity and policy decisions should have the rigor to stand up to questioning. Quality checks are a valuable method to ensure that data is accurate and can be trusted to make decisions. The interviews shed light on the importance of having a way to address the problem of quality checks in a citizen science project.

Change to the rubric: A question about quality checks was added into the subelement *Data Quality*: “Is data quality accounted for in analysis?", which helps the user look at the project and decide if the project's data quality methods are present. One drawback present in the question is that it requires the project manager to have more personnel, which requires more financial backing when done properly.

User Experience Changes:

The EcoCentre’s existing rubric lacks instructions to guide the user

Key finding: Anna Ridgway from the Abbotsford Riverbankers and Kade Mills from the Victorian National Parks Association, two individuals who have used the EcoCentre rubric, noted that there is no explanation on how to use the rubric if an organization did not attend a workshop. To corroborate the interviews, a literary review of the New South Wales Citizen Science Project Guide and United States Environmental Protection Authority Citizen Science Quality Assurance and Documentation Handbook was conducted. The New South Wales Citizen Science Project Guide begins with a section titled “Starting Out” which discusses the components that make up a citizen science project.[21] At the beginning of the United States Environmental Protection Authority Citizen Science Quality Assurance and Documentation Handbook, clear instructions on how to use the handbook are included.[29] Based on the interviews with Ms. Ridgway and Mr. Mills

and the literary review, adding an overview of citizen science and how to use the rubric is beneficial to the usability of the tool.

Change to the rubric: To explain the process of using the rubric, a series of introduction pages help guide the user through the rubric. The "Why Choose Citizen Science'' page gives a brief motivation for using citizen science to encourage readers to continue their efforts. Next, "Designing Strong Citizen Science" explains the timeframe it takes to finish an evaluation and introduces the rubric's new icon system, seen in Figure 17. These icons help to differentiate which subelements are of particular interest to a citizen science organization based on the goals of their project. "The Four Elements of a Citizen Science Project" defines the four elements within the rubric. Finally, "How To Use the Rubric" gives a clear, three step process for completing the evaluation of a subelement.

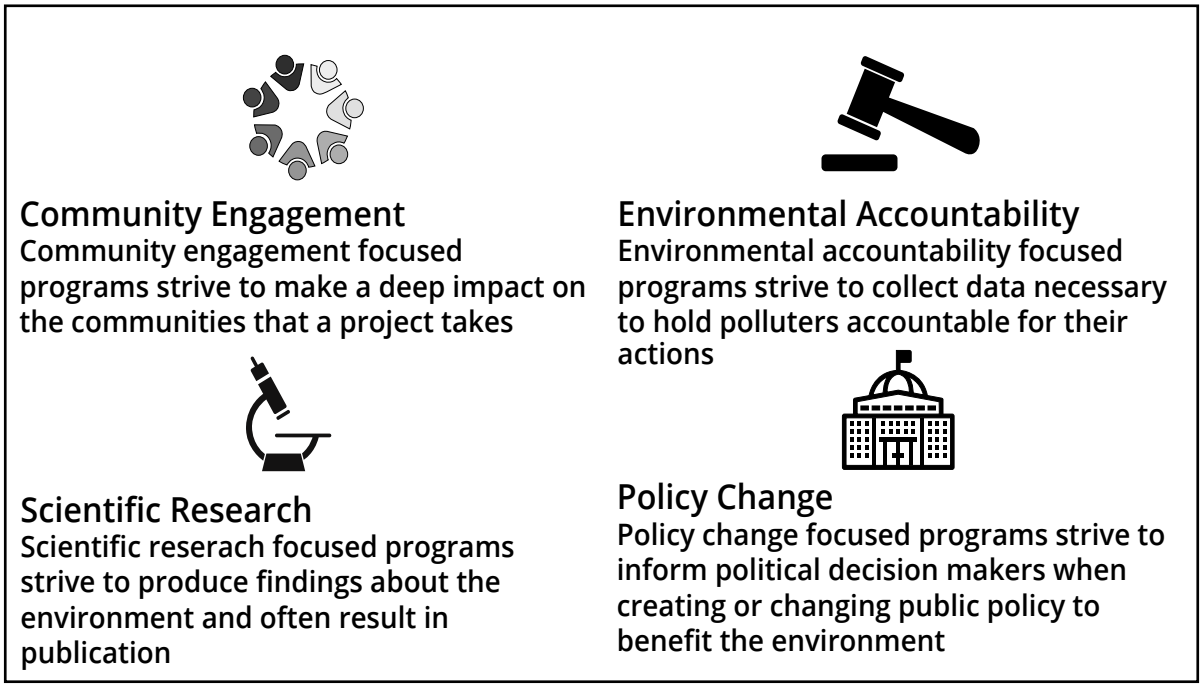


Figure 17: The rubric's new icon system.

<u>The rubric does not accommodate smaller organizations</u>

Key finding: Although the rubric is quite comprehensive, it may not be inclusive to every type of organization. Not consciously accommodating organizations of varying capabilities hinders the rubric's ability to accurately assess a project. Anna Ridgway brought up concerns about this during her interview. She discussed how the rubric provides a negative assessment of organizations that are smaller and unable to cause the same caliber of change as larger organizations such as the EcoCentre. This results in smaller organizations getting lower scores on the rubric as they may not have the resources to achieve good scores in all of the elements. Additionally, many smaller organizations do not have the resources to cover some of the subelements listed in the rubric at a high score. For example, when using the *Project Robustness* subelement, smaller organizations are less likely to distribute their findings to the scientific community as it is often not their goal to make scientific discoveries. In the *Project Quality* subelement, smaller organizations may not have enough trained staff or resources to ensure data quality is accounted for. This resulted in organizations receiving a low score on subelements not relevant to their projects.

Change to the rubric: Due to these obstacles, a more accommodating design to organizations that are either limited in resources or staff expertise was established. A "not applicable" option in the evaluation section relieves pressure to cover every subelement. Second, the formatting of the rubric now allows organizations to focus on particular sections and move through the rubric on a step by step basis. This allows organizations to grade their projects based on the desired scope rather than trying to cover the entirety of this comprehensive and detailed rubric.

A summary of the elements increases user friendliness

Key finding: Literary review of the BioScience rubric and its "Outcome assessment and program review" section led to the idea of a summary section. A summary section allows the user to reflect on where a project is aiming to be versus where it currently is to identify areas of improvement. This was further confirmed in an interview with Kade Mills. His opinion is that organizations often do not have time to look through the whole rubric to find how to improve the project, so instead, a smaller evaluation tool is used to help fast-track improvement areas.

> ***Utilizing a full rubric, while that would probably be best practice, is not something that we all have time to do and particularly if you're running quite a few different projects. Something that sort of summarizes [the rubric] and touches on the key elements would be a handy starting point. Something like that would be advantageous for a lot of different groups in citizen science.***
>
> **- Kade Mills, VNPA ReefWatch Coordinator**

Change to the rubric: To implement a new summary feature, a deep dive into each of the individual subelements within an element allowed for the most important information to be extracted and compiled into the *summary*. Then, this information was combined to create a four level system, shown by Figure 18, that summarized each individual element. They were then formatted similarly to the rest of the rubric with the exceptions questions were removed and two summarized elements were put per page. This summarized version was positioned at the front of the rubric to provide an overview of the entire rubric. These pages are not a substitute for the larger, more in-depth, rubric but complement the larger rubric by allowing the user to fast-track their project improvements.

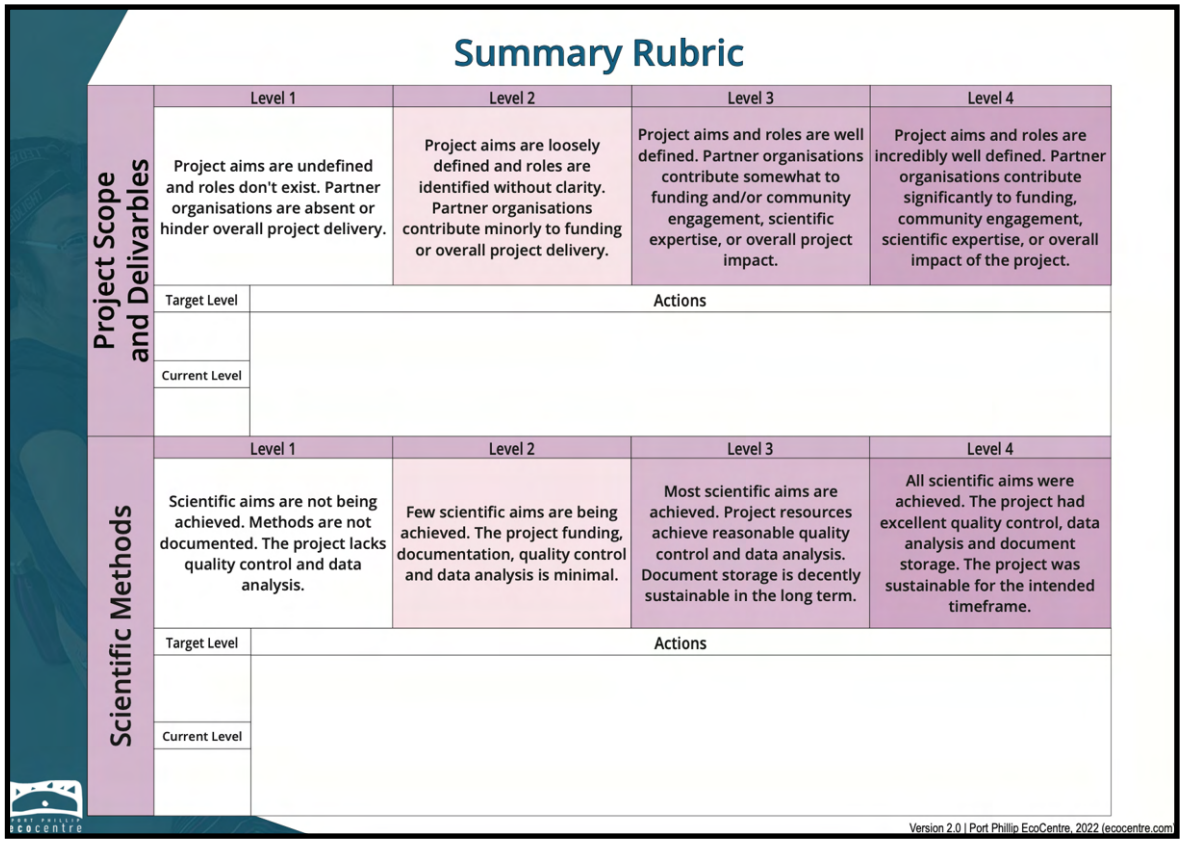
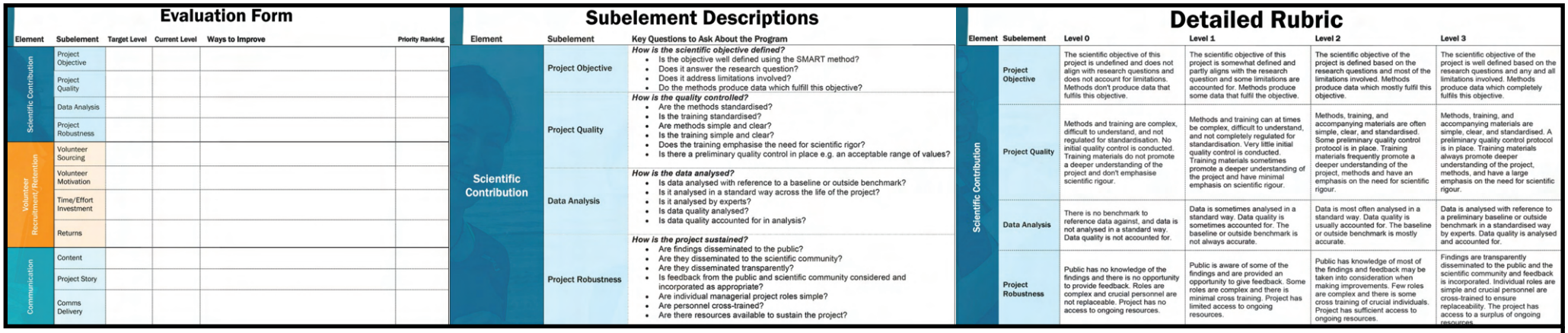


Figure 18: *Summary* Rubric Page 1.



Evaluation Form

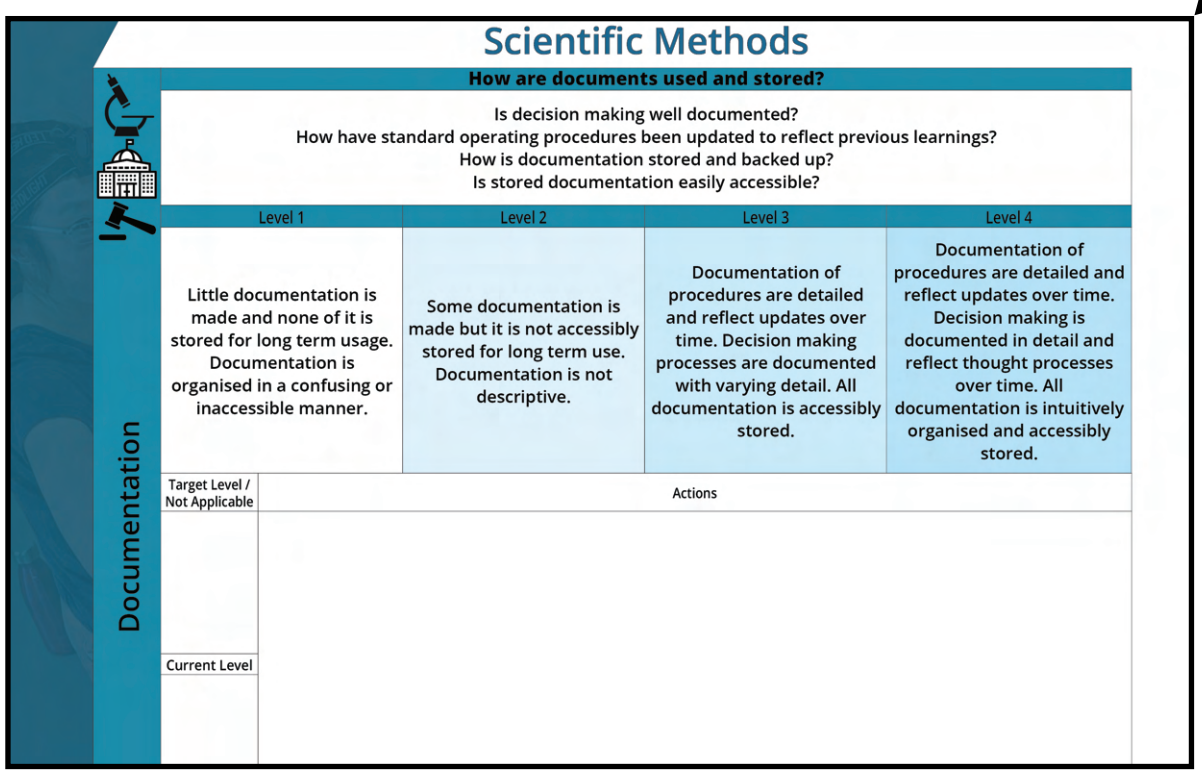
Element	Subelement	Target Level	Current Level	Ways to Improve	Priority Ranking
Scientific Contribution	Project Objective				
	Project Quality				
	Data Analysis				
	Project Robustness				
Volunteer Recruitment/Retention	Volunteer Sourcing				
	Volunteer Motivation				
	Time/Effort Investment				
	Returns				
Communication	Content				
	Project Story				
	Comms Delivery				

Subelement Descriptions

Element	Subelement	Key Questions to Ask About the Program
Scientific Contribution	Project Objective	***How is the scientific objective defined?*** • Is the objective well defined using the SMART method? • Does it answer the research question? • Does it address limitations involved? • Do the methods produce data which fulfill this objective?
	Project Quality	***How is the quality controlled?*** • Are the methods standardised? • Is the training standardised? • Are methods simple and clear? • Is the training simple and clear? • Does the training emphasise the need for scientific rigor? • Is there a preliminary quality control in place e.g. an acceptable range of values?
	Data Analysis	***How is the data analysed?*** • Is data analysed with reference to a baseline or outside benchmark? • Is it analysed in a standard way across the life of the project? • Is it analysed by experts? • Is data quality analysed? • Is data quality accounted for in analysis?
	Project Robustness	***How is the project sustained?*** • Are findings disseminated to the public? • Are they disseminated to the scientific community? • Are they disseminated transparently? • Is feedback from the public and scientific community considered and incorporated as appropriate? • Are individual managerial project roles simple? • Are personnel cross-trained? • Are there resources available to sustain the project?

Detailed Rubric

Element	Subelement	Level 0	Level 1	Level 2	Level 3
Scientific Contribution	Project Objective	The scientific objective of this project is undefined and does not align with research questions and does not account for limitations. Methods don't produce data that fulfils this objective.	The scientific objective of this project is somewhat defined and partly aligns with the research question and some limitations are accounted for. Methods produce some data that fulfil the objective.	The scientific objective of the project is defined based on the research questions and most of the limitations involved. Methods produce data which mostly fulfil this objective.	The scientific objective of the project is well defined based on the research questions and any and all limitations involved. Methods produce data which completely fulfils this objective.
	Project Quality	Methods and training are complex, difficult to understand, and not regulated for standardisation. No initial quality control is conducted. Training materials do not promote a deeper understanding of the project and don't emphasise scientific rigour.	Methods and training can at times be complex, difficult to understand, and not completely regulated for standardisation. Very little initial quality control is conducted. Training materials sometimes promote a deeper understanding of the project and have minimal emphasis on scientific rigour.	Methods, training, and accompanying materials are often simple, clear, and standardised. Some preliminary quality control protocol is in place. Training materials frequently promote a deeper understanding of the project, methods and have an emphasis on the need for scientific rigour.	Methods, training, and accompanying materials are simple, clear, and standardised. A preliminary quality control protocol is in place. Training materials always promote deeper understanding of the project, methods, and have a large emphasis on the need for scientific rigour.
	Data Analysis	There is no benchmark to reference data against, and data is not analysed in a standard way. Data quality is not accounted for.	Data is sometimes analysed in a standard way. Data quality is sometimes accounted for. The baseline or outside benchmark is not always accurate.	Data is most often analysed in a standard way. Data quality is usually accounted for. The baseline or outside benchmark is mostly accurate.	Data is analysed with reference to a preliminary baseline or outside benchmark in a standardised way by experts. Data quality is analysed and accounted for.
	Project Robustness	Public has no knowledge of the findings and there is no opportunity to provide feedback. Roles are complex and crucial personnel are not replaceable. Project has no access to ongoing resources.	Public is aware of some of the findings and are provided an opportunity to give feedback. Some roles are complex and there is minimal cross training. Project has limited access to ongoing resources.	Public has knowledge of most of the findings and feedback may be taken into consideration when making improvements. Few roles are complex and there is some cross training of crucial individuals. Project has sufficient access to ongoing resources.	Findings are transparently disseminated to the public and the scientific community and feedback is incorporated. Individual roles are simple and crucial personnel are cross-trained to ensure replaceability. The project has access to a surplus of ongoing resources.



Scientific Methods

How are documents used and stored?

Is decision making well documented?
How have standard operating procedures been updated to reflect previous learnings?
How is documentation stored and backed up?
Is stored documentation easily accessible?

Documentation

Level 1	Level 2	Level 3	Level 4
Little documentation is made and none of it is stored for long term usage. Documentation is organised in a confusing or inaccessible manner.	Some documentation is made but it is not accessibly stored for long term use. Documentation is not descriptive.	Documentation of procedures are detailed and reflect updates over time. Decision making processes are documented with varying detail. All documentation is accessibly stored.	Documentation of procedures are detailed and reflect updates over time. Decision making is documented in detail and reflect thought processes over time. All documentation is intuitively organised and accessibly stored.

Target Level / Not Applicable	Actions
Current Level	

Figure 19: The updated rubric incorporates information from three separate pages (top) from the original rubric into one page (bottom).

Rubric simplicity and clarity benefited from feedback provided by EcoCentre staff

Key finding: In addition to content changes, the EcoCentre staff requested lowering barriers to its use. Through a series of discussions, it was determined that the workflow and the wording of questions called for improvement to achieve better usability.

Change to the rubric: A restructuring of the rubric overhauled the user experience to provide a more focused and straightforward experience. In the original rubric, a user would have to flip back and forth between three pages (Evaluation Form, Subelement Descriptions, and Detailed Rubric) to complete the evaluation of a single subelement. The updated rubric provides the content of all three of these pages on a single page, such that a user can stay focused on a single subelement without referencing multiple pages. This reorganization, seen in Figure 19, also allows for far more room to write action items (formerly "Ways to Improve").

An overhaul of the subelement guiding questions and level descriptions simplifies the rubric to promote wider use. For example, the question "Is the message tailored to the demographics using each medium?" in the *Communication Methods* subelement now reads "Is the story tailored to target demographics in simple, everyday language?" in the new rubric. This update clears up confusion about what "each medium" refers to in the context of target demographics. It also specifies that the communication in question is the project's story, rather than leaving the user to interpret what "the message" means. Changes to wording and workflow boost the user friendliness and simplicity of the rubric, hopefully leading to higher adoption.

The updated rubric

With content changes based on literature analysis and interviews, including the new summary section, a new element and subelements, and revised guiding questions and level descriptions, the rubric now exhibits content that is up to date and caters better to citizen scientists. Additionally, collaborations with the EcoCentre led to user experience and formatting updates that streamline the process of evaluating a program, including new introductory pages and a reimagined workflow. These updates culminate to a rubric that is more accessible and insightful to citizen science practitioners.

Workshop Design

With findings incorporated into a new and improved rubric, a means of promoting its uptake could be developed. This took the form of a workshop intended for presentation at citizen science related conferences. The primary focus of this workshop is promotion of the rubric to people involved with organizations interested in citizen science.

An internal pilot of the workshop yielded useful feedback about its effectiveness and avenues for future improvement. Nine participants encompassed a representative cross section of the EcoCentre's diverse staff. These participants varied from professional scientists to community engagement experts. A debrief and discussion after the workshop supplemented a feedback form to gather data about the workshop's performance.

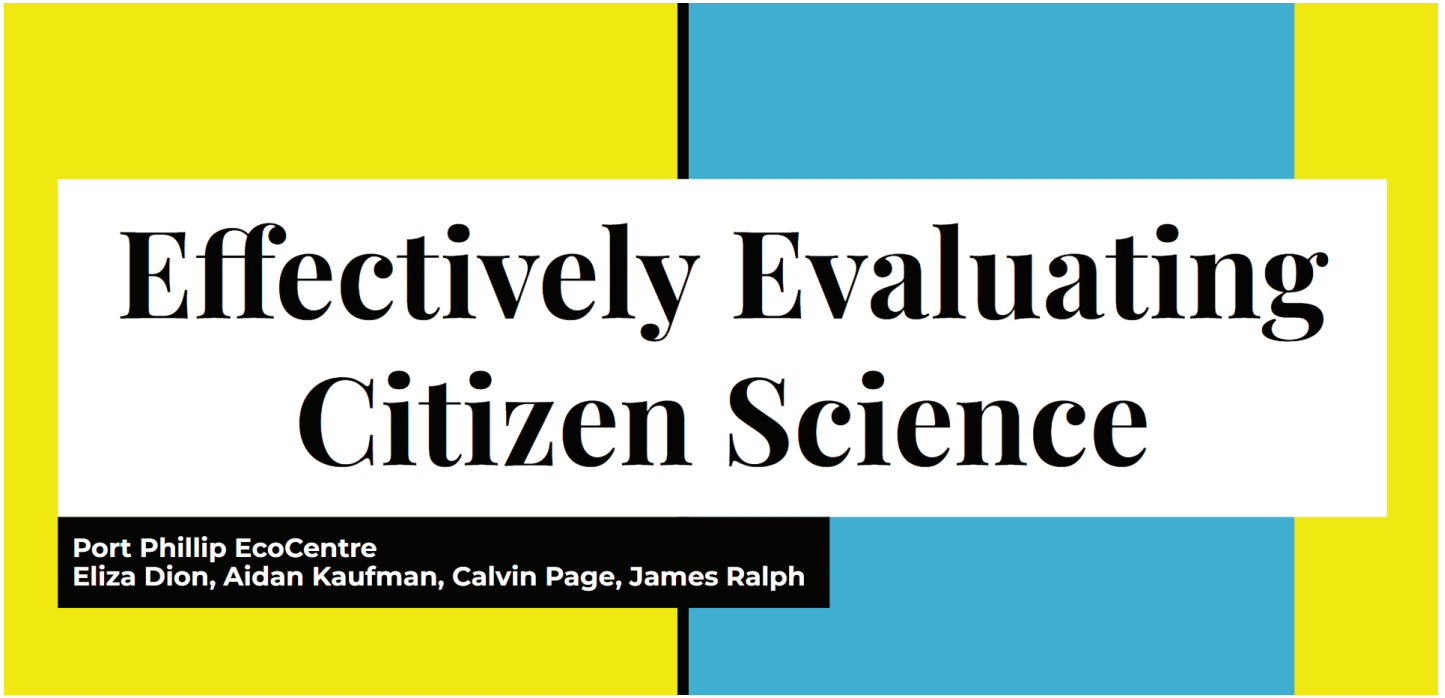


Figure 20: Workshop title slide

The workshop was designed using the FIDO teaching method

FIDO, a teaching metaprocess recommended by the EcoCentre's Executive Officer April Seymore, provided a clear path to designing an effective workshop. The FIDO Workshop Design Roadmap, available in supplemental materials, outlines all of the outcomes, decisions, information, and process designs that led to the design of the workshop. Most notably, the desired outcomes were to inspire participants to make their own citizen science programs, encourage further rubric use, and get participants comfortable with using the rubric. These outcomes would be achieved if participants decide that citizen science is useful to their organization and the rubric is a valuable tool for citizen science program design. The FIDO metaprocess helped determine that the workshop would not be a dense lecture teaching mastery of the rubric, but rather an engaging, interactive taste of what citizen science and the rubric could do for one's organization. This was in part facilitated by the rubric's new introductory pages that allow it to be self-taught. Workshop participants do not need to leave the workshop as fluent users of the rubric, they just need to be inspired to look into it further.

An interactive component in a workshop keeps the audience engaged

As stated previously, the workshop incorporated both a lecture and interactive component. The interactive portion included the opening icebreaker and the rubric activities in the workshop. This allowed the workshop to feel more like a conversation at times than a presentation even with the inclusion of lectures on necessary background information. The incorporation of an interactive portion was a pivotal finding learned from Betsabe Ortiz, the EcoCentre's Education Programs Facilitator, where she provided a workshop strategy that put emphasis on engaging the audience throughout the entirety of the workshop. Ms. Ortiz's strategy is displayed in Figure 21. The workshop started with an opening icebreaker to create a comfortable environment for the participants. Moving forward, a brief lecture was given prior to activities to provide the audience with any necessary background information. Weaving these interactive activities into the workshop's content immediately after the lecture was of the utmost importance as this is where the participants often become disengaged according to Ms. Ortiz. Lastly, closing the workshop with an open floor discussion where participants discuss their perspective of the workshop allowed them to actively reflect on the content conveyed in the workshop while also maintaining conversational flow between the facilitators and participants. During this open floor discussion, the participants expressed their enjoyment of the interactive content as it allowed them to "get up on their feet and move around" as well as "kept them consistently interested in the content presented in the workshop." Therefore, the interactive component was very effective in keeping the audience engaged.

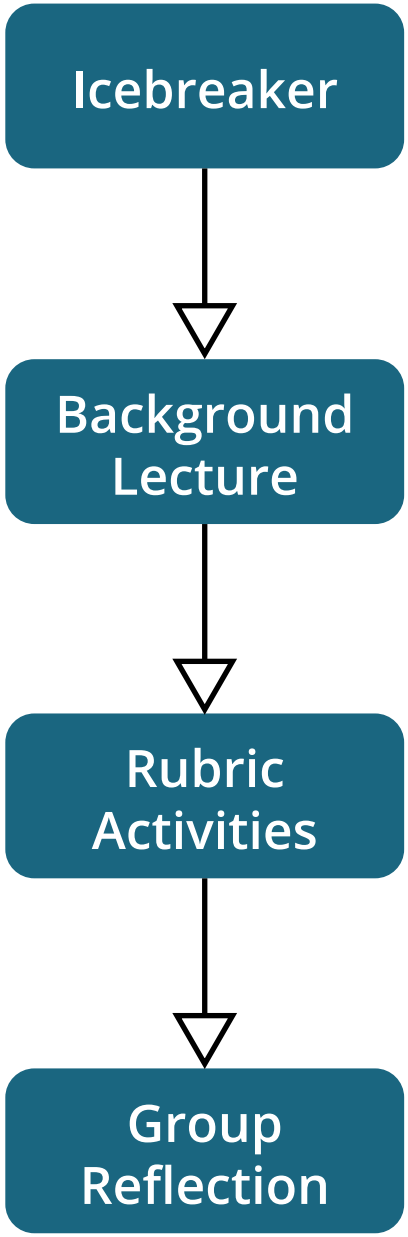


Figure 21: Workshop activity timeline.

Figure 22: James Ralph presents an icebreaker activity in the pilot workshop.

<u>The workshop's activities increased the likelihood of future rubric use</u>

To educate the participants on the utilization of the rubric, a number of interactive activities were included in the workshop. Prior to the interactive portion, an explanation of the individual parts of a rubric subelement in the form of a diagram (located in supplementary materials) ensured the participants' understanding of the layout of the subelement pages and the use of each section. After the explanation, the participants were invited to ask any clarifying questions to ensure their full understanding of the subelement sections. Moving forward, the performance of a subelement evaluation walkthrough with the help of the workshop facilitators allowed the participants to feel comfortable using the rubric prior to using it on their own. Using a case study, the participants and workshop facilitators worked together using the *Project Objectives* subelement to practice the utilization of the different sections of a subelement with the end result of producing a score for the case study. Once the participants felt comfortable with using the rubric, the main rubric activity began. This activity consisted of the participants splitting into three separate groups, each assigned to evaluate the same case study but using different elements. A facilitator inserted themselves in each of the three groups to answer any clarifying questions. Following the completion of the evaluation, a group discussion took place with the purpose of learning how the participants felt during the exercise.

Following the workshop, the feedback form included a series of statements relative to the interactive component of the workshop for the participants to respond with on a Likert scale. These statements included "[t]he rubric activities in the workshop were clear and easy to follow" and "I am confident in my ability to use the rubric after the workshop." For the statement regarding the clarity of the rubric activities, seven out of eight respondents agreed or strongly agreed that these interactive activities were easy to follow. For the statement regarding confidence in the ability to use the rubric, seven out of eight respondents strongly agreed or agreed that they felt confident with using the rubric after the workshop. Due to the majority of the responses positively reflecting on the interactive portion of the rubric, it is clear the interactive activities effectively taught the participants how to use the rubric and encouraged future use.

Figure 23: Participants complete an interactive activity in the pilot workshop

Feedback received after the workshop allowed for improvements to the workshop

At the conclusion of the pilot workshop, the EcoCentre staff offered a plethora of feedback on the workshop. First, Fam Charko, the EcoCentre's Marine Biologist, felt that the workshop was verbose with limited figures and images. She brought up the fact that some people are visual learners and therefore, word-centric workshops do not equally reach all people. April Seymore, the EcoCentre's Executive Officer, voiced that the workshop undersold its credibility. The audience was not aware of the level of rigor used to create the rubric.

During the rubric exercise one group evaluating the *Participant Retention and Recruitment* subelement expressed confusion on the leveling system. Neil Blake, one of the members in the group, emphasized this confusion during the discussion. The rubric icons were another area of confusion in the workshop. This was confirmed during the discussion by four of the eight participants. These individuals explained that the icons are a very smart idea, but the explanation and execution in the workshop needed to be improved for better audience understanding.

Figure 24: Participants work together to complete the pilot workshop's rubric activity.

Improvement Opportunities

The team implemented findings collected throughout the project to create two deliverables: rubric version 2.0 and a workshop. The iterations made to the rubric resulted in a more user friendly and visually appealing design and evaluation tool. An accompanying workshop aided the distribution and training on use of the rubric. While both have been accomplished, some feedback and findings are beyond the scope of this project. The following recommendations are provided for individuals to pursue and build on this project in the future.

Moving Forward

Simplify the rubric's wording to make it more appealing

Although updates to the rubric made strides toward refining its content and user experience, there is still room for improvement. The EcoCentre could update the rubric by revising the wording to achieve even greater clarity and simplicity. Iterative changes to the rubric can be made using insight from discussions with workshop participants. An emphasis on optimizing the rubric's simplicity and conciseness would make a citizen science practitioner more willing and likely to use the rubric.

Create a website to increase usability and accessibility

The rubric, as it stands, is a long and dense document. The EcoCentre's web designers, or potentially a future team of interns or WPI project team, should create an interactive digital version of the rubric. A digital medium would allow for additional information on guiding questions and level descriptions to be shown upon request and hidden otherwise. Additionally, user tracking could let the EcoCentre accurately gauge the rubric's use, among other benefits.

Present the workshop at citizen science related conferences

During the workshop's design process, science, environmental, and community volunteering conferences were the prime uses envisioned for workshop delivery. The EcoCentre should target these conferences and deliver the workshop there to disseminate the rubric. Such conferences provide an audience that is engaged with organizations that conduct or may consider conducting citizen science, and would be an effective avenue to promote adoption of the rubric. The participants, even if they do not conduct citizen science for a given organization, can report back to others at their organization if they feel inspired to spread knowledge of the rubric.

Advertise the rubric on a number of platforms to increase use

When speaking with EcoCentre staff, they noted that use of the rubric was largely unquantified to date. One reason for this may be the lack of dissemination. The EcoCentre could write a blog post to include on their website explaining the rubric's aims and encouraging organizations to use the rubric as a design or evaluation tool. Additionally, moving the rubric outside of the resources page and giving the rubric its own page under "News + Events" would increase its visibility to citizen science practitioners viewing the EcoCentre's website. On the EcoCentre's website, annual tracking of downloads would provide quantifiable data on the influence and use of the rubric. Also, the EcoCentre should advertise the rubric with the EcoCentre's social media pages and in a newsletter to aid the rubric's distribution. Along with this, the EcoCentre could upload the tool to the Australian National Library and Victorian State Library, increasing the rubric's visibility to people searching at the libraries.

Develop the workshop to better accommodate a wide range of audiences

At the conclusion of the pilot workshop, the EcoCentre staff offered a plethora of suggestions to improve audience understanding of the rubric during the workshop. The next iteration of the workshop completed by the EcoCentre should include more graphics and images on the slides. Fam Charko, a workshop participant, explained that the pilot workshop was very word centric and did not accommodate all types of learners. Changing slides to have more graphics while still including some of the words will allow for both visual and reading/writing learners to understand the material presented. As a result, the workshop can be effectively conducted for a wide range of audiences.

Additionally, future workshops should include a more extensive explanation of the rubric's scoring system. A more thorough explanation of the scoring system's purpose would be a prudent addition to the workshop. This would eliminate the confusion about the uses of the scoring system.

Acknowledgements

We would like to thank our sponsors, the Port Phillip EcoCentre, specifically, April Seymore, Michelle Fisher, Fam Charko, Neil Blake, and Bestabe Ortiz for their support and guidance throughout our time in Melbourne.

We would also like to acknowledge all of our interview participants who kindly took the time to provide us with valuable information for our project.

Additionally, we would like to thank our advisors, Professor Holly Ault, Professor Tanja Dominko, and Professor Stephen McCauley for their advice and encouragement over the course of our project.

Conclusion

The Port Phillip EcoCentre strives to promote sustainability and connect individuals to their environment. The citizen science evaluation rubric contributes to fulfilling this ambition by assisting organizations with designing and evaluating their citizen science programs. Through an in depth literature review, a series of interviews, and collaboration with EcoCentre staff, informed updates to the EcoCentre's citizen science rubric and delivery of an interactive promotional workshop were successfully accomplished. The citizen science evaluation rubric benefits from significant improvements to its content and usability. Additionally, the pilot workshop received optimistic reviews and generated constructive suggestions, showing a clear path to future enhancement and delivery. These achievements work towards improving the effectiveness and impact of environmental citizen science, ultimately leading to a cleaner, healthier planet.

References

1. Guerrini, C. J., Majumder, M. A., Lewellyn, M. J., & McGuire, A. L. (2018). Citizen science, public policy. Science, 361(6398), 134–136. https://doi.org/10.1126/science.aar8379

2. Mapping citizen science. Inspiring Australia. (2020, May 6). https://inspiringnsw.org.au/2020/05/06/mapping-citizen-science/

3. About Port Phillip Ecocentre: Our history and people. Port Phillip EcoCentre. (2021, November 8). https://www.ecocentre.com/about-us

4. Cottam, D., McGuire, C., Mossop, D., Davis, G., Donlen, J., Friend, K., Lewis, B., Boucher, E., Kirubakaran, H., Goulding, R., Jovanovic, D., McCarthy, D., Seymore, A., Martino, C., & Zuccala, K. (2021). Drain Detectives: Lessons Learned from citizen science monitoring of Beach drains. Citizen Science: Theory and Practice, 6(1), 20. https://doi.org/10.5334/cstp.383

5. Environment Protection Authority Victoria. (2020, December 11). Drain Detectives Program. Drain Detectives program. https://www.epa.vic.gov.au/for-community/get-involved/citizen-science-program/citizen-science-projects/drain-detectives

6. Port Phillip EcoCentre Annual Report 2018-2019. (n.d.). https://www.ecocentre.com/wp-content/uploads/2021/07/EcoCentre-Annual-Report-2019.pdf

7. Port Phillip Ecocentre (@ecocentrestkilda) - instagram. (n.d.). https://www.instagram.com/ecocentrestkilda/

8. iNaturalist's global 2022 year in Review. iNaturalist. (2022, December 4). https://www.inaturalist.org/stats/2022/

9. Fraisl, D., Campbell, J., See, L., Wehn, U., Wardlaw, J., Gold, M., Moorthy, I., Arias, R., Piera, J., Oliver, J. L., Masó, J., Penker, M., & Fritz, S. (2020). Mapping citizen science contributions to the UN Sustainable Development Goals. Sustainability Science, 15(6), 1735–1751. https://doi.org/10.1007/s11625-020-00833-7

10. European Commission, Directorate-General for Research and Innovation. (2016). In Open innovation, open science, open to the World: A Vision for Europe (p. 34). essay.

11. Walker, D. W., Smigaj, M., & Tani, M. (2020). The benefits and negative impacts of citizen science applications to water as experienced by participants and Communities. WIREs Water, 8(1). https://doi.org/10.1002/wat2.1488

12. Borda, A. (2019). Citizen science models in health research: An Australian commentary. Online Journal of Public Health Informatics, 11(3). https://doi.org/10.5210/ojphi.v11i3.10358

13. State of the Environment 2018 Report. CES. (2018, March 19). https://www.ces.vic.gov.au/state-of-reports/state-environment-2018-report

14. State of the marine and coastal environment 2021 report. CES. (2021, December 8). https://www.ces.vic.gov.au/state-of-reports/state-marine-and-coastal-environment-2021-report

15. Ecocentre redevelopment. City of Port Phillip. (n.d.). https://www.portphillip.vic.gov.au/about-the-council/projects-and-works/ecocentre-redevelopment

16. Community programs: EcoCentre: Environmental education hub. Port Phillip EcoCentre. (2021, November 5). https://www.ecocentre.com/programs/community-programs/

17. Port Phillip EcoCentre Annual Report 2020-2021. (n.d.). https://www.ecocentre.com/wp-content/uploads/2021/07/EcoCentre-Monitoring-and-Evaluation-Framework-2021-2024.pdf

18. Port Phillip EcoCentre. (n.d.). Port Phillip Baykeeper - Ecocentre. Port Phillip Baykeeper PROGRAM FRAMEWORK 2021-2026. https://www.ecocentre.com/wp-content/uploads/2021/07/Baykeeper-Program-Framework.pdf

19. Bergstrom, N., Sorensen, N., Duquette, S., & Healey, M. (2017). From Streets to Sea: Evaluating Citizen Science Programs with the Port Phillip EcoCentre. Melbourne: Worcester Polytechnic Institute.

20. Tredick, C. A., Lewison, R. L., Deutschman, D. H., Hunt, T. A. N. N., Gordon, K. L., & Von Hendy, P. (2017). A rubric to evaluate citizen-science programs for long-term ecological monitoring. BioScience, 67(9), 834–844. https://doi.org/10.1093/biosci/bix090

21. Citizen Science Hub Project Guide. NSW Government. (n.d.). https://www.seed.nsw.gov.au/citizen-science-hub-project-guide Citizen science handbook - US EPA. (2019, March). https://www.epa.gov/sites/default/files/2019-03/documents/508_csqapphandbook_3_5_19_mmedits.pdf

22. Citizen science handbook - US EPA. (2019, March). https://www.epa.gov/sites/default/files/2019-03/documents/508_csqapphandbook_3_5_19_mmedits.pdf

23. Bison, M., Yoccoz, N. G., Carlson, B. Z., & Delestrade, A. (2018). Comparison of Budburst Phenology Trends and precision among participants in a citizen science program. International Journal of Biometeorology, 63(1), 61–72. https://doi.org/10.1007/s00484-018-1636-x

24. Elliott, V. L., Chheng, P., Uy, S., & Holtgrieve, G. W. (2019). Monitoring of tropical freshwater fish resources for sustainable use. Journal of Fish Biology. https://doi.org/10.1111/jfb.13974

25. Eberhard, R., James, J., & Jago, D. (2021, September 14). Put some bite into your facilitation with Fido - enablers of Change. Enablers of Change - Enablers of Change. https://www.enablersofchange.com.au/put-some-bite-into-your-facilitation-with-fido/

26. Eriksen, M., Lebreton, L. C., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., Galgani, F., Ryan, P. G., & Reisser, J. (2014). Plastic pollution in the world's oceans: More than 5 trillion plastic pieces weighing over 250,000 tons afloat at sea. PLoS ONE, 9(12). https://doi.org/10.1371/journal.pone.0111913

27. Bauer, S., & Lim, D. (2019). Effect of communication practices on volunteer organization identification and retention. Sustainability, 11(9), 2467. https://doi.org/10.3390/su11092467

28. Tse, D. C. (2018). Volunteers' felt respect and its associations with volunteering retention, daily affect, well-being, and mortality. The Journals of Gerontology: Series B, 75(8), 1625–1636. https://doi.org/10.1093/geronb/gby117

29. What makes a citizen science project? NSW Government. (n.d.). https://www.seed.nsw.gov.au/citizen-science-hub-project-guide/starting-out/what-makes-a-citizen-science-project