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Challenges and solutions to establishing and sustaining citizen science projects in South Africa

Citizen science is a term for research that engages non-scientists in the collection and generation of data. Many citizen science projects exist within South Africa and, because of their success, we expect more projects will be initiated. In this Commentary, we discuss three projects based in, but not confined to, the Western Cape Province to provide context for their methods, specific objectives and overall desired impacts. We then identify a few challenges that we have faced from the researcher perspective and we provide recommendations for those interested in initiating a citizen science project in South Africa.

Many projects involve citizen scientists because their participation enhances the breadth of the research through the collection of data over greater spatio-temporal scales.¹⁻³ However, not all projects in South Africa have purely research objectives, some are education-oriented with the specific objective of empowering the participants. In some cases, the educational objectives may be motivated by the desire to engage local communities or by the understanding of ubuntu wisdom. Citizen science is therefore a powerful approach to address multiple objectives, but there are many challenges to achieving the desired outcomes. We outline these challenges below within the context of an education-oriented project, a research-oriented project and a project that combines the two objectives.

limbovane Outreach Project

The limbovane Outreach Project (<http://www0.sun.ac.za/limbovane>) is a science education project based in the DST-NRF Centre of Excellence for Invasion Biology at Stellenbosch University. The word 'limbovane', meaning 'ants' in isiXhosa, represents the project's engagement of learners in the collection and identification of ants.⁴ The project is primarily education-oriented now, but it has led to advances in knowledge about ant diversity throughout the region since it was initiated in 2005.⁴ limbovane supports Grade-10 Life Sciences teachers and students by enhancing educational outcomes through stimulating workshops and activities that provide resources and hands-on learning about the theoretical biodiversity concepts covered in the Life Sciences curriculum. Learners are exposed to the various stages of the scientific method and gain practical experience conducting biodiversity studies, all while advancing knowledge about the diversity of ants in South Africa. limbovane is the longest running citizen science project that specifically engages youth in South Africa. In this time, limbovane has empowered thousands of learners to understand and value the biodiversity of the Western Cape Province.

rePhotoSA

rePhotoSA (<http://rephotosa.adu.org.za>) is the repeat photography project of southern African landscapes. It is a joint project between the Plant Conservation Unit and the Animal Demography Unit at the University of Cape Town. In contrast to limbovane, this project is mainly research-oriented. rePhotoSA is founded on one of the largest historical landscape photograph collections in Africa, which currently consists of over 20 000 images.⁵ Approximately 6000 photographs have been uploaded to an interactive map available online. Citizen scientists can search for and download historical images to find the exact location from where the original photograph was taken. The primary objective is to enhance the understanding of landscape change over time.⁵ Ground-based repeat photography has a long history in documenting landscape change and has been used in many research projects to better understand: (1) the drivers of vegetation change in the Karoo^{6,7}, (2) population changes in plant species, such as the endangered Clanwilliam Cedar⁸ and the quiver tree⁹, and (3) human impacts on the environment. Contributions to rePhotoSA therefore provide a valuable resource for research and provide a platform to monitor long-term vegetation change into the future.

Cape Citizen Science

Cape Citizen Science (<http://citsci.co.za>) is a programme co-hosted by the University of Pretoria and Stellenbosch University. The programme receives support from the DST-NRF Centre of Excellence in Tree Health Biotechnology and the Forestry and Agricultural Biotechnology Institute. Cape Citizen Science invites citizens (including school groups) to participate through many methods spanning the gradient of education to pure research. Some citizens have learned through workshops and educational hikes, and others have contributed to advancing knowledge by submitting physical samples or reporting unhealthy plants through online tools.¹⁰ Cape Citizen Science has demonstrated that research projects can provide opportunities for informal education¹¹ and that citizens can contribute to advancing scientific discovery in South Africa.

Project summary

Together, these initiatives represent some of the diversity of citizen science projects based in southern Africa. Each project has its own objectives and target groups for participation, but they overlap in the overall motivation to engage the public. Each project serves its own niche in the interface between the public and scientists because of the diversity of communities and the availability of resources in South Africa. For these reasons, we suggest that there is great opportunity to establish and sustain citizen science projects in South Africa, but we caution prospective project practitioners to be aware of ongoing projects to avoid duplication. The mixture of available resources and communities provides great opportunities for collaboration on projects, and for the sharing of tools and resources. We therefore encourage support for a network of projects to nurture a dialogue between project leaders. We anticipate that fostering stronger connections between projects will enhance the quality and breadth of opportunities to empower more people to make observations and critical decisions.

Challenges and solutions

The purpose of this Commentary is to identify some of the challenges and potential solutions that we have experienced in South Africa in initiating and maintaining a citizen science project. We outline some of the challenges we have faced below by first reviewing available literature and then providing context within the projects discussed above. Understanding these challenges will prepare future project leaders to overcome barriers and enable their projects to better contribute to advancing knowledge and positively influencing society.

Experimental design

Incorporating effective experimental design can be a major challenge for many citizen science projects. Careful design is critical for collecting adequate sample sizes without fragmentation or sampling bias.¹² One approach to alleviating this challenge is to incorporate a design that targets specific areas for sampling.¹³ This design was incorporated in the 'Go Outside for Science' phase of Cape Citizen Science. Participants were asked to physically collect samples in randomly selected sampling locations to avoid sampling bias and ensure strong coverage throughout the region. However, this phase could only be promoted to groups with permission to collect samples in protected areas because South Africa has many protected species. Therefore, the strict sampling permission requirements presented a challenge to the implementation of the experimental design. Cape Citizen Science was able to overcome this challenge by engaging professional staff (e.g. nature reserve managers) in the research.

Data quality

Data quality is central to the immediate and long-term success of any citizen science venture. While volunteer participation can create possibilities for otherwise cost-prohibitive projects, careful attention is needed to ensure the data collected by volunteers are high quality.¹⁴ This challenge can be overcome by providing training for participants¹⁵ and implementing methods of quality assurance or using tools that are monitored by the greater community such as inaturalist.org.¹⁶ Future projects will also need to include efforts towards overcoming data quality skepticism in the greater science community.¹⁷ Training of participants and implementation of targeted sampling designs in combination can result in extensive and useful data sets that will help generate support for future projects.¹³ We expect that more support for citizen science projects will become available if it can be demonstrated that the data collected by citizens are valuable and high quality.

Data quality is particularly important for rePhotoSA. For example, photographs need to be taken in the exact same location in order to overlay the images and quantify landscape changes, such as the health of individual trees.⁸ To overcome this challenge, rePhotoSA produced a thorough set of instructions for taking repeat photographs. The project team is also currently developing complementary online video tutorials and intends to expand their public engagement to demonstrate how to capture research-grade repeat photographs in the field. Together these resources are examples of methods that can be incorporated into any project to improve data quality.

Project management and sustainability

Another major challenge in South Africa, which may be similar elsewhere, is that many of the citizen science projects are championed by postgraduate students, postdocs, or outreach coordinators who have fixed-term appointments or limited availability. This challenge emphasises the importance of managing expectations and deciding on the appropriate lifetime for a project. For example, Cape Citizen Science was established to facilitate research for one student's project, but has now grown into an umbrella programme for other projects because of shifts in the scientific capacity, the depletion of project funds, or simply because the research was completed for those projects. While only one PhD student is needed to start a citizen science programme, many are needed to keep the programme running. We therefore recommend that the ideal lifetime of future projects be identified early on in the project planning process. The apparent expiration may even motivate participation. An alternative

solution, employed by limbovane, is to hire a project coordinator who is solely dedicated to the project. Such a coordinator can relieve pressure on the researcher and dedicate efforts to sustaining the project over the long term. While this capacity may not be financially feasible for most projects initially, it is an approach that would help overcome the challenge of sustaining projects or programmes.

Financial support

Limited funding challenges most research in South Africa. However, this challenge has different implications for citizen science programmes. Establishing a citizen science programme may not require a large investment, but the merit of establishing a programme depends on the availability of sustained funding. For example, one-time small grants from the Table Mountain Fund and the Faculty of Agrisciences at Stellenbosch University have both contributed to citizen science projects in the Western Cape Province, but a different funding structure is needed if the projects are to evolve into sustained programmes that host multiple projects. Most financial support for research is project based; however, establishing a citizen science programme to facilitate a single research project may not be worthwhile unless it is sustained across multiple projects. An ideal funding structure in South Africa would involve longer-term (3–5 years) support for a single laboratory to initiate and sustain a programme that could incorporate multiple short-term projects.

Specific costs of each project vary, but the biggest expenses of the projects mentioned above are the salaries of project coordinators (or bursaries for students) and travel (e.g. transporting youth to nature reserves). Some other costs are hosting and maintaining data sets on servers, sequencing microbial cultures, general laboratory supplies and outreach materials. For example, the limbovane Outreach Project budgets a large amount toward materials such as workbooks, ant identification keys and promotional resources. Similarly, Cape Citizen Science tries to provide awards (e.g. plant identification field guides, biodiversity posters and dissection kits) to youths who successfully answer questions after presentations in outreach activities. In general, the costs of these materials and activities are easy to underestimate.

While securing financial support for research may be difficult in general, citizen science programmes may be able to adopt creative approaches to overcome the challenge. For example, Cape Citizen Science has received public support through two crowdfunding campaigns (*Discovering Plant Destroyers in South Africa* and *Engage Kayamandi Youth in Cape Citizen Science with Vision Afrika*) and other projects have generated support as beneficiaries of 'MySchool MyVillage MyPlanet' or through corporate sponsorship. However, even if public or private support is a feasible funding mechanism, connecting with philanthropists in these situations can be challenging. One solution may be to collectively identify the citizen science projects that are present in South Africa and to create a repository of projects open to support from philanthropists. Such a repository could be maintained by a government agency or third party (similar to 'MySchool MyVillage MyPlanet'), but eligibility would need to include small and short-term projects without marketing campaigns or the required designation as a non-profit organisation (NPO).

Project guidance

Alternatively, even if funding is available, some researchers may be uncertain how to use it to achieve educational outcomes. Because citizen science is relatively new in South Africa, universities do not have capacity to guide researchers into the interface between their research programmes and the greater public. A financial incentive (e.g. internal grants) may be the top-down approach to enhancing societal impact, but additional training and guidance is critical for economic efficiency. Enhancing the network between projects, showcasing projects at broader scales, or offering workshops to other faculties interested in initiating projects would increase efficiency. In the meantime, we encourage those in this position to join the online group at <https://groups.io/g/CitSciSA> to seek guidance.

Attracting and maintaining citizen scientists

The number of registrants or people who express interest in participating in citizen science projects may far exceed the number of actively participating

members. This phenomenon has been described within the social sciences through the theory of planned behaviour: simply, a gap often exists between intention and behaviour.¹⁸ Citizens may intend to participate but there are barriers to the behavioural expression of this intention. Some of the attitudinal barriers we have identified, particularly with rePhotoSA, are impatience or confusion with the technicality of taking and uploading a repeat photograph, ambivalence or indifference as a result of a lack of knowledge of the application of repeat photography, or loss of interest because of an insufficient number of historical images in the participant's area of interest. Citizen scientists who initially struggle to participate in a project are unlikely to try again in the future.¹ This challenge underscores how critical it is to tailor an experience that firstly captures the interest of a potential citizen scientist and then creates a participatory environment that is both intuitive and rewarding.

One approach to recruiting potential participants who may have barriers to getting involved, is to use social media platforms to raise awareness. This approach has been implemented in many citizen science projects where emerging technologies have characterised a new avenue of public engagement.¹⁹ rePhotoSA has observed the advantages of social media in cultivating support from the public, equipping citizens with knowledge of repeat photography protocols, validating citizen repeat photographs, and disseminating the results of scientific studies using repeat photography. Therefore, implementing similar strategies with emerging technologies (such as social media campaigns) should not be overlooked in future projects because it can help overcome challenges in building communities and sharing resources.

Project redundancy

Many citizen science projects can coexist in South Africa without overlap because of the diversity and abundance of communities. For example, Cape Citizen Science and limbovane coexist in the same university and target the same age groups, but work with different communities. Cape Citizen Science has established partnerships with many NPOs and limbovane works directly with schools and schoolteachers. While both projects strive to provide meaningful engagement opportunities for similar age groups, there are many different communities and groups of learners with which to engage.¹¹

Conversely, the diversity of communities can also present opportunities for redundancy. For example, there are at least three online tools which citizens can use to report observations of biodiversity.¹⁰ Each of these tools has their own community of participants who may be unaware of the other communities or tools. This might be a consequence of recently emerging technologies and we may see a merger of communities as one tool becomes more popular. However, it is important for projects to take note of and consider using existing tools and platforms rather than creating new ones in the future. In some cases, it may even be feasible to extend an existing tool or project into new communities. Similarly, it is also critical that projects which exist in similar spaces communicate and work together to avoid redundancy and provide diverse opportunities to communities.

Socioeconomic context

The socioeconomic diversity in South Africa provides great opportunity for citizen science projects to coexist and serve separate niches in society, but it can also be a challenge for projects to accommodate multiple groups. For example, projects such as rePhotoSA require access to equipment that can be a barrier to participation for some groups. As an online repeat photography project, citizen scientists need access to a stable Internet connection and at least a smartphone, if not a digital camera and tripod. While an online database may increase accessibility to the project for many,¹ it may also, together with the type of equipment required, actively exclude others. The unique requirement for high-resolution images (≥ 3 Mb) to be uploaded in this project provides a significant constraint for many participants, even those with Internet connections, as these connections can be slow and unstable, especially in rural southern Africa. Despite the limitations, the online format for disseminating historical photographs and receiving repeats is the most efficient at present, but alternatives have been provided on a case-by-case basis. The smartphone may form a potential avenue for data collection in the future and the development of a 'gamified'

repeat photography application is being considered. This development may provide more opportunities for participation by opening the project up to citizens without access to expensive camera equipment or computers and increase participation with entertainment.

Conclusion

The objective of this Commentary was to highlight some challenges we have faced as practitioners of citizen science projects in South Africa. We recognise that additional challenges likely exist for citizen engagement outside of the researcher perspective (e.g. the educator perspective), but we suggest that addressing the challenges herein will promote the sustainability of future citizen science projects. Prospective project leaders are encouraged to subscribe to the online group to join a network of projects in South Africa. Although we have identified many challenges, we believe there is ample opportunity to initiate citizen science programmes in South Africa. Cumulatively, our projects demonstrate that the citizen science approach can be applied to achieve many objectives, even simultaneously, across many communities. Although each project serves a distinct niche in society and the research institutes, there are still many communities in which opportunities for engagement from local universities or research agencies do not exist. We therefore encourage increased support for the establishment and sustainability of citizen science projects. Such support would provide more South Africans with opportunities for informal education and enhanced citizenship.

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