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Citizen science in South Africa: Rhetoric and reality

Peter Weingart
University of Bielefeld, Germany

Corlia Meyer
Stellenbosch University, South Africa

Abstract

Citizen science, and *public engagement with science*, has become prominent in science policy programmes. Given the expectations attached to citizen science in academic and science policy discourses, it is worthwhile to look at where the actual work is done. The case of South Africa, the study focus, is interesting because the country follows similar programmes as many developed countries, but has a socioeconomically and educationally more unequal society. Thus, South Africa presented a test example of whether the institutional similarities of science or socioeconomic and educational differences prevail in shaping the reality of citizen science. Results from 56 projects showed that nearly all of them were limited to data collection in life science fields and were managed largely by one university and mainly communicated within the respective science communities. This led us to conclude that the ambitious rhetoric accompanying citizen science in science policy programmes is not matched by reality.

Keywords

citizen science, participation, public, research, South Africa

1. Introduction

Science policies around the world encourage science communication and engagement to increase the societal value of science (Brouwer and Hessels, 2019). These efforts of *public engagement with science* can come in the form of *citizen science* described as 'the most dramatic development in science communication in the last generation' (Lewenstein, 2016: 1). The term, first coined by Irwin (1995), has become increasingly popular in the media and science policy discourses (Kennedy, 2016; Strasser and et al., 2019). Early use of the term reflected on the relationship between science and citizens as responding to citizens' concerns and needs and on engaging

Corresponding author:
Corlia Meyer, DST-NRF SARChi in Science Communication, Centre for Research on Evaluation, Science and Technology, Stellenbosch University, RW Wilcocks Building, 52 Ryneveld Street, Stellenbosch 7600 South Africa.
Email: corliameyer@gmail.com

untrained or 'non-expert' citizens in the process and understanding of science (Bonney and et al., 2009; Davies and et al., 2016; Irwin, 1995; Riesch and Potter, 2014).

There has been a surge in usage of the term *citizen science* both in scholarly literature (Silvertown, 2009; Van Brussel and Huyse, 2019) as well as in science policy documents, and it has increasingly gained legitimacy (Storksdieck and et al., 2016; Van Brussel and Huyse, 2019). To assess the dynamics of the rhetoric propagating citizen science, it helps to keep the genealogy of a distinction in mind: the history of science is one of differentiation of scientific practice and language from society. Over the course of the nineteenth century, the role of the scientist became professionalised and distinguished from the amateur (Weingart, 2010). The term *citizen science* implies that this differentiation should be reversed. Yet, the further functional differentiation has progressed and the more specialised science has become, the more unrealistic is the inclusion of amateurs into research. There are differences of specialisation between disciplines as well as in the objectives attributed to citizen science, which allow for different degrees of participation of amateurs. When the term was coined, it was supposed to mean the participation of citizens in science policy decisions (Irwin, 1995). Subsequently, the meaning of the term was broadened to mean citizens' participation in scientific research (Bonney, 1996). As such, the meaning was usurped by the science policy discourse and connected to innovation (Chilvers and Kearnes, 2020), while the science and technology studies (STS) discourse invested more audacious hopes of a democratisation of science (Kullenberg and Kasperowski, 2016).

Given the fact that science is the most specialised, self-referential social system – which does not appear, at first sight, to be accessible to the participation of the general public – the alternative outcome is that the expectations raised by lofty rhetoric are disappointed (Kennedy, 2016). With this we join in the growing interest within the social sciences in analysing the citizen science rhetoric more thoroughly than has hitherto been done (Riesch and Potter, 2014; Storksdieck and et al., 2016). We limit the analysis to South Africa, which is a special case worth investigating. Its science policy programmes follow those of developed countries and propagate citizen science in similar ways. On the other hand, the country is educationally and socioeconomically more unequal than developed countries. Hence, the question is whether these conditions affect the reality of citizen science.

2. Literature review

An increasing number of publications discussing the values, potential and possibilities of *citizen science* indicate the wider acceptance of this form of research (Brouwer and Hessels, 2019; Lukyanenko et al., 2016). Past literature has concentrated on public engagement of science through citizen science (Aceves-Bueno et al., 2015; Brouwer and Hessels, 2019; Storksdieck and et al., 2016), democratising science (Irwin, 1995; Strasser and Hacklay, 2018) through participating in citizen science projects, the learning outcomes of citizen science projects (Aceves-Bueno et al., 2015; Lewandowski and et al., 2017; Resnik et al., 2015) and science policy outcomes of citizen science projects (Nascimento et al., 2018; Strasser and Hacklay, 2018).

Additional research also specifically pertains to the benefits citizen science provides to *both* researchers and citizens: from enlisting the help of participants that enables researchers to easily collect data at large spatial and temporal scales (Hulbert et al., 2019; Lewenstein, 2016; Resnik et al., 2015; Rotman and et al., 2012; Theobald and et al., 2015) to innovation through the exchange of ideas and information, and ultimately advancing scientific knowledge (Silvertown, 2009).

Strasser and Hacklay (2018) explain four key concepts of citizen science:

1. Citizen science is a kind of scientific practice that involves the public, non-experts or non-professionals;
2. The members of the public are producing knowledge through research or inquiry;
3. The knowledge that is being produced through citizen science is scientific in nature; and
4. Citizen science should promote social justice, and not just be done purely for the interest of science.

Models of citizen science

Several authors reflect on citizen science and attempt to systematise different formats into several models and typologies (for a detailed description, see Table 1). As these attempts are based on the analysis of a large number of citizen science projects, they may be taken to be interpretive frameworks for the analysis of the projects in South Africa.

Bonney et al. (2009) and Shirk et al. (2012) split citizen science projects into three categories based on the *level of collaboration* between scientists and citizens. This view was more recently shared by Schrögel and Kolleck (2019). Dickinson and Bonney (2012: 6) describe citizen science projects as varying along four major axes: (1) who initiated the project, (2) the scale of the project, (3) type of questions asked, and (4) project goals. Wilderman et al.'s (2004) distinction of three models for *community engagement science* is based on an increasing degree of community participation. Another classification is based on the *outcomes* of the citizen science project (Alender, 2016; Wiggins and Crowston, 2011).

Finally, Schrögel and Kolleck's (2019) *participatory science cube* is convincing for its openness. The 'cube' is constructed following Fung's (2006) *democracy cube* on the premise that the issues arising in terms of participatory governance and participation in science are similar. These are *who* is eligible to participate; *how* does the public participate; and *how much* power is delegated to the participating public?

Schrögel and Kolleck (2019: 89) state,

> The cube constitutes a descriptive framework on a macro level and is intended to provide a basic typology [. . .] [it] aims at reflecting the heterogeneity in the field of science participation while at the same time offering categories to structure the diversity. It allows users to compare and distinguish participatory approaches across the wide spectrum of epistemic and normative influence on the conduct of scientific research.

The cube could help to reveal national styles. Each axis represents the different configurations of the dimensions as the continuum. That allows for a wide variety of different types possible. At the same time, the cube avoids pursuing a normative agenda but rather permits to fine-tuning evaluations against different criteria.

However, the model has the limitation that it does not say anything about the origin of the projects under examination, that is, who has initiated a project. This matters, because the establishment of citizen science projects may be a spontaneous response to some problem calling for a knowledge-based solution or it may be 'staged' for other than the proclaimed purposes. It also matters whether citizen science projects are funded and organised by just one or two institutions or whether the organisational backing is spread and shared by many, that is, whether citizen science is a top-down strategy of science policy agents or a bottom-up movement originating in the citizenry.

Why study citizen science in South Africa?

In the 1980s and 1990s, South Africa was a front runner in citizen science research, with large organisations supporting citizen science research – examples include BirdLife SA, the Animal

Table 1. Models of citizen science.

Reference	Model		Description
Bonney and et al., 2009; Skirk et al., 2012; Schrögel and Kolleck, 2019	Based on the level of collaboration	Contributory projects	citizen science participants help with data collection for projects designed by scientists
		Collaborative projects	scientists and participants design the projects together
		Co-created projects	scientists and participants are part of all aspects of project development and completion
Dickinson and Bonney, 2012	Projects vary along four axes	Initiator of the project	professional scientists or the public
		Scale and duration of the project	whether local or global and short term or long term
		Types of (research) questions being asked	ranging from pattern detection to experimental hypothesis testing
		Project goals	research, education, and behavioural change
Wilderman et al., 2004	Community engagement science	Community consulting	the community defines the problem and institutional scientists design the study, collect and analyse the data, and interpret the results
		Community workers	community members are responsible for data collection, and institutional scientists define the problem, design the study, analyse data and interpret the results
		Community-based participatory research	the community is responsible for all steps in the scientific process
Alender, 2016 Wiggins and Crowston, 2011	Based on the *outcomes* of the citizen science project	Action projects	initiated by participants and designed to help with local concerns
		Data collection projects	aim to answer a scientific research question or reach a specific scientific research outcome
		Conservation projects	specifically address natural resource management goals
		Investigation projects	focus on a specific research goal in a physical setting
		Virtual projects	focus on research goals, but are based on volunteer interaction with information technology
		Education projects	aim to increase participant knowledge about science and the scientific process
		projects that influence policy and management decisions	
Schrögel and Kolleck, 2019	Participatory science cube	Normative focus	which is related to the degree of involvement of the public in the decision-making process
		Epistemic focus	which aspects of the knowledge process citizens contribute to
		Reach	which publics are reached with the science engagement

Demography Unit (ADU) and the South African National Biodiversity Institute (SANBI) – but the past decade has not lived up to expectations created from this (Harrison, 2020). In 2015, South Africa adopted the Science Engagement Strategy (SES) to develop a society that is knowledgeable and literate about science and able to form opinions about science issues (United Nations Commission on Science and Technology for Development UNCSTD, 2019). In South Africa, citizen science takes place within this context.

The most recent South African White Paper on Science, Technology and Innovation, while quite explicit about an 'engagement strategy' up to the point of planning to establish a separate agency (albeit in the service of innovation) (Department of Science and Technology [DST], 2019: 33), is much less explicit about citizen science. The DST (2019: 33) remarks, '(i)Incentives for open science will be fostered through education programmes and career development programmes for researchers. A focus on citizen science will also be introduced'. The South African NRF defines citizen science as 'scientific research conducted, in whole or in part, by amateur (or nonprofessional) scientists' (Osman, 2019: 29).

However, strategies of inclusion face particular challenges in countries like South Africa. The most serious of them is the low level of literacy (Inglehart and et al., 2014), which must be seen as a barrier to participation in citizen science. This is due, above all, to the economic inequality (Central Intelligence Agency [CIA], 2020). It may be assumed that both the level of interest in and the ability to take part in citizen science projects are seriously impeded under these circumstances. Looking at countries that follow similar science policy strategies, but have quite different socioeconomic conditions will potentially allow determining whether enhanced inclusiveness in research depends on economic well-being, a relatively high level of literacy, and a culture of education and science normally found in rich societies or whether patterns of inclusion are determined by the exigencies of the research process.

Understanding the current scope of citizen science projects could shed light on the opportunities and constraints of public involvement in research, understanding its full potential for science as well as society (Strasser and Hacklay, 2018). This will control the rhetoric of participation in and democratisation of science, thereby providing a more realistic picture of what engagement of citizens could actually achieve (Davies and et al., 2016). As Harrison (2020, p.192) comments, 'There is certainly nothing wrong with these [citizen science] ideas in theory, but perhaps the time has come to question what citizen science can and cannot do at this point in history'. To this end, the current study provides evidence of citizen science in South Africa.

3. Research questions

The involvement of citizens in research projects assumes quite different forms, ranging from simple data collection guided by scientists to the interpretation of results. Based on the models of citizen science described by Bonney et al. (2009), Shirk et al. (2012) and Schrögel and Kolleck (2019), the first research question was:

> *RQ1*. In what ways are members of the public engaged with South African citizen science projects?

Citizen science projects may be initiated from the *top down* as an activity promoted by governments and/or academic institutions, such as universities, or they may be initiated from the *bottom up* as activities by citizens' groups trying to respond to practical problems (Burgess and et al., 2017). Thus, based on the model by Dickinson and Bonney (2012), the next research question was:

RQ2. Who is responsible for initiating and managing citizen science projects in South Africa?

Science disciplines differ considerably regarding their accessibility. It must be assumed that access to research projects is partly dependent on the ability to understand the respective science and/or to be trained at least in the basics. Therefore, the third research question asked:

RQ3. What is the distribution of such projects across the disciplinary spectrum?

Public communication from citizen science projects could either be to recruit new participants, or communicate what is happening in the project to said participants and potentially the larger public. Depending on which of these two objectives is primarily pursued, the addressees and channels of the communication might vary (Johnston et al., 2017). When recruiting new participants, communication formats will most likely be informal and addressed to a broader public. To communicate scientific research, results will most likely be communicated in scholarly journals or reports (Burgess and et al., 2017: 114).

RQ4. Which audiences do South African citizen science projects target with their communication when recruiting participants?

RQ5. What channels do these projects use to communicate to their participants?

Citizen science is also supposed to serve, in principle, two objectives: to benefit participants through informal science education (Kullenberg and Kasperowski, 2016), and to contribute to institutional scientific research (Johnston et al., 2017) The next question addressed the issue regarding the extent to which citizen science in South Africa primarily supports scientific research, or a more informal public science education output:

RQ6. Do citizen science projects in South Africa have a predominantly scientific or educational output?

4. Methodology

From June to September 2019, a web-based search using the phrases '*citizen science South Africa'*, and '*citizen science projects South Africa*' (Theobald and et al., 2015; Wiggins and et al., 2011) as well as a list of projects provided by Vallabh et al. (2016) resulted in a data set of 56 citizen science projects (Table 2) found in South Africa, a larger data set than to be found in other studies. The set of projects, although perhaps not exhaustive, provided a good impression of the state of citizen science at the time of the research, and represented some of the diversity of citizen science projects based in South Africa.

To collect information about the 56 projects, an analysis of citizen science projects based on their online sources (such as websites and social media platforms) was performed from October to November 2019. Information on the projects collected comprised project name, year of start, research discipline based on the Science Europe (2018) classification, stakeholders or partners, size of project (number of data records and number of participants), initiating and administering institution (academic, government, non-governmental organisation (NGO) or private), project goal or output (scientific knowledge or educational). Other information collected included the

Table 2. List of South African citizen science projects used in the analysis.

Project		Age of project in 2020 (years)	Number of participants	Number of observations
1	African Dragonflies & Damselflies Online (OdonataMAP, previously ADDO)	10	2,914	196,903
2	Atlas of Seabirds at Sea (AS@S)	11		112,486
3	Astronomical Society of Southern Africa (ASSA) Citizen Science Section	2	0	0
4	Biodiversity Observations	10		371
5	Bird Pictures Archive (BirdPix)	8		94,362
6	Birds with Odd Plumage (BOP)	8		497
7	Birds in Reserves Project (BIRP)	28	847	1,648,924
8	Cape Citizen Science	5	250	650
9	CAR: Coordinated Avifaunal Roadcounts	27		
10	Custodians of Rare and Endangered Wildflowers (CREW)	17		
11	Coordinated Waterbird Counts (CWAC)	28		
12	DungBeetleMAP	5		26,568
13	EarthWatch Institute: South Africa Expeditions	47	2,583	
14	EchinoMap	8		2,124
15	South African Elasmobranch Monitoring (ELMO)	5	100	5,883
16	FishMAP	5		1,325
17	FitzPatrick Institute of African Ornithology: Virtual Museum	10		
18	FrogMAP	24	1,389	5,2681
19	Hadeda Ibis Project	14		
20	ifoundahedgehog project (IFAH)	7		
21	Iimbovane Outreach Project	14		
22	Karoo BioGaps			
23	LacewingMAP	6		16,076
24	LepiMap	13		529,935
25	MammalMAP	10		585,010
26	miniSASS	6		
27	MushroomMap	6		9,797
28	MyBirdPatch	7		
29	NRF|SAEON Calendar Gardens Project	9		
30	Oceanographic Research Institutes Cooperative Fish Tagging Project (ORI-CFTP)	36	6,000	336,719
31	OrchidMAP	6		7,710
32	Penguin Watch	6		
33	Protea Atlas Project	28	478	252,513
34	Red List Alert			
35	rePhotoSA: The repeat photography project of southern African landscapes	5		
36	ReptileMap	15		158,751
37	Southern African Bird Atlas Project 1 (SABAP1)	33		7,000,000
38	Southern African Bird Atlas Project 2 (SABAP2)	13	2,844	234,186
39	The South African Bird Ringing Unit (SAFRING)	72	253	2776,699

(Continued)

Table 2. (Continued)

Project		Age of project in 2020 (years)	Number of participants	Number of observations
40	SANBI SeaKeys: Unlocking Foundational Marine Biodiversiy Knowledge	6		
41	ScorpionMAP	7		3,869
42	Sea Turtle Citizen Science Initiative	7	0	0
43	SeaKeys SA Jelly Watch			
44	SeaKeys Sea Coral Atlas		33	4,009
45	SeaKeys Sea Fish Atlas		99	7,934
46	SeaKeys Sea Shell Atlas		59	1,318
47	SeaKeys Sea Slug Atlas		66	4,127
48	SeaKeys Seaweed Atlas		29	1,361
49	Southern African Butterfly Conservation Assessment (SABCA)	15		
50	Southern African Reptile Conservation Assessment (SARCA)	15		
51	SpiderMap	7		12,215
52	The Endangered Western Leopard Toad Project	16		
53	ToadNUTS	13		
54	TreeMAP	10		28,493
55	VultureMAP	4		1,232
56	Weaver Watch (PHoWN – photos of weaver nests)	10	439	28,979

communication channels the projects used to communicate with their participants and with the public. From November to December 2019, all 56 project managers were contacted, via email, to provide any missing information that resulted from the web search. After initial contact, they were contacted twice again in an attempt to gather missing data. Of the 56 projects to which we reached out, only 10 project managers responded (17.8%). The low response rate was because many projects (more than half) were no longer actively managed at the time of our inquiry, and for a fair number of the active ones no phone numbers of managers could be found so that email contact remained the only option.

At the time of data collection, the average active years of South African citizen science projects was approximately 11 years ($n = 50$). This includes projects that had drawn to a close at the time of data collection and those that were still active. The Citizen Science Section of the Astronomical Society of South Africa (ASSA) project started in 2018, the youngest in the sample. The oldest citizen science project was SAFRING (South African Bird Ringing Scheme). It has been using citizen scientists for data collection in South Africa for 72 years (started in 1948) and was still active in 2020.

The number of participants in a project ranged from zero (Sea Turtle Citizen Science Initiative) to over 6000 (ORI-CFTP (Oceanographic Research Institute's Cooperative Fish Tagging Project)) per project. At the time of data collection, one active project had not started data collection (ASSA Citizen Science Section) and therefore not yet recruited any participants. The Sea Turtle Citizen Science Initiative was unsuccessful and never recruited any participants. The Calendar Gardens Project (NRF (National Research Foundation)|SAEON (South African Environmental Observation Network)) was considered inactive by the authors, due to online inactivity and missing response when contacted directly.

Table 3. Types of institutions that are responsible (either alone or in collaboration with one another) for initiating and managing citizen science projects in South Africa ($N = 56$).

Institution(s)	Alone	Collaborative	Total
Academic	19		19
Academic and government		3	3
Academic and NGO		2	2
Academic and other		2	2
Academic, government and NGO		6	6
Academic, NGO, other		3	3
Government	3		3
Government and NGO		10	10
Government, NGO and other		1	1
NGO	1		1
NGO and other		1	1
Other	2		2
All 4		3	3
Total	25	31	56

NGO: non-governmental organisation.

5. Results

RQ1. In what ways are members of the public engaged with South African citizen science projects?

Citizens contributed to the projects predominantly through data collection ($n = 50$). Three projects were managed exclusively by citizens and had no input from institutional scientists: ToadNUTS, The Endangered Leopard Toad project and ifoundahedgehog. In these three projects, participants defined the research question and managed collection and analysis of the data on their own. In none of the projects in our sample did participants use project outcomes to contribute to policy debates and/or discussions.

RQ2. Who is responsible for initiating and managing citizen science projects in South Africa?

Various institutions are responsible for managing citizen science projects in South Africa. We distinguish academic, government, NGO and 'other' (i.e. private companies or citizens).

In South Africa, academic institutions (i.e. universities), either individually ($n = 19$) or in collaboration with other institutions ($n = 19$), are predominantly responsible for initiating and managing citizen science projects (Table 3). However, slightly more than half of the citizen science projects ($n = 31$) were collaborations between different types of institutions

The majority of citizen science projects in South Africa were initiated and managed by one particular academic institution: The University of Cape Town (UCT) ($n = 33$). The Animal Demography Unit (ADU), based at UCT, is the leader in ATLAS projects using citizen scientists in the country (Underhill, 2018). The South African National Biodiversity Institute (SANBI) is the most important government institution involved in citizen science projects ($n = 20$). And the World Wildlife Fund for Nature (WWF) is the NGO in South Africa most frequently involved in citizen science projects ($n = 7$).

RQ3. What is the distribution of citizen science projects in South Africa across the disciplinary spectrum?

Citizen science projects in South Africa can be categorised mainly as belonging to the life sciences ($n=52$). Only two projects each fell under arts and humanities (Iimbovane Outreach Project; Biodiversity Observations), and natural sciences (NRF|SAEON Calendar Gardens Project, Astronomical Society of Southern Africa's Citizen Science Section).

RQ4. Which publics do citizen science projects target with their communication?

When recruiting participants and communicating their findings, South African citizen science projects do not target just a specific public, but rather an array of publics. Forty-five projects claimed that they recruited participants from a broad spectrum of people. For example, the goal of the Cape Citizen Science Project was to gather citizen science data from professional scientists, interested publics (i.e. those with particular interest in the field) as well as the broader public. Eleven projects targeted a more specified audience, for example, miniSASS (Stream Assessment Scoring System), which only targeted pupils to help with data collection.

RQ5. What channels do projects use to communicate to their participants?

Almost all projects used social or new media (Facebook, blogs, website, Wikipedia, Twitter, email lists and Instagram) to communicate with and to their participants and the general public ($n=53$). Fewer projects ($n=19$) used traditional media channels (magazines, newspapers, television, radio, newsletters, reports and other non-peer-reviewed publications). Fifteen projects made use of academic publications (peer-reviewed articles, theses, books and conference proceedings) as part of their public communication strategies, and only five projects made use of other means (public talks, applications, guides and children's books).

RQ6. Do citizen science projects in South Africa have a predominantly scientific or educational output?

The citizen science projects analysed in our study differed with respect to the specificity of their goals and outputs. In South Africa, the majority of citizen science projects ($n=41$) claimed that scientific outputs were their main goal. Ten projects focussed on both scientific and educational outputs and only three projects stated that educating the public was their main goal: Iimbovane Outreach Project, Penguin Watch and Biodiversity Observations. For two projects, their goal was unclear (ToadNUTS and The Endangered Western Leopard Toad Project).

6. Discussion

Some South African literature provides definitions of citizen science, but it lacks a coherent definition and fails to consider the broader use of the term. Périquet, Roxburgh, Le Roux, and Collinson (2018) simply define it as a new type of data collection that involves public participation. Hulbert (2016 and 2019) also states merely that citizen science is a term for scientific research that employs non-scientists in data collection and generation.

Citizen science projects vary in the extent to which participants are involved in research. Historically, citizen science relied heavily on data collection (Kennedy, 2016; Mugdal, 2018;

Science Europe, 2018; Turrini and et al., 2018). This is still the case in South Africa (see RQ1) where most citizen science participants today are involved in scientist-driven, contributory projects, as identified by Bonney et al. (2009) and Shirk et al. (2012), using citizens in the traditional form of data collection. The results could indicate that researchers see citizen science participants in South Africa merely as unpaid 'hired hands', collecting large quantities of data (Kimura and Kinchy, 2016: 337), as there are too few scientists to get it all done (Harrison, 2020). This is especially true for wildlife monitoring projects; examples from South Africa include SABAP1 (South African Bird Atlas Project) and 2, MammalMAP and FishMAP.

Regarding RQ2, citizen science projects in South Africa are strongly associated with academic institutions. Similar to the United States, Canada and the United Kingdom (Wiggins and Crowston, 2011), where citizen science projects had strong academic support, most projects in South Africa were initiated and/or managed by academic institutions, while few were managed by citizens or private organisations. Citizens have little or no contribution to knowledge production (epistemic focus) other than collecting data. Results presented here are the same as observed in the European Union (EU), where only up to 9% of citizen science projects were run by private citizens or companies (Mugdal, 2018; Science Europe, 2018). However, Mugdal (2018) cautions that privately led projects may be underrepresented as they might not have a web presence or they might not feature in academic publications.

The ADU, based at UCT, is the leader in ATLAS projects using citizen scientists in the country (Underhill, 2018). This best illustrates the concentration of citizen science projects in one of the leading universities in the country and, thus, the possibility of such activities involving very few people and institutions. Similarly, the relatively high occurrence of government-supported projects reflects the effort by government to expand and accelerate the role of citizen science in South Africa, and in the case of the WWF – an NGO and major role player in environmental conservation – the concentration of South African citizen science projects in that area is evidenced.

The results regarding RQ3 indicate that South African citizen science projects were mainly categorised as belonging to the life sciences. These results are similar to those from across Europe, where over 75% of citizen science projects were categorised as belonging to the same discipline (Science Europe, 2018). These South African citizen science projects comprise the fields of ornithology, botany, entomology, biodiversity, conservation and ecology, comparable to those from across the globe (see Kullenberg and Kasperowski, 2016). These fields are most likely to rely on widely distributed data collection, which does not require specialised knowledge (Pandya, 2012).

South African citizen science projects also varied according to their target audience or participants (see RQ4). The type of research can influence the target audience (Soleri and et al., 2016) and may range from families to young students to scientists (Rotman and et al., 2014). Each project might have its own goals and target audiences for participation; however, they overlap in the overall motivation to engage the public (Hulbert et al., 2019).

Citizen science projects have become easier to manage due to advances in and better public access to communication and information technologies (Bannatyne and et al., 2017). These technologies and other communication channels are often used for communication between projects and their participants (RQ5). Social media are becoming increasingly popular to keep citizen science participants engaged with the projects' activities (Mugdal, 2018).

At least two goals or outcomes of citizen science projects can be identified (as per RQ6), although they often overlap: (1) An educational output through actively encouraging public engagement in science or fostering science communication, and (2) a scientific output by way of scientific publications and science career progress (Johnston et al., 2017).

The proportionately higher share of projects with a purely scientific objective versus those that aim to have an educational output could indicate that science education is considered merely an

additional benefit of data acquisition (Johnston et al., 2017). However, it is important to note that, even though most South African citizen science projects do not have science education as a goal, other studies have shown that participants do gain content knowledge about the discipline where they are involved (Overdevest et al., 2004). Furthermore, the goals of a citizen science project may change over time in response to needs, obstacles and/or opportunities (Kimura and Kinchy, 2016).

7. Conclusion

We can draw several conclusions from our study. First, the fact that the findings in South Africa do not differ decisively from those observed in the United States, the EU or the United Kingdom indicates that it is not cultural and socioeconomic differences between countries, but rather *similarities* among their science systems that account for the ways citizen science appears in South Africa. The similarity, even identity, of the range of disciplines, which are accessible, and even welcome the participation of citizens across countries, is sufficient evidence of the opportunities, but also the limitations of involving the lay public in actual research. It is not surprising that most STEM (science, technology, engineering and mathematics) fields are inaccessible to cooperation without prior training, and no enthusiasm for inclusivity and participation will change that. The crucial prerequisite for participation in these fields is scientific literacy.

Second, and in a similar vein, the dominance of scientific institutions in initiating and managing citizen science projects, and the concentration of such efforts at one university are significant. The expectations of a widespread grassroots movement of citizens or communities launching research projects to apply scientific methods to the solution of local problems, thereby circumventing established scientific experts, are not reflected by the reality on the ground.

Third, the objective of citizen science, as it was envisaged by Alan Irwin (1995), to engage citizens in science policy decisions, has not been realised in the case of South Africa. Policy discussions or influencing policy debates are often only deemed important once the goals of data collection and citizen engagement are reached (Van Brussel and Huyse, 2019). Participation by citizens in research is predominantly contributory and limited to the 'classic', more easily accessible fields of research.

Fourth, it is highly doubtful whether the lofty goal that citizen participation in research projects could ultimately lead to a widespread 'empowerment' of those in the population who are traditionally distant from science, is being realised. Although we do not have reliable data at this particular point, it becomes evident that most of the communication from South African citizen science projects is directed at the scientific community rather than at a larger public. The general public is the secondary audience being addressed largely by websites and similarly accessible online sources. We are confident that the obvious limitation of our data, that is, the low response rate from citizen science project managers and the small sample of South African projects, does not compromise this conclusion as this is rather supported by the institutional context of citizen science.

Not to be misunderstood, the criticism of citizen science following from the analysis of its practical reality in South Africa is not aimed at the normative ideal of citizens' enlightenment and empowerment through inclusion and participation in the process of knowledge production. Rather, it is directed at the instrumentalisation of the discourse by communication specialists and policymakers, supported by scholars, both from the Public Understanding of Science (PUS)/Political, Economic, Social and Technological (PEST) and from the hard sciences, each having different interests, all competing to gain power of definition. Burdening the very term *citizen science* with increasingly ambitious rhetorical claims to what it is supposed to achieve – from the 'democratisation of science' to the empowerment of citizens – may even have a paradoxical consequence. It could be that the traditional mainstream 'citizen scientists', that is, the bird watchers, insect

catchers, amateur botanists or star gazers, who have been around for centuries, are being belittled for not living up to the 'new expectations' developed in the dominant discourse on *citizen science*. The reality of citizen science should give reason for some rhetorical restraint and analytical soberness.

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ORCID iDs

Peter Weingart https://orcid.org/0000-0002-8275-525X

Corlia Meyer https://orcid.org/0000-0002-2965-4054

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Author biographies

Corlia Meyer received a Master of Science in Zoology, working with citizen science projects and received her PhD in Science and Technology. She is currently a postdoctoral fellow at the Centre for Research on Evaluation, Science and Technology, Stellenbosch University, doing research on science communication practices in South Africa.

Peter Weingart is professor emeritus of Sociology, Sociology of Science and Science Policy at the University of Bielefeld. He was appointed to the SARChi Chair for Science Communication at Stellenbosch University in South Africa 2015–2020. He is editor-in-chief of the journal *Minerva*. His current research interests are science advice to politics, science – media interrelation, science communication, especially in the context of social media.