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Social Ecological Economic Development Studies (SEEDS) Sustainability Program

Student Research Report

Citizen Science at UBC: A Framework and Future Recommendations

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Themes: Citizen Science, Climate and Biodiversity Crises

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Executive Summary

Growing concerns of climate change and biodiversity loss have been forefront topics of discussion recently. New committees, policies, and projects worldwide have been established as a direct response to take action on these global issues. In December of 2019, UBC declared a climate emergency, devoting its research and initiatives to find solutions that will mitigate the effects of climate change. As a result, new programs and policies have been enacted to fulfill UBC's commitment, such as the creation of the Climate Crisis in Urban Biodiversity (CCUB) initiative. However, engaging the public in science is a crucial obstacle to overcome before UBC can further advance its goals.

UBC is poised to be a leading institution to tackle climate change and biodiversity issues by integrating citizen science into its existing policies. Citizen science as a practice has the capacity to conduct sound scientific research on a large scale while also engaging the public in science. It bridges the gap between research and practice by disseminating the knowledge learned from scientific research to the people participating in projects. Furthermore, it builds trust in science, which is greatly needed in a world full of misinformation. Participants who engage in citizen science learn, unlearn, and relearn the stigma behind research and can also contribute to it.

Key Recommendations and Next Steps

Listed are some next steps to advance citizen science at UBC. These recommendations are geared towards engaging faculty, staff, and students in the scientific process by increasing visibility and accessibility to science.

1. Create an online platform listing all current citizen science projects and other UBC-led research. A portal accessible by the UBC community will increase the visibility of ongoing research conducted by UBC members, attracting new and interested audiences.
2. Baseline the biodiversity on the UBC campus and develop a biodiversity atlas. Identifying gaps in our knowledge and making informed policy decisions requires a survey and visualization of the species present on campus. In addition, a baseline enables researchers to identify new research opportunities and advance UBC's biodiversity and climate initiatives.
3. Develop an open database for all data collected by UBC-led research to be stored and accessed freely. Increasing accessibility to data provides more opportunities to build on top of existing work and collaborate on new projects.
4. Host citizen science projects in classes. Engaging students in scientific research and providing applied learning opportunities increases their scientific literacy and allows them to take action on global issues.

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Introduction

Project Purpose

In December of 2019, the UBC Board of Governors declared a climate emergency, realigning some of the university's goals to take action on climate change. A vital component of this declaration recognizes the need to engage the community and calls for breakthrough solutions created by UBC education and innovation. Since then, committees such as SEEDS and CCUB have been prominent in sustainability initiatives, engaging students and creating student-led research opportunities to address climate issues. This project aims to support action on climate change and urban biodiversity loss through the creation of a citizen science framework for the UBC Vancouver campus.

Objectives

- Advance citizen science on the UBC Vancouver campus
- Develop a citizen science framework for UBC faculty, staff, and student groups
- Identify citizen science initiatives and projects underway as well as opportunities for future initiatives
- Suggest recommendations and next steps for citizen science at UBC

What is Citizen Science?

Citizen science, a practice where the public participates in scientific research in collaboration with scientists, has existed in many fields such as medicine, astrology, and agriculture for a few millennia. For instance, ancient Chinese residents recorded migratory locusts to help track outbreaks for over 2000 years. More recently, citizen science has been a growing practice in climate and biodiversity research due to growing societal concerns.

The term "Citizen Science" was coined in the mid-1990s by Alan Irwin, a social scientist based in the UK. Its definition has gone through many evolutions since without a definitive consensus by the scientific community. For example, the Oxford English Dictionary defines citizen science as "scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions." In contrast, Alan Irwin defines it holistically, suggesting it is "science which assists the needs and concerns of citizens" and is "a form of science developed and enacted by the citizens themselves" (Irwin, 2018). Nevertheless, both definitions ultimately describe the same concept: concerned individuals collaborate with scientists to address a pressing concern through scientific research.

The general definition this paper will follow and recommended for UBC will pertain to the following:

Citizen science is the practice of conducting scientific research in collaboration between trained scientists and interested parties to address public concerns and increase scientific knowledge.

This definition avoids the use of exclusionary words - such as amateur scientists or non-experts - as levels of expertise and experience can differ between people, regardless of educational background. Also, the term "scientific knowledge" is used to encompass the entirety of the scientific process, as participants will learn about the topic of interest and the work that goes into research.

It should be noted that there has been a discussion to change the word "Citizen" to "Community" to increase inclusivity for those who may not be citizens of a country (Audubon Center at Debs Park, 2018). The transition aims to encompass and value everyone's contribution to science, no matter the participant's status in a country. However, for the purpose of this paper, the term "Citizen Science" will be used in place as it is the more well-known terminology.

Why Citizen Science at UBC?

With growing concerns about climate change and loss of biodiversity, alongside new strategy plans to engage students in conservation and climate crisis work, citizen science provides a framework for UBC students and faculty to involve themselves in scientific research (Leru). Not only does it democratize knowledge production, but it also presents a friendly opportunity for people to join the UBC community and collectively participate in biodiversity and climate research. Moreover, with recent discussions amongst faculty and staff about student engagement in science, incorporating citizen science into a student's curriculum through classes or campus-wide events can help address these concerns.

Benefits

As an accredited institution leading in conservation and climate research, citizen science can advance ongoing UBC initiatives while also providing various benefits for students, staff, and faculty. In addition, there lies potential in building stronger connections between scientists and the public by facilitating an environment that encourages participation in research. The following list of benefits was curated and adapted from PARTHENOS, a Horizon 2020 project funded by the EU Commission (Dublin, n.d.).

General Benefits

- **Bridge the gap between academia and the public by increasing transparency and accessibility of the scientific process.** Much research by academics usually ends up in scientific journals, which have audiences of other scholars and rarely the general public. Nevertheless, citizen science has the potential to make science more approachable to the

untrained individual where people can learn about research topics without having to access the literature.

- **Build trust in science amongst the general public.** There has been a growing concern of fake news damaging the reputation of academia. However, citizen science projects can facilitate opportunities to learn about scientific research and provide a skill set for participants to identify fake news in the media. The European Commission has already recognized this, endorsing it through new policies and establishing committees dedicated to citizen science (Vohland et al., 2021).
- **Address societal concerns through scientific research.** With global issues such as climate change and biodiversity loss that are of high priority, citizen science has the flexibility to address these concerns and ensure that scientific agendas align with people's interests.
- **Democratize knowledge and knowledge production.** Those who participate in citizen science projects are likely to be more informed and positively influence decisions about social policies. It can also break the stigma around gatekeeping scientific research to only academics.

Benefits for Faculty and Staff

- **Increase engagement and collaboration internally at UBC and with external communities.** The collaborative nature of citizen science will lead to networking with other experts and exploring new partnerships with organizations that have similar interests. Inviting others to be part of a team will broaden the range of expertise available and increase the project's reach when shared through collaborative networks. Moreover, it can create a sense of community effort, and future projects and research questions can rely on these established relationships for more collaborations.
- **Investigate questions in a deeper approach and collect data on a larger scale.** With regard to long-term monitoring or surveying an area for species, observations and analysis can be labour-intensive for small research teams. Expanding the scientific process to interested parties through citizen science can increase its speed and efficiency.
- **Input and local knowledge from participants can provide unexpected insights leading to new research questions.** While scientists contribute their scientific expertise to citizen science projects, participants can bring in a variety of information that is not publicly known, such as local policies or habitat conditions of their community. For instance, butterfly enthusiasts may join a butterfly monitoring program and suggest areas of interest to researchers.
- **Disseminate research to a broader audience.** Those who participate in citizen science projects will inadvertently gain a better understanding of the investigated research question and may even share news of the work with their peers. It is beneficial to bring attention to necessary research that can impact future social policy decisions or address the needs of the public.

Benefits for Students and Project Participants

- **Encouragement to take action on growing global issues.** Citizen science provides an outlet for people to express their interests and through scientific research. Simultaneous learning and knowledge building while also giving people a greater voice to scientific and research matters.
- **Join a growing community of biodiversity and conservation.** Participants, especially students, look for a place to fit in with those that have similar ideals and goals. Citizen science programs usually attract people interested in investigating a research topic, creating a welcoming community of like-minded individuals driven to take action.
- **Increase scientific literacy and understanding of scientific research.** Through participation, people will enhance their scientific skill set. Citizen science provides opportunities to gain research experience and learn about the work that goes into science, an integral step for students who wish to become scientists.

Issues and Limitations

Although citizen science is a powerful tool that benefits the community, it has its limits and cannot address every research question or apply to every project team. Since its foundation is built on collaboration, bringing people together from different areas of expertise has its caveats. Project stakeholders might have different agendas they wish to achieve than the researchers, and public engagement takes time that might not be available for research teams.

When deciding whether to develop a citizen science program for your research, consider the type of data you need and the resources available to you. Expanding a project team to facilitate citizen science might not be feasible unless the research question requires a large amount of data with other goals to engage the public in science. Compare the benefits above and the common issues and limitations listed below before designing a project.

Bias

Selection bias and cognitive blindness are often criticisms of citizen science regarded by most academics (Jordan et al., 2012). Participants who lack training and experience when collecting data may skip over critical data because of an interest in a specific species. Fink & Hochachka (2012) suggests creating citizen science programs based on spatial and temporal constrictions rather than taxa to reduce selection bias amongst participants. In turn, there is less emphasis on finding specific species that can lead to species blindness of others. Using an invasive plant species monitoring program as an example, ask participants to survey a transect rather than looking for specific plants. Analyze and identify the data later to sort through invasive and native plants of that area.

Ethics

As with other scientific research, ethical issues arise when implementing citizen science programs, especially when including a public component in the research process. When designing a project, issues such as data management, legal considerations, and participant benefits need to be considered. Resnik et al. (2015) go into extensive detail about ethics in citizen science and provide suggestions for the project design.

Resources

Citizen science is a public-facing practice that requires an investment of time, money, and resources. For example, project team members will need to be paid salaries, and engaging the public and project participants takes time. Moreover, supplying physical tools or licensed access to online services for participants requires money and comes will other liability risks. Finally, consider that participants who join projects look for benefits to gain, which can come in the form of education, access to journals or networks, or a community of like-minded people. Project leaders will need to provide such rewards to retain participants and attract new ones.

The Ten Principles of Citizen Science

The foundation of citizen science builds on the collaboration between researchers and citizens. For a project to find success, it is vital to have standards that everyone can follow. Robinson et al. (2018), an international community of scientists, created this list of the Ten Principles of Citizen Science that provide a list of principles for researchers and group leaders to adhere to when establishing their project.

1. Citizen science projects actively involve citizens in scientific endeavour that generates new knowledge or understanding. Citizens may act as contributors, collaborators, or project leaders and have a meaningful role in the project.
2. Citizen science projects have a genuine science outcome. For example, answering a research question or informing conservation action, management decisions or environmental policy.
3. Both the professional scientists and the citizen scientists benefit from taking part. Benefits may include the publication of research outputs, learning opportunities, personal enjoyment, social benefits, satisfaction through contributing to scientific evidence, for example, to address local, national and international issues, and through that, the potential to influence policy.
4. Citizen scientists may, if they wish, participate in multiple stages of the scientific process. This may include developing the research question, designing the method, gathering and analyzing data, and communicating the results.
5. Citizen scientists receive feedback from the project. For example, how their data are being used and what the research, policy or societal outcomes are.

6. Citizen science is considered a research approach like any other, with limitations and biases that should be considered and controlled for. However, unlike traditional research approaches, citizen science provides opportunity for greater public engagement and democratization of science.
7. Citizen science project data and metadata are made publicly available and where possible, results are published in an open-access format. Data sharing may occur during or after the project, unless there are security or privacy concerns that prevent this.
8. Citizen scientists are acknowledged in project results and publications.
9. Citizen science programmes are evaluated for their scientific output, data quality, participant experience and wider societal or policy impact.
10. The leaders of citizen science projects take into consideration legal and ethical issues surrounding copyright, intellectual property, data-sharing agreements, confidentiality, attribution and the environmental impact of any activities.

Components to a Citizen Science Project at UBC

The key to creating and sustaining a citizen science project in your community is defining a structure on which your team can build. Although each project will vary depending on your goals, these five components should be used as a guide when creating your framework.

1. Research Question(s) or Goal(s)

What do you plan to achieve with this project? What research questions do you want to address, and what data do you want to collect? Who do you want to engage and educate? It is essential to set a question(s) to address or a goal(s) to achieve before starting so you have something to reference and keep yourself on track.

Keep in mind that your project participants will vary in the degree of observation skills in the beginning. Thus, monitoring studies that utilize basic skills, such as counting or encountering species, are less complicated to establish with citizen science. That is not to say that projects with complex designs and various components cannot benefit from citizen science; continuous project refinement and communication with participants can bring success to any project.

2. Building a Project Team

Any big project requires a team made up of passionate people willing to work together. Citizen science is a collaborative effort between scientists and citizens, where both need to be engaged with each other to achieve the project's goals. Therefore, your team must work well with each other in every step of the project, and each member should bring skills that cover a broad range, such as:

- **Scientific knowledge** - Your project design will need to deploy scientific methods and analysis to address the research question or goal. A citizen science project backed by sound science also solidifies its legitimacy and places trust in the public that its findings are accurate.
- **Data analysis** - Analyzing the collected data is crucial as you will need to report your findings to your participants and possibly lead to publication.
- **Communication** - Internal communication with your team members and externally with your participants is crucial for success. It might be ideal only to have one or two team members dedicated to communicating with project participants to decrease the chance of miscommunication.
- **Project design** - Measure twice and cut once. Drafting out a plan for your project and anticipating contingencies makes any project run smoothly. However, project design is not an easy skill to acquire and should be taken seriously.

Either you are a researcher or an interested party, reach out to your community through online platforms or recommendations from established networks. Passionate people, such as avid birders and plant enthusiasts, will have local knowledge that scientists usually lack, translating to an improved project design if brought on board. When building a project team, every member needs to pull their weight and commit, as they are role models for project participants. Set regular meetings and deadlines to help each other stay on top of their tasks.

3. Communication

As with any team-based project, cooperation with your team members is crucial for success. However, citizen science is a collaborative effort, and communication with your participants is also necessary to retain their interest and sustain the project's longevity and progress (Goad et al., 2020). Listed are some tips to incorporate into the project design:

- **Effective and timely communication** with your participants shows that you are engaged and interested in your project.
- **Adapt based on feedback.** Your participants may struggle with your project design, and you should be able to assist them or make minor adjustments to your plan.
- **Communicate your findings and progress** to your project participants. Communication may come in the form of numbers, reports, or local media, showcasing the progress of your project and the impact people are creating in the scientific field.
- **Hold regular meetings or schedule updates to check in with your participants.** Use this time to get some feedback from them and report some of your findings from their data.

It is essential to remember that many people participate in citizen science to learn about a topic and take research-based action. Therefore, be diligent in your communication with your project's participants and not be afraid to show some of the work that goes into scientific practices. These little actions will help bridge the gap between research and practice while increasing public trust in science.

4. Community Engagement

Building and engaging your community to participate in your citizen science project is a defining success metric. A project's short-term and long-term outcomes rely heavily on contributions by participants. However, attracting new members and retaining those who have already joined while maintaining budget and resources can prove difficult without careful planning. This is where collaborations in citizen science show their strength because different parties can pool their resources and work together.

People who join projects will have different motivations they hope to fulfill through participation. For example, some may want to find a community of like-minded individuals, while others seek benefits such as access to resources or education. Therefore, it is essential to facilitate an environment that encourages input from participants while also providing attractive incentives that will not expend too much time and money. Listed are some recommendations to consider when designing a project.

- **Reach out to external organizations or student groups.** If the project's research question or goal allows, targeting a specific audience with similar ambitions will have a greater chance of engagement and participant retention. There might also be an established network that can be used to increase a project's reach.
- **Provide incentives and rewards for participation.** Incentives for participants can either be tangible or intangible, depending on the audience and their motivations. For example, those with career-orientated goals will look to find opportunities where they can learn new things, gain experience, or be rewarded materialistic awards. Other motivations may include empowerment, social involvement in environmental issues, or experiencing nature (Prysby, 2020).

5. Tools and Training for Data Management and Visualization

The tool(s) chosen will determine the project's direction and focus. For example, your project may focus on analyzing data from previously collected datasets or on data collection to address a research question.

This is a non-exhaustive list of tools available to use for citizen science projects. The tools on this list are curated with the following qualities in mind when considering their purpose: accessibility, user-friendliness, and open-accessibility to data. They have their capabilities marked off for convenience and are grouped into four categories: data-entry, analytical tools, visualization tools, and databanks.

Tools	Bees	Birds	Butterflies	Plants	Trees	Database	Data Analysis	Visualization	Description
Data Entry									
iNaturalist	✔	✔	✔	✔	✔	✔			A powerful identification tool used by most project teams. Has a mobile app and browser version to upload observations. Data are marked as research-grade and exported to GBIF once verified by experts. Datasets can also be downloaded locally from the website. iNaturalist.org
eBIRD	✔					✔			A documentation project dedicated to birds run by the Cornell Lab of Ornithology. Observations are uploaded onto the website Data are marked as research-grade and exported to GBIF once verified by experts. Data can also be viewed and downloaded locally from the website. ebird.org
Bumble Bee Watch		✔				✔			A project dedicated to recording bumblebee sightings. Observations are uploaded onto the website and identified by experts. Data are marked as research-grade and exported to GBIF once verified. Data can also be viewed locally on the website. bumblebeewatch.org
i-Tree					✔	✔	✔	✔	A software suite from the USDA Forest Service that provides a variety of tools for forest management, inventories, and health assessments. i-Tree Eco, its flagship software, has been adapted for use in Canada and existing data can be imported into new inventories. itreetools.org

Analytical Tools									
Github							✔		A for-profit development platform to build and host software. Developers use it to manage and store their code, with many researchers using it to analyze datasets. github.com
Jupyter							✔	✔	A non-profit, open-source project containing tools for collaborative programming. Jupyter Notebook and JupyterLab already have many uses, with capabilities to add new modules. jupyter.org
Excel							✔	✔	A spreadsheet software with capabilities to write equations and create simple visualizations. microsoft.com/en-us/microsoft-365/excel
R							✔		A free software mainly used for statistical computing and graphics. Many use it for its ease with creating publication-quality plots and data visuals. r-project.org
Visualization Tools									
QGIS								✔	Open-source and free GIS software run by volunteers. It is used to view and analyze geospatial data and create graphical maps.
Gephi							✔	✔	Open-source and free software to visualize data. It has a variety of analytical tools to display and analyze data patterns. gephi.org
Tableau Public								✔	Free software to create and share data visualizations online. It can connect to multiple data formats, such as Excel, CSV, and Google Sheets. Data visuals can be published to their servers and publicly shared at no cost. public.tableau.com
Databanks for Download: Open Access									

GBIF						✔			An international data infrastructure providing open access to biodiversity data. Data is sourced from many sources and goes through a data standard before being published. Datasets are readily available for download. gbif.org
Data.Sustain Repository						✔			An upcoming data repository supported by the CIRS. Open datasets relating to sustainability, biodiversity, and more will be available when finished. It aims to make data more accessible for UBC students, faculty, and staff. data.sustain.ubc.ca
UBC Sustainability Data Portal						✔			A work-in-progress database powered by CKAN. It plans to provide access to open datasets pertaining to sustainability and biodiversity data. dashboard.sustain.ubc.ca/dataset
Abacus Data Network						✔			A repository containing open and licensed data hosted by UBC Library. Licensed data is available to those with university login credentials. abacus.library.ubc.ca
Opendata Vancouver						✔			A portal to access all of the City of Vancouver's public data. Datasets are available for download in multiple file formats. opendata.vancouver.ca
Databanks by Request: Closed Access									
UBC Botanical Gardens						✔			A collection of ~30000 plants from ~8000 accessions representing 5000 taxa from temperate regions around the world. Data is uploaded to GBIF and can be viewed upon request. botanicalgarden.ubc.ca/research-collections/plant-collections/
Beaty Biodiversity Museum						✔			Over two million specimens are organized into six collections that are available to be viewed upon request. Biodiversity researchers often access collections for access to historical data.

									beatymuseum.ubc.ca/research-2/collections/
E-Fauna BC						✔			An online biogeographic atlas of the wildlife species of BC. Data is collected through citizen science and is used to provide scientifically accurate information about BC taxa. linnet.geog.ubc.ca/biodiversity/efauna/
E-Flora BC						✔			An online biogeographic atlas of the vascular plants, bryophytes, fungi, and lichens of BC. Combines citizen and expert data to provide information about BC flora species. linnet.geog.ubc.ca/biodiversity/eflora/

Generalized Steps to Create a Citizen Science Project

Following the components mentioned above, this is the general process in creating a citizen science project. From forming the research question or goal to sustaining the project long-term, this journey map covers the steps you and your team should take to find success (adapted from Bonney et al., 2009, "Design a Project", n.d.).

1. **Scope a research question/goal**

   Explore the problem/topic at hand, such as its priorities, public interest, and what you want to achieve. In some cases, concerned parties may present an agenda and collaborate with scientists to develop a research project supporting their claims. However, project leaders should still create their own questions and goals they want to address before starting.
   Note: You should also consider the application of citizen science and if your project will benefit from crowdsourcing the data. Unfortunately, not all research topics can benefit from citizen science; it may cause more headaches than good when involving more people.

2. **Design your project**

   Project design is an essential step in creating a citizen science project. Its success, long-term sustainability, and participant attraction and retention depend on the accessibility and ease of your project. Provided are the three main components to consider in your project design.

Types of projects

There are various established project models to consider when designing the framework. Each type will determine the amount of collaboration expected from project participants. Listed below are the five most common project types found in the literature (Bonney et al., 2009; Schaefer & Kieslinger, 2016):

- **Contractual** - The community or individuals approach scientists to investigate a scientific topic and report on the results.
- **Contributory** - Scientists design a project to which citizens primarily contribute data.
- **Collaborative** - Scientists design a project to which citizens primarily contribute data and help with project design, data analysis, and input their findings.
- **Co-created** - Scientists and citizens actively work together in most/all elements of the research processes.
- **Collegial** - Citizens conduct independent research and receive a varying degree of recognition from institutions.

Resources

Curate a list of readily accessible resources and identify those that need to be obtained. Some resources include budget/financial aid, tools and equipment for data collection, associated training materials, and people participating in the project. If a resource is unavailable at UBC, reach out to external organizations or other groups on campus. Potential donors or interested parties may want to participate in citizen science and provide the necessary support. It needs to be emphasized that citizen science requires an investment - particularly time and money - so plan thoroughly.

Methodology and Data Entry

The research question or goal determines the methodology of a citizen science project. For instance, surveying an area for species presence and absence over the span of five years will require long-term monitoring, while a bioblitz only provides a snapshot of identified species in a specific area.

In addition, consider the tools that participants will use to collect data, and its associated training to teach project members appropriate data collection techniques. Proper training is required to provide a fundamental understanding of the project's goals and decrease the variability in data entry. Have a uniform approach and ask for specific formats, alongside examples, when training project members on the tools used.

3. Engage the community

As stated previously, citizen science relies on its participants and input from the community. Therefore, attract participants to your project through collaborations with partner organizations or marketing towards a target audience. For example, engage with one of the many UBC-based student groups centred around biodiversity and sustainability, or reach out to the AMS or faculty undergraduate societies to engage the general student body.

A non-exhaustive list of student groups, UBC departments, and external organizations with initiatives in biodiversity and sustainability are visualized in this Kumu map: Potential Citizen Science Peoples Network. This list is not representative of every group related to UBC with sustainability goals. However, the ones listed were chosen as potentially key players in citizen science at UBC because of their goals and initiatives.

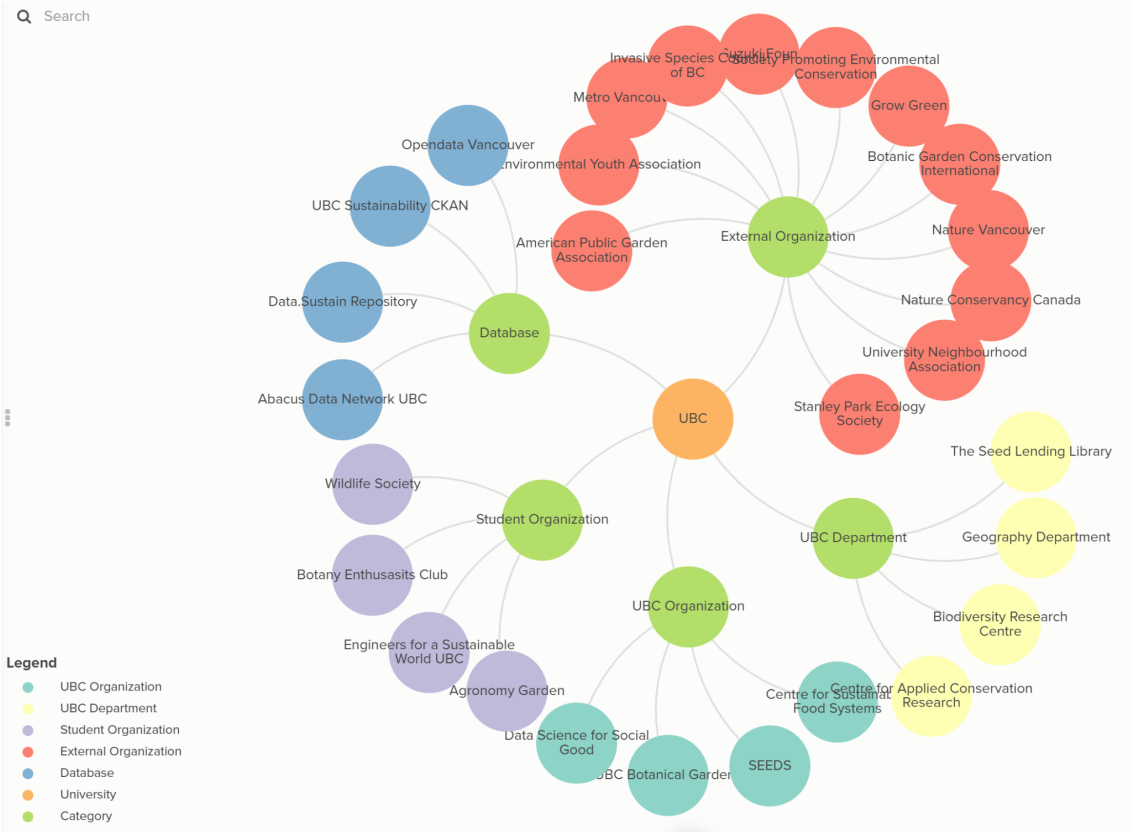

Image 1. Potential Citizen Science Peoples Network Kumu Map. Depicted are organizations within and externally from UBC with initiatives that have potential for citizen science collaboration. Orange circle represents UBC and green circles represent different categories to which the other colour circles belong.

4. **Manage and analyze your data**

Since citizen science has the ability to generate large datasets, managing and analyzing data can become a tedious task, especially for small research teams. The tool(s) used and the methodology determined during project design will also influence how data can be accessed and managed. For example, tools such as iNaturalist or GBIF already have research-grade datasets that have been verified by experts and can be downloaded from their database for analysis. On the other hand, special tools designed for a specific project may require its data to be validated by experts. Account for errors and try to estimate variance when participants enter their observations.

Also, consider providing an opportunity for participants to contribute to data analysis if they are interested. Although data privacy and ownership can be topics of concern in citizen science, create open datasets if there is unanimous agreement by the project team beforehand to mitigate these issues.

5. **Sustain and improve your project based on feedback**

As stated previously, communication with project members improves engagement and the project's likelihood of success. People are more likely to continue with a citizen science program if there are ongoing interactions between the scientists and project participants. It showcases the researcher's dedication and commitment towards the project's goals, motivating people to uphold their responsibilities as citizen scientists. Goad et al. (2020) suggest some ways to engage members to sustain and improve a project.

Participant Retention

- **Provide feedback and regular updates of the data collection to participants.** Illustrating the impact people have had on the project can empower them to continue with their work.
- **Hold socials/recognize top contributors with rewards or recognition.** Demonstrating a role model may encourage others to match or exceed their efforts. However, be sensitive to the language being used as some participants may not have the time or resources to contribute as much as others, leading to feelings of discouragement.

Attracting new participants

- **Showcase the impact participants have had on the project through data visuals.** People who are hesitant to join a citizen science program may be drawn to it once they see some success achieved by project members.
- **Hold workshops and presentations at conferences to engage new audiences.** Presenting the project's research and progress at networking events will increase its reach and potentially attract new participants. Some annual conferences at

UBC include the Student Leadership Conference[1], Multidisciplinary Undergraduate Research Conference[2], and Life Sciences Research Night[3].

- **Provide incentives and educational opportunities for participants.** Many who voluntarily join citizen science projects will look to gain experience in scientific research or knowledge about the research area. Some audiences (i.e. classes, faculty members) may require tangible incentives to appeal to them, which can come in the form of grades, recognition in a published paper, or monetary value.

Project improvements

- **Be adaptive and flexible when addressing project design issues.** Technical difficulties may arise with participants and the project design may need to be adjusted to accommodate design oversights. Common issues usually arise during data entry due to technological inadequacies. Always have an alternative option for participants to submit their observations and record any design flaws for future improvements.
- **Ask for feedback and project improvements.** Ask project members for feedback about the project and suggestions for future improvements. Have effective and timely communication with your participants to showcase your dedication.

Notes by UBC audience groups

Drawing from the generalized steps, this section includes some extra steps and tips to consider for different audiences at UBC. These suggestions are aimed to encourage the development of "creative space where grassroots initiatives can flourish side-by-side with more established forms of scientific knowledge production and a platform where the community can meet and exchange ideas" (Schaefer & Kieslinger, 2016).

Special considerations for student clubs

One of the major difficulties for student clubs and organizations is outreach and funding. Unbeknownst to many, there is already a large network of biodiversity and sustainability groups present on the UBC campus and Metro Vancouver area that would be willing to partner with UBC student clubs. Regarding this, here are some tips to consider during project design:

- Reach out to NGOs and non-profit organizations with similar goals and objectives. Some of these groups have networks and stakeholders who are willing to contribute some of their resources to student initiatives as it is part of their target objective to engage with students.

[1] https://students.ubc.ca/slc/student-leadership-conference
[2] https://students.ubc.ca/career/events-workshops/multidisciplinary-undergraduate-research-conference
[3] https://www.uroubc.com/lsrn/

- Contact representatives from Metro Vancouver, the UNA, or the UBC faculty. They have an established network of experts and projects with which they can connect. Engagement and outreach to organizations outside UBC can be difficult without a representative as many collaborations are started through word-of-mouth and require a vouch.

Special considerations for classes

Running a citizen science project in classes can be a fantastic way to engage and teach students about scientific methods and collaboration skills. Post-secondary students generally have a deeper understanding of specific topics and methods, so including more nuanced steps in the project design should not hinder the project's flow. This unlocks the possibility of using tools or methods requiring more training, as there is generally more trust placed in students because of their increased scientific literacy. Moreover, professors can foster an applied learning environment as it is possible to assign project tasks to students while concurrently teaching related class material. For example, a statistics class can analyze data collected in a citizen science project while also teaching students the proper equations and statistical analyses to use. Another example is engaging a Forestry class in a campus-wide tree inventory. Utilize student participation to measure and count trees on campus while teaching them the different strategies used to identify tree species.

When considering a citizen science project for classes, subdivide the project steps amongst the participants or in time intervals. Either some classes or students can collect the data, and others analyze it, or the project steps can be arranged into phases that span across multiple school terms. For instance, a long-term species monitoring program on campus may include some ecology classes observing a specified area on a rotating basis, while a biostatistics class analyzes the data generated through a class project.

It needs to be noted that students generally have personal growth interests and look for benefits that are more career-orientated when looking to participate in citizen science []. Although there are many benefits associated with incorporating citizen science in classes, incentivizing students to participate by offering extra marks for their participation or making it a part of their curriculum can enhance the effort they put in. Many classes in the UBC Psychology department offer bonus grades to their students if they contribute a certain number of hours to psychology studies. This concept can be applied universally to incentivize students to participate in citizen science.

Special considerations for faculty/departments

As a faculty member or researcher, you will be representative of UBC and its strategic plans. Many organizations in Metro Vancouver and the lower mainland have extensive networks working on biodiversity and sustainability initiatives. Many want to involve themselves with a world-renowned institution such as UBC, so be proactive when attracting new participants to citizen science projects.

Also, consider engaging other faculties/departments when creating a project team. Citizen science has the potential to facilitate an inclusive environment that promotes diversity and interdisciplinary knowledge. Experts from different faculties may have similar goals and would be willing to collaborate on a project.

UBC Context and Opportunities for Scaling up Citizen Science Recommendations for UBC

The increase of accessibility to science and engaging people to take action on climate research are a few of the driving assets behind citizen science. Creating an infrastructure that promotes opportunities for the UBC community will advance initiatives set out by UBC groups. The suggested opportunities below are made based on a gap analysis of current UBC systems and examples from other institutions worldwide. These recommendations have been divided into three sections: general, faculty, staff, & students, and classes.

General

- **Baseline the biodiversity** of the UBC campus and create an easily accessible biodiversity atlas to display the information of these spaces.

  To identify the gaps in our knowledge for future research opportunities, we need to baseline the biodiversity on the campus. Although there are many datasets already available that contribute to this initiative, they are scattered in various locations, making it difficult for researchers to collate the data. Moreover, it is next to impossible to identify missing data and continue advancing sustainability initiatives if we do not have a general sense of the existing biodiversity on campus.

  Similar to the city of Barcelona's Biodiversity Atlas[4] and the United Nations' FAOSTAT database[5], UBC needs to have a continually updated atlas or open database that visualizes the biodiversity on campus. This allows for any interested parties to analyze the data, or the lack thereof, to come up with new research opportunities. Datasets can start to be drawn from upcoming UBC databases, such as Data.Sustain and the UBC Sustainability Repository.

- **Map the network** of people and organizations on campus working on biodiversity and sustainability initiatives on campus and in Metro Vancouver.

  Identifying those working on biodiversity and climate initiatives can help create opportunities for collaboration between faculty, staff, and student organizations on campus. A component in finding project stakeholders and participants in a citizen science project is knowing the extent of the network that already exists within the community.

[4] https://ajuntament.barcelona.cat/ecologiaurbana/en/barcelona-biodiversity-atlas

[5] http://www.fao.org/faostat/en/

The Kumu map shown above is a starting point towards visualizing the number of people and organizations related to UBC working on biodiversity and climate initiatives. This should be expanded to include individuals and other organizations not represented.

- Develop a **public forum** of all current and previous biodiversity and sustainability projects hosted by UBC faculty and students.

  Taking reference from Austria's Österreich Forscht, UBC needs a dedicated platform listing all the biodiversity and sustainability projects currently being worked on. This eliminates the need to search through hundreds of web pages to get a sense of the projects and initiatives held by the UBC community. Instead, an accessible online portal for UBC members will contain information about ongoing biodiversity and climate work, allowing people to reach out to and potentially join projects of their interests. This will include research that may not involve citizen science in the project design, as others may find the potential to explore it in future research questions.

- Host **workshops and conferences** about ongoing citizen science initiatives.

  Taking inspiration from URO's Environmental Science and Sustainability Research Night, UBC needs to hold more workshops and conferences promoting citizen science projects hosted by UBC faculty, staff, and students. This will increase engagement between student groups with UBC faculty and staff in hopes to connect them to advance each others' goals. This can be furthered by extending invitations to external organizations that may want to promote their line of work in biodiversity and climate fields and connect with UBC partners.

- Host a **free, accessible, and centralized database** that stores all datasets collected by UBC-run projects

  Although there are a few emerging databases created by Data.Sustain and UBC Sustainability that aim to provide open access to data, more support needs to be provided to expand their scope of work. These repositories have the potential to remove the barriers that deter people from engaging in science, such as organizing data into a centralized location and removing paid walls to access datasets. Having open data that is readily accessible to the public encourages people to explore topics of interest and make informed actions based on sound science.

Faculty, Staff, and Student Groups

- **Develop a program or incentives** for researchers to participate in citizen science programs and become experts in different citizen science tools.

  Tools such as iNaturalist require experts to verify data entries to become research-grade. UBC lacks people on these platforms that can do such, leading to backlogged data in the verification step. In turn, this leads to delays in data analysis if the

project design requires only research-grade data. To address this issue, provide incentives such as community hours towards tenure or friendly competitions between departments that can encourage faculty and staff to participate in citizen science projects. In addition, many tools require a minimum number of entries on the platform to be verified as an expert. By increasing researchers' engagement with these tools, the number of UBC experts will increase that can help identify data entries to become research-grade.

- Provide **funding or other resources** (i.e. space, supplies, etc.) **for student clubs and groups** with biodiversity or sustainability initiatives.

  Student engagement through AMS clubs is a great way to introduce citizen science projects to the student body and involve them in climate and biodiversity initiatives. Although these groups often lack the network necessary to reach a larger audience, their engagement with other students fosters a more profound connection because of similarities in priorities as post-secondary students.

  UBC faculty and staff should be willing to provide aid and resources to assist student groups with their initiatives, such as a location to host an event or experts for speaking at a workshop. Moreover, reach out to students and provide opportunities to partake in project team positions if initiatives align between the two parties. Undergraduate and graduate students can gain a lot of experience if they help coordinate a citizen science project and engage other students.

Classes

- **Develop programs and projects for classes** (e.g. Forestry - UFOR 220, UFOR 401; Biology - BIOL 314, BIOL 324).

  Many classes at UBC can benefit from incorporating citizen science projects into their curriculum. Not only will researchers have a knowledgeable audience willing to participate, but students can also benefit from participating in scientific research and apply the knowledge learned in their courses. This, in turn, provides more opportunities for applied learning experiences and increases student engagement with science.

  Furthermore, students generally have a deeper understanding of the research area being studied if the topic aligns with their curriculum. This allows for a more detailed project design that may require elevated training. For example, student participants may utilize complex instruments to record specific data that may confuse those who are not well-versed in science.

UBC Policy/Goals Alignment

Climate Emergency Task Force (CETF)

Since the declaration of the climate emergency in December of 2019, the CETF identified in their report[6] "nine priority areas that span community, academic (teaching, learning and research), and operational dimensions" (2019) that need to be prioritized in initiatives underway at UBC. Some of these areas highlight the need to support climate research at UBC, expand climate education, and foster an environment of engagement on climate action. These recommendations can be integrated within existing UBC plans and initiatives by incorporating citizen science into the classroom and on campus. People who participate in scientific research are motivated to take action on environmental issues and will inadvertently learn in-depth about the science driving climate change.

Social Ecological Economic Development Studies and Climate Crisis in Urban Biodiversity (SEEDS & CCUB)

The SEEDS Sustainability Program has connected students with faculty and staff to advance sustainability initiatives since its conception in 2000. In the Fall of 2019, SEEDS launched CCUB, an initiative geared towards creating student-led research opportunities to tackle the climate and biodiversity crises. Both utilize similar ideas of combining students' enthusiasm with faculty members' research expertise and staff members' knowledge of the campus to impact sustainability efforts through collaborative projects.

Including citizen science for campus initiatives - primarily through classes - addresses these goals set out by SEEDS and CCUB. Participation in scientific research will be more accessible, especially for underrepresented students who lack access to applied research opportunities. Furthermore, citizen science can enhance a student's learning by providing applied learning opportunities through a project. Observing or analyzing data allows students to employ the knowledge gained from their classes and connect them with real scenarios. There also lies the opportunities to engage disciplines in the climate and biodiversity crises. Finally, citizen science breaks down the barrier of entry to participate in research by subdividing the scientific method into manageable steps for the inexperienced.

Campus Urban Biodiversity Strategic (CUBS) Plan

Created by the Campus Biodiversity Initiative: Research and Demonstration (CBIRD), the CUBS Plan serves as a set of goals to guide the CIBRD committee. Its second and third goals are most notable: engaging students to co-develop biodiversity solutions and increasing public awareness and knowledge. Steps towards these goals can be achieved through citizen science on campus as it increases public engagement with all aspects of science. One of its main benefits is

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6 http://bm-climate-emergency-2020.sites.olt.ubc.ca/files/2021/02/4_2021.02_Climate-Emergency-Engagement.pdf

the democratization of knowledge production amongst its participants, providing impactful learning opportunities and disseminating science from researchers to their surrounding communities.

Examples of Citizen Science at UBC

The following are a few examples of citizen science projects taken place on the UBC Vancouver Campus or in collaboration with UBC faculty and staff.

Butterflyway Project[7]

The David Suzuki Foundation's Butterflyway project was launched in 2017, engaging residents in five cities across Canada to become Butterflyway Rangers and to plant gardens of native wildflowers that attract pollinators. However, in December of 2020, the foundation approached UBC researchers Dr. Michelle Tseng and Tara Moreau of UBC Botanical Garden to join the project as scientists to answer the question: Do Butterflyway patches increase the population of native butterfly species? As a result, the project in BC was transformed into an ongoing citizen science program over the course of 2021 and a project team of scientists, volunteers, and students were established.

The project design included participants walking transects that span neighbourhoods across the Lower Mainland and engaging schools to partake in a two-week bioblitz. In its first year, it has engaged over 1000 people, and citizen science has been adopted as one of the three streams of focus in the David Suzuki Foundation. The significant progress that has been made in just eight months was because of the collaborative effort between UBC faculty and staff and the volunteers on the project team.

eBird ID[8]

Avid birders frequent the UBC campus and UBC Botanical Gardens to observe and take pictures of birds, which in turn is uploaded to eBird. In addition, many routinely wake up early in the morning to look for and identify birds out of their interest, which they then voluntarily upload. Although they are not directly working with researchers on a citizen science project, their observations have contributed to scientific research that has analyzed eBird data.

Broader Data Science for Citizen Science[9]

Using data gathered by citizen science, three students took part in the UBC Data Science for Social Good program. They developed a prototype web tool that visualizes the biodiversity

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[7] https://davidsuzuki.org/take-action/act-locally/butterflyway/

[8] https://ebird.org/canada/hotspot/L367520

[9] https://focus.science.ubc.ca/visualizing-vancouvers-biodiversity-127ca0bb9a45

found in different parts of Metro Vancouver. It was intended to help urban planners make more ecologically sound decisions and identify the gaps in the data for researchers. As of now, the prototype tool is being refined by a dedicated team at Metro Vancouver for it to reach its full potential.

Conclusion

This report aims to highlight the role of citizen science as a way to mobilize action in response to the climate emergency and the ongoing biodiversity crisis. As a leading institution in biodiversity and climate research, UBC is in a key position to make substantial progress in advancing sustainability commitments and addressing societal issues of growing concern. However, there needs to be a collective effort if we are to solve these problems of climate change. Only by increasing the accessibility to scientific research will the public be able to take necessary actions to tackle these critical issues.

Citizen science bridges the gap between scientists and their community, connecting and empowering those motivated by curiosity to advance research and make a difference in their immediate environments. UBC is filled with many passionate people willing to involve themselves in scientific and research matters, allowing citizen science to be a powerful tool in academia. Researchers can investigate a question more deeply on a larger scale by engaging the public, democratizing knowledge production and disseminating findings to the public. On the other hand, participants can directly involve themselves in research, gaining a greater say in and commitment to these global issues.

The framework outlined here is a starting point for UBC faculty and staff to consider including citizen science into campus initiatives. Mobilizing resources and adjusting policies to incorporate these components will take time and effort but will have many benefits in return. Collaboration is the foundation of citizen science and will be the only way UBC can tackle climate change and biodiversity loss.

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