

## Diversifying citizen science through the inclusion of young people

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### Abstract

The study presents findings on motivations, barriers and recommendations that enhance youth engagement in citizen science particularly, those with no prior citizen science experience. We conducted focus groups targeting young people with and without citizen science experience. Qualitative findings identify a range of motivations including career development, new interests and knowledge, altruistic values, social interactions, inclusivity and connections to new places and nature. Several barriers were identified including logistical constraints, lack of knowledge and interest, programmatic and organisational issues. We discuss the implications of our findings to broaden the diversity of citizen scientists toward a younger demographic.

### Keywords

Citizen science; Participation and science governance; Social inclusion

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### Introduction

Citizen Science (CS) refers to the engagement of the public in scientific research to generate knowledge of relevance for science and society [Vohland et al., 2021, p. 1]. Such initiatives are popular in biodiversity research where citizen scientists participate in the identification, recording and monitoring of biodiversity [Theobald et al., 2015]. CS has benefitted science by contributing data to peer review articles [Aristeidou et al., 2021], environmental monitoring and reporting [Billaud, Vermeersch & Porcher, 2021] and policy implementation [Turbé et al., 2019]. Public participation in CS can contribute to personal and social benefits for participants through increased interest in a subject, literacy, skills, changes in attitudes, self-efficacy and behaviour [Peter, Diekötter & Kremer, 2019; Phillips, Ballard, Lewenstein & Bonney, 2019]. However, the representation of participants does not always adequately reflect the demographics of general populations, excluding certain age-groups, genders, ethnicities and socio-economic groups from these benefits [Pateman, Dyke & West, 2021].

Gender biases exist in different programmes often toward older white males with high levels of education and income [Wright, Underhill, Keene & Knight, 2015],

while others are aggregated toward highly educated middle-aged females [National Academies of Sciences, Engineering, and Medicine, 2018]. Low levels of participation among historically disadvantaged groups in science (e.g. of African descent, Latinos, American Indians) have been documented [National Academies of Sciences, Engineering, and Medicine, 2018]. Age also shapes participation with lower levels among younger age groups (e.g., 25–34-year-olds) compared to middle-aged and older people [Mac Domhnaill, Lyons & Nolan, 2020; Pateman et al., 2021]. Improving diversity within CS has the potential to bring new aspirations, perspectives and knowledge to support scientific enquiry [National Academies of Sciences, Engineering, and Medicine, 2018].

In this paper, we focus on the issue of broadening diversity in CS through the engagement of young people from different CS backgrounds. A range of benefits for young people emanate from their participation in CS including: educational and learning opportunities, emotional and physical benefits and improved interpersonal and social skills [Schuttler, Sorensen, Jordan, Cooper & Shwartz, 2018; Straub, 2020]. However, research shows connection to nature dips during teenage years [Hughes, Rogerson, Barton & Bragg, 2019]. Connection to nature can benefit people's health and well-being and influence conservation behaviour [Pritchard, Richardson, Sheffield & McEwan, 2020; Richardson & Sheffield, 2017]. Therefore, participation in environmental CS maybe one means to strengthen this connection.

Young people are motivated by CS projects that offer learning and skills development [Pateman et al., 2021], align with their careers [West, Dyke & Pateman, 2021] and offer social interaction [Takase, Hadi & Furuya, 2019]. Such motivations can be commonly categorised as *Egoism* motivations, through bolstering an individual's welfare [Batson, Ahmad & Tsang, 2002]. However, motivations can also be linked to *Altruism*, to increase the welfare of others, *Collectivism* to support a group and *Principlism*, upholding personal principles [Batson et al., 2002]. However, barriers to participation include: limited time and resources [Martin & Greig, 2019], inadequate technological infrastructure [Rotman et al., 2014] and feelings of not fitting in [Merenlender, Crall, Drill, Prysby & Ballard, 2016]. Such knowledge can inform the design of CS projects, as well as the implementation and impact of engagement strategies [Herodotou, Aristeidou, Miller, Ballard & Robinson, 2020].

To our knowledge, much research on what engages young people in CS centres on existing volunteers. Efforts to understand what may motivate those who have not previously participated in CS are lacking. In this study, we explore factors that determine young people's (aged 18–29) participation in CS with different CS experiences. Our research centres on a case study CS project being initiated by the Royal Society for the Protection of Birds (RSPB) titled: the Volunteer Monitoring of Farm Wildlife (VMFW) project where volunteers carry out multi taxa biodiversity surveys to support long-term monitoring and conservation efforts on farmland. This study aims to explore the motivations, opportunities and barriers for engaging volunteers in such an initiative. The data will be used to inform CS project design, volunteer recruitment strategies, with a broader aim to enhance the diversity of volunteers and the design of volunteering activities into the future. The following research questions were explored: (1) What are the motivations of young people for participating in CS initiatives? (2) What are the barriers for engaging young people

in CS initiatives? and (3) How can these barriers be overcome to encourage the participation of young people in our prospective CS initiative?

## Methods

Qualitative data was collected through online focus group discussions (FGDs) conducted via Zoom. Qualitative methods are important because they are less structured, more open and flexible than quantitative approaches and enable opportunities for reflexivity of responses, in-depth analysis and the generation of novel findings [Drury, Homewood & Randall, 2011]. FGDs centre on engaging selected groups of people to discuss perspectives on a specific topic, to share understandings and to identify the influence of different voices in the group [Drury et al., 2011].

We selected participants between the ages of 18–29 with previous environmental CS experience (E-CS), those with non-environmental CS experience (NE-CS) and those with no CS experience (N-CS). Participants were recruited via a series of online advertisements through a network of environmental volunteering organisations and their social media platforms. These organisations were identified through a snowball sampling approach beginning with the first authors own organisational affiliations and then asking other organisations to recommend other places to advertise through their own networks. In order to reach participants beyond the environmental sector the first author, identified a list of organisations outside of the environmental sector that offer citizen science opportunities as well as a number of university union organisations, colleges and community groups to advertise the focus group opportunity more widely. Participants were asked prior questions about their previous CS experience, gender and residence in urban or rural settings to allocate them to different FGDs (Table 1). Four people couldn't attend the FGDs during the allocated times and provided written responses to the FGD questions.

An information sheet outlining the aims and objectives of the study, details of the date, time and location of the FGDs, use and storage of the data, issues of informed consent and confidentiality were circulated prior to discussions. The information sheet asked participants for their signed informed consent which was approved by the RSPB Centre for Conservation Science Human Ethics Committee.

The FGDs took place on April 2021 on Zoom for a period of two hours. At the beginning of each FGD, we went through the consent form to ensure everyone signed the form and asked permission for the FGD to be audio recorded. The FGDs

**Table 1.** Summary of participants in the FGDs of young people aged 18–29.

<i>Selection criteria</i>	<i>No of focus groups</i>	<i>Group size range</i>	<i>Total</i>	<i>No from rural/urban areas</i>	<i>No of males/females</i>
Environmental CS experience (E-CS)	2	6–8	15	7 rural/8 urban	3 males/12 females
Non-environmental CS experience (NE-CS)	2	5–7	12	6 rural/6 urban	6 males/6 females
No CS experience (N-CS)	1	7	7	1 rural/6 urban	6 males/6 females

**Table 2.** Focus group discussion guide.

<i>Theme</i>	<i>Questions</i>
Theme 1: Introduction	<ul style="list-style-type: none"><li>– Please tell us a bit about yourself and what keeps you busy these days?</li></ul>
Theme 2: Engaging young people in citizen science	<ul style="list-style-type: none"><li>– What does citizen science mean to you?</li><li>– <i>Qs for those who have taken part in a citizen science project before:</i> Please tell us about what has previously motivated you to take part in a citizen science project?</li><li>– <i>Qs for those they have not taken part in a citizen science project before:</i> Why have you not taken part in a citizen science project before?</li><li>– Why do you think some young people never consider taking part in citizen science?</li></ul>
Theme 3: Motivations and barriers for participation	<ul style="list-style-type: none"><li>– Explained proposed concept of our proposed citizen science project</li><li>– What would make you consider taking part in such a scheme?</li><li>– What would discourage/prevent you from participating in such an initiative?</li><li>– What kind of support would you need to overcome these issues?</li></ul>
Theme 4: Recommendations for broadening participation	<ul style="list-style-type: none"><li>– What sort of things could we do to make this opportunity more interesting/attractive to you?</li><li>– How do you think we can involve a wide range of people and offer opportunities for all?</li></ul>
Closing remarks	<ul style="list-style-type: none"><li>– Do you have anything else you would like to share with us today?</li></ul>

were semi-structured and guided by a series of themes and open-ended questions giving opportunities for respondents to elaborate on their thoughts (Table 2). Questions explored understanding of the meaning of the term CS, interest, motivations and barriers for participating in CS in general and our case study and recommendations for broadening participation.

### *Data analysis*

FGDs were audio recorded, transcribed verbatim and coded using a modified grounded theory approach to interpret the data that allowed for priori categories/codes coupled with the identification of emergent themes, which allow the researcher to identify and apply relevant theoretical frameworks [Emerson, Fretz & Shaw, 2011]. The strengths of this interpretative analysis allow for the identification of novel themes, categories and interpretations that participants drew upon when describing their motivations, barriers and recommendations for participating in CS. The transcripts were deductively coded for dominant narratives that encompass young people's motivations, barriers and recommendations. Participant's anonymity and confidentiality was ensured by giving each interviewee an identification code (e.g., V1) and an identifying code of the FGD.

Young people's motivations for participating in CS were linked to opportunities for career development, developing new interests and knowledge, altruistic values, forging social connections, inclusivity and connection to new places and nature (Table 3).

**Table 3.** Motivations for participating in citizen science.

	<i>Environmental CS experience (E-CS)</i>	<i>Non- environmental CS experience (NE-CS)</i>	<i>No CS experience (N-CS)</i>
<b>Career development</b>			
Volunteering a pre-requisite to secure work in the conservation sector	✓	✓	
Gain a diversity of skills	✓	✓	✓
Improve resume		✓	✓
Strengthen university applications and future job prospects		✓	✓
Obtain referees			✓
Opportunity for mentorship			✓
<b>New interest/knowledge</b>			
A pre-established interest in a particular cause	✓	✓	✓
Learn something new	✓	✓	✓
Ascertain your own interests	✓	✓	
Put your own knowledge and skills into practice	✓	✓	
<b>Altruistic values</b>			
Giving back to a cause/Having an observable and positive impact on a cause	✓	✓	✓
Offer support and own expertise	✓		
Raising awareness of your own privileges		✓	
<b>Social connections</b>			
Meet new and likeminded people	✓	✓	✓
Learn about the local community	✓	✓	
Build your network	✓		
Raise profile and reputation	✓		
Meet new people from other backgrounds		✓	
Build confidence		✓	
Find role models and mentors			✓
<b>Inclusivity</b>			
Welcoming environment	✓	✓	✓
No hierarchical management structures	✓		
Open to all regardless of experience	✓		
Voice own opinions	✓		
Take ownership of a project	✓		
<b>Connection to new places and nature</b>			
Experience and live in new places	✓		
Be immersed in nature	✓		
Physical activity	✓	✓	
Get outside	✓	✓	✓

### *Career development*

For young people with E-CS and NE-CS experience, volunteering was seen as pre-requisite to secure work in the conservation sector. Many graduate students with conservation-related degrees believed their course did not provide adequate practical skills and training therefore, participation was essential for employability. Across all FGDs, CS was an opportunity to gain specific work skills such as managerial expertise, bolster resumes and inform future career paths:

*I guess the thing about that opportunity was that it was very science and monitoring focused, which was the area that I was looking to gain experience within and team like opportunities. There were many supporting pieces that allowed me to get involved with visitor experience, an event or practical work on a reserve. It was a very good way of testing whether you want to work within this sector (V4, E-CS).*

Those with NE-CS and N-CS experience, were motivated by opportunities that strengthened university, or job applications and improved their resume. Meanwhile, those with N-CS experience, were interested in opportunities for mentorship and sourcing referees.

### *Developing new interests and knowledge*

Across all FGDs, young people believed a prior interest in a topic was essential for their participation. Among all FGDs, young people were interested in gaining new insights and knowledge into a topic they found interesting or to obtain a greater understanding of an industry or organisation. Those with E-CS and NE-CS experience, viewed their participation as an opportunity to determine their interests in a subject and to put their knowledge and skills into practice.

### *Altruistic values*

Across all FGDs, young people were motivated to give back to a cause that aligned with their personal values, made a positive contribution to the environment, local area, or community. Similarly, young people across all groups, were attracted to opportunities where they were making an observable difference. This could include helping a community to secure funding for a project, creating a habitat for a species and seeing the benefits of their work:

*Doing something as well is quite nice for nature, and often volunteering is quite rewarding when you are seeing the difference in what you're doing. For example, if you have created something or you're seeing new species moving into an area, after providing a habitat for them (V1, E-CS).*

Young people with E-CS experience were attracted to opportunities that allowed them to contribute their knowledge and expertise to support a cause. A few individuals with NE-CS experience described situations where they worked with other volunteers from a different cultural background. In one example, a participant described how social interactions with other volunteers made her

aware of other people's life experiences causing her to self-reflect on her own privileges. From this experience, she was attracted to opportunities that allowed her to work with people from disadvantaged backgrounds and projects that furthered a specific social cause.

### *Social connections*

Across all FGDS, young people were motivated to meet new and like-minded people. Those with E-CS and NE-CS experience, were interested in getting involved and learning about their local community:

*I have volunteered for other organisations which aren't in the environmental sector and I would do that to help the community, especially when I moved to a new place. That's a good way to meet new people and to learn about the community (V15, NE-CS).*

Those with E-CS experience, were also looking to build their social networks, reputation and profile in a particular field of interest. In contrast, those with NE-CS experience, were interested in meeting people from different backgrounds and building their confidence through social interactions:

*For me with like talking to people [I] sometimes find it quite hard. So, it's been really nice to serve customers and build my confidence in that way, so I think volunteering gives that (V22, NE-CS).*

Those with N-CS experience, were interested in opportunities to find new roles models and mentors.

### *Inclusivity*

Across all FGDS, young people were attracted to a welcoming and friendly environment. Young people with E-CS experience, were attracted to projects without hierarchical management structures and opportunities that were open to all regardless of prior experience. A young woman who worked on several activist projects stated:

*I liked how inclusive it was and there's space for you, it was inclusive because you didn't have to have skills to join, it wasn't like a hierarchical structure at all. Everyone is welcome, and you're openly welcome every time that you go. And it's like whoever can do the work, does the work. And there's no like barrier to it at all (V6, E-CS).*

Opportunities allowing young people to share their knowledge, opinions and take ownership of a project were also attractive.



### Connection to new places and nature

Young people with E-CS experience were motivated to get outside and live in new places, as well as opportunities to immerse themselves in nature through their interactions with wildlife. Across all FGDs, individuals were motivated by a desire to get outside by acknowledging the recent isolation of the COVID-19 pandemic and the well-being benefits of exercise, fresh air and pursuing outdoor activities they enjoy:

*I've taken on a desk job, and I wanted to get out in the fresh air, be active and feel good (V15, NE-CS).*

### Barriers to participation

A range of factors were identified by young people that would prevent them from taking part in CS including logistical constraints, lack of knowledge and interest and programmatic and organisational issues (Table 4).

**Table 4.** Barriers for participating in citizen science.

<i>Barriers</i>	<i>Environmental CS experience (E-CS)</i>	<i>Non-environmental CS experience (NE-CS)</i>	<i>No CS experience (N-CS)</i>
<b>Logistical constraints</b>			
Timing of CS opportunities	✓	✓	✓
Access to transport/accommodation	✓	✓	✓
Unpaid	✓	✓	✓
Costs of participation		✓	✓
<b>Lack of knowledge and interest</b>			
Poor advertising	✓		
Lack of social or family network to be aware of opportunities	✓	✓	✓
No established interest in the topic		✓	✓
Not seeing people from a similar socio-economic background		✓	✓
No opportunities available in the local area			✓
Perceptions that CS is for older people			✓
Judgement from project organisers			✓
<b>Programmatic and organisational issues</b>			
Complete application procedures	✓	✓	
Unwelcoming environment	✓		
Poor working relationships	✓		
Lack of confidence in own practical skills and training	✓		
Not having a clear or impactful role	✓		
Boring activities		✓	✓
Competitive environment			✓
Ineffective management of the project			✓
Fear of lone working and safety		✓	✓



### *Logistical constraints*

Among all FGDs, young people discussed the unpaid aspect of volunteering which has negative impacts due to the high costs of living, the problem of maintaining full-time work and high participation costs such as transport, accommodation and equipment purchases. Across all FGDs, a lack of access to transport was cited, particularly in rural areas. Similarly, a lack of available accommodation was a major concern:

*I think there's a lot of factors, like access, and physical transportation, especially in rural communities, transport is a big issue and that's a barrier to get to certain sites that are more rural. Secondly, I would say that unpaid volunteering can be hard for people who don't have the time to do that, because they need money to pay rent and food, and just living. Thirdly, in certain areas, housing is also expensive (V6, E-CS).*

Across all FGDs, the timing of events was mentioned. Many individuals described how most opportunities take place during the working week, offering limited flexibility for those in full-time study or employment.

### *Lack of knowledge and interest*

Across all FGDs, a lack of knowledge of opportunities was attributed to a lack of peer, family or co-worker networks who were not active in CS:

*Firstly, it's the whole being aware of what's around you, you might be able to go and visit lots of like Wildlife Trust reserves, but not necessarily know that the volunteering goes on there. So, I think that can be sometimes a problem. Especially if you don't know people that are already volunteering, or you don't have people around you that are aware (V1, E-CS).*

A lack of knowledge of opportunities was associated with poor advertisements and marketing. Several individuals with E-CS experience, explained that searching for opportunities online was overwhelming particularly, when advertisements did not effectively communicate the role, purpose, requirements and benefits of the scheme. A lack of interest in a particular subject was frequently cited among those that with NE-CS and N-CS experience and the importance of seeing young people from similar socio-economic backgrounds:

*I know a lot of people with backgrounds in council estates in central London that would love the opportunity to go into rural areas and volunteer in something that they feel would make a difference. The difficulty in involving them is that they wouldn't want to do it without others from a similar background and even if they had heard of it, many wouldn't get involved in an organisation they knew nobody from (V22, NE-CS).*

Among those with N-CS experience, CS was often associated with older people therefore, the potential benefits accrued from participating were often unknown or not relatable. This group also highlighted how negative judgements from project organisers and other volunteers of their abilities would negatively affect their confidence to participate:

*You wouldn't want to be looked down upon, by your lack of like knowledge or insight into the area (V27, N-CS).*

### *Programmatic/organisational issues*

Those with E-CS and NE-CS experience, identified complex and demanding application processes and roles that require specialist skills as deterring them from applying. Similarly, those with E-CS experience, highlighted unwelcoming environments and poor or hostile relationships between project staff and volunteers. This group also identified a lack confidence in their role due to poor training, communication and support from project leaders:

*They plonk you down in a field and it's like OK go, you've received no training or very minimal training, especially if you know, can't hop on WhatsApp, and ask the other volunteers. I'm having this problem, what do I do? I think the idea of just not knowing 100% what you're doing and feeling alone is a huge turn off (V8, E-CS).*

Those with NE-CS and N-CS experience, explained that being allocated the boring and repetitive tasks would deter them due to a lack of variety, as well as fears of lone working on farms particularly for women. Those with N-CS experience, were not attracted to competitive working environments, or poorly managed projects.

### *Recommendations for diversifying youth in citizen science*

A range of recommendations were identified from FGDs to broaden the diversity of young people in our proposed CS initiative including: overcoming logistical constraints, raising awareness and improving communications, overcoming programmatic and organisational issues, enhancing social opportunities, diversifying CS roles and create tangible impacts (Table 5).

#### *Overcoming logistical constraints*

Those with NE-CS and N-CS experience, advocated for organisations to cover the expenses of citizen scientists. Across all FGDs, several individuals suggested reimbursing participant transport, accommodation and equipment costs, providing lift shares or residential accommodation. Extending the timing of events to evenings in the summer, weekends and student vacation periods and offering taster sessions for new volunteers to experience an event before making a longer-term commitment was also important.

#### *Raising awareness and improve communications*

Across all FGDs, participants identified a need to improve the content of advertisements by describing the purpose, cause, expectations, support offered and the benefits of the initiative to prospective citizen scientists. Some individuals suggested encouraging citizen scientists to document and share stories of their experiences through blogs and videos so others could learn about the project. Across all FGDs, several individuals suggested broadening the dissemination of adverts through social media platforms and connecting with universities and colleges, workplaces, churches and community groups to advertise opportunities more widely:

**Table 5.** Recommendations for broadening participation of young people in citizen science.

<i>Recommendations</i>	<i>Environmental CS experience (E-CS)</i>	<i>Non-environmental CS experience (NE-CS)</i>	<i>No CS experience (N-CS)</i>
<b>Overcome logistical constraints</b>			
Provide support for transportation and accommodation	✓	✓	✓
Flexible working hours	✓	✓	✓
Offer taster days	✓	✓	✓
Cover expenses		✓	✓
<b>Raise awareness and improve communications</b>			
Improve the content of adverts	✓	✓	✓
Broaden the dissemination of advertisements	✓	✓	✓
Dissemination of project news/updates	✓		
<b>Overcome programmatic and organisational issues</b>			
Allow experienced surveyors to mentor, train and support amateur surveyors	✓		
Create a buddy system or ‘task force groups’ where citizen scientists work together on specific tasks	✓		
Simplified application process	✓	✓	
Create a forum to give feedback to inform the project development/progress	✓		
Welcoming environment	✓	✓	✓
<b>Create social opportunities</b>			
Use online networks (WhatsApp, Slack) to bolster communications between scientists, and citizen scientists	✓		✓
Foster an online community of events for citizen scientists through introductory events, meet-ups, training events, and regular talks	✓	✓	✓
Create a buddy system to overcome issues of lone working	✓		
Allowing new citizen scientists to bring friends to events		✓	
<b>Diversify CS roles</b>			
Create digital roles for citizen scientists to take photographs, blogs, or newsletters of their experiences	✓	✓	
Create public engagement and outreach roles	✓	✓	
Create desk-based roles to support data entry and analysis		✓	
<b>Create tangible impacts</b>			
Create evidence of skills obtained	✓		
Evidence impacts of volunteer contributions	✓	✓	
Create mentoring schemes where scientists support a citizen scientist to provide guidance and advice on career progression	✓		
Allow citizen scientists to present the results of the work to stakeholders	✓	✓	
Provide regular project updates	✓	✓	
Create a reward system		✓	

*I feel the best way to get involved with them would be to partner with other community projects that they are aware of and know the people that run them. (V22, NE-CS).*

Those with E-CS experience, believed sustained participation was dependant on maintaining regular communications with volunteers through blogs, newsletters, and engagement events to keep them updated on project progress.

### *Overcoming organisational/programmatic issues*

Those with E-CS experience, suggested making some CS roles less specialist and open to amateurs. Several individuals emphasised the importance of providing adequate training and support and developing a buddy system or 'task force groups' where participants work together. These activities were thought to foster team cohesion and overcome issues of lone working. In turn, giving citizen scientists a voice to offer feedback on project progress through face to face and online discussions with project staff was important. Across all FGDs, fostering a welcoming environment with opportunities to recognise and reward volunteers to cultivate a sense of belonging was suggested:

*The community garden projects that I'm part of, you know, sharing in the benefits of that, like getting the crop shares and sharing the food and the resources and there's little things that just help make you feel connected to something that builds that sense of community and belonging and you know a sense of like value and purpose to your engagement (V7, E-CS).*

### *Create social opportunities*

Across all FGDs, young people suggested developing face to face and online events for participants to socialise with one another and project organisers. Those with E-CS and N-CS experience, suggested facilitating communications online through forums, or messaging groups for citizen scientists to raise issues and offer feedback. Those with NE-CS experience, suggested allowing participants to bring friends from different backgrounds along to events to encourage wider participation:

*Anyone who maybe isn't middle class wouldn't ever apply to anything like this. Because they would feel like they look like they are they're less privileged, and they would feel really out of place, so they wouldn't want to do it. I think being able to sign up with a friend and do it with a friend would be nice especially someone who you know maybe is not so interested in conservation (V22, NE-CS).*

### *Diversifying citizen science roles*

Those with E-CS and NE-CS experience, suggested creating digital CS roles and working with students from arts and digital backgrounds to bolster project communications for example, by documenting and sharing experiences through blogs, newsletters and videos. Similarly, engagement and outreach roles were suggested where individuals act as ambassadors to give talks and raise awareness of the project to target groups, or to help meet the needs of the landowners where the research was taking place:

*It would be great to have a platform through which volunteers and farmers could communicate with each other such as a community forum. I know of a farm where the farmer rents out strips of his fields for agroforestry. The strips can be planted with different trees which companies can then make use of (such as nut trees). This gives us an opportunity for farmers to rent out land and connect with people outside of farming. When buffer zones are introduced next to water for example, on farmland these areas can be used for biodiversity to grow a new crop. Could volunteers then be responsible for helping to market the new crop? (V6, NE-CS).*

Those with NE-CS experience also suggested creating desk-based roles for individuals interested in diversifying their research and analytical skills.

### *Create tangible impacts*

Those with E-CS experience, valued projects that provided evidence of their participation through a certificate of skills acquired, or logbook of volunteer hours. Those with E-CS and NE-CS experience, discussed the value of making a visible impact on a particular cause. For example, in our proposed initiative, several young people expressed an interest in working with farmers and scientists to create management plans from the wildlife survey data and giving talks to share project news with farmers and community groups. Those with NE-CS experience, discussed the importance of recognising the value citizen scientists bring to a project through reward systems that make young people feel valued and appreciated such as certificates of acknowledgement and organising events for volunteers and team members to celebrate their contributions.

## **Discussion**

### *Motivations*

There was an overlap in motivations expressed for participating in CS among young people with different CS experiences, but also some key differences. Our research findings showed that motivations for career progression were unified across the groups, matching previous studies [West et al., 2021]. Individuals from all CS experiences were drawn to opportunities that offered diverse experiences to bolster their knowledge and practical skills, although the focus differed across groups, with different ambitions to build their resume, support university and job applications, establish networks, mentorship and build their reputation [Alender, 2016; Lopez, 2021; Ng, Duncan & Koper, 2018]. Our study identified mentorship as a unique motivation to those without previous CS experience, these individuals described previous internships and work placements that allowed them to further their skills and knowledge in particular sectors. Mentorship discussions were also linked to securing reliable references to advance their careers. Therefore, one strategy for attracting non-engaged groups may be to include a mentorship component to enable knowledge sharing and learning for participants [Ng et al., 2018], with the added value of mentors serving as first time referees.

The opportunity to learn new things was also a common motivator for participation across different CS experiences [Asingizwe et al., 2020; Ganzevoort, van den Born, Halffman & Turnhout, 2017]. However, our study found that only participants with previous CS experience were motivated by experiences that

allowed them to develop and ascertain their own interests. CS offers volunteers a chance to try out a diversity of roles including data collection experiences, independent fieldwork, analysis and dissemination of data to better understand their skill sets and interest. Creating flexibility within CS roles to allow citizen scientists to carry out a diversity of tasks may create new learning opportunities and pathways for career progression.

Our study also found that young people across all CS experiences exhibit altruistic motivations for participation and were attracted to initiatives that allow them to visibly impact a particular cause. In our study, young people also demonstrated a preference for CS projects that also offer social interactions for volunteers to meet likeminded people particularly, when moving to a new area. Altruistic motivations are common among young people in the initial phases of recruitment, but also to sustain their long-term participation particularly, for projects which centre on fostering social interactions through enhanced community engagement and advocacy [Ward-Fear, Pauly, Vendetti & Shine, 2020]. Interestingly, only those with NE-CS experience, identified several unique motivators including the social aspect of meeting other volunteers and community members from different backgrounds that caused them to 'raise their awareness of their own privileges'. The integration of community engagement goals to a project may enhance feelings of being part of a community, belongingness and enhanced knowledge and awareness of social issues that are rarely touched on in the literature.

Inclusivity was also highlighted as a common motivator among all groups particularly when CS projects are open to all irrespective of prior experience. Young people were motivated to contribute their own knowledge and expertise to a cause and were attracted to opportunities that provide a forum to voice their ideas and opinions. CS has the potential for scientists and citizens to interact and mutually share knowledge. However, this level of involvement is dependent on the type of CS project [Rüfenacht et al., 2021]. Contributory projects operate where citizen scientists act primarily as data collectors, collaborative projects, allow opportunities for participation beyond data collection and co-created projects, are co-designed, developed and executed by scientists and the public [Shirk et al., 2012]. Examples of co-created CS initiatives include the Networked Youth Research for Empowerment in the Digital society (WYRED) Project that have developed a framework to promote the transfer of perspectives, knowledge and ideas among young people and decision-makers on topics related to gender stereotypes on the internet [García-Holgado, García-Peñalvo & Butler, 2020]. Other researchers have suggested that giving a broader voice to participants in CS may provide intangible benefits through increased empowerment and self-efficacy [Chesser, Porter & Tuckett, 2020; King et al., 2020].

Finally, unique to those with E-CS experience, citizen scientists were attracted to opportunities that allow them to connect with new places and nature. Young people with E-CS experience enjoyed participating in projects where they could pursue outdoor activities such as birdwatching. Human-wildlife interactions have also been shown to have positive impacts on human well-being [Brock, Perino & Sugden, 2017] through stress alleviation and attention fatigue, highlighting the benefits of being outside [Cobar, Borromeo, Agcaoili & Rodil, 2017; Ratcliffe, Gatersleben & Sowden, 2013]. In our study, physical activity and exercise was identified as a common motivator for young people across all groups. Across all



groups, the need to get outside was also justified by the recent lockdowns enforced under the COVID-19 pandemic. One study highlighted the role that time outdoors and in nature can play in bolstering young people's resilience to stressors such as the COVID-19 pandemic; underscoring the need to facilitate outdoor recreation opportunities for youth during times of crisis [Jackson, Stevenson, Larson, Peterson & Seekamp, 2021].

### *Barriers for participation*

Participation in CS requires financial resources and an investment of time. In our study, across all groups, logistical barriers such as being unpaid, the lack of transport or accommodation, prohibitive participation costs and the timing of volunteer opportunities were clear barriers to participation commonly reported in the literature [Winch, Stafford, Gillingham, Thorsen & Diaz, 2021].

A lack of awareness of CS opportunities were a barrier, attributed to poor social, family or work networks. A plethora of research identifies a positive relationship between the social capital of individuals, defined as the ability of actors to secure a benefit by virtue of membership in a social network [Portes, 1998] and volunteering [Layton & Moreno, 2014]. Therefore, people with low levels of social capital may be less likely to participate, because they lack the networks that know of CS opportunities [Forbes & Zampelli, 2014]. No prior interest in the topic was also cited as a barrier for participation following other studies that have shown similar findings [Pandya, 2012]. For those with no CS experience, lacking knowledge or formal education in a particular subject limited confidence in their own abilities to participate. This is corroborated by other studies that show a higher dominance of participants in CS with higher education levels [Merenlender et al., 2016].

Poor advertising by not selling the benefits of the programme was also a barrier for participation. A recent review paper of volunteerism suggests young people can hold negative views about volunteering that influences their participation [Southby, South & Bagnall, 2019]. Similarly, in our study it was a common assessment among those with no CS experience, that CS and volunteering were for older people. Therefore, this group could not easily envisage the benefits of their participation. Related to not seeing benefits, is not seeing people from the same socio-economic background, that prohibited certain groups of young people from participating. Sometimes CS opportunities may also be organised in unfamiliar, alienating, or non-inclusive environments [Hinojosa, Swisher & Garneau, 2021]. For example, some environmental CS projects are often located in the countryside. As well as the logistical barriers for young people from urban areas, a further barrier can be the lack of a sense of belonging in rural landscapes that are traditionally seen as places inhabited by middle class white people [Neal & Agyeman, 2006; Ward Thompson et al., 2003].

The participation of young people may also be affected by the conduct of CS organisations. Some unique issues identified in this study include fears of lone working, competitive environments and poor relationships between project organisers and volunteers which have been less frequently cited in the literature. In other CS projects, volunteers have reported negative perceptions of scientists who have been described as aloof, intimidating, used unfamiliar jargon and rarely



interacted with volunteers which hindered trust building [Rotman et al., 2014]. Conversely, other studies have reported concerns among scientists that if citizen scientists lack the necessary skill or proficiency to follow project protocols or scientists lack confidence in their skills, data may be de-valued or even discarded [Burgess et al., 2017]. Such concerns may negatively impact the perceived legitimacy of the project in the eyes of both volunteers and scientists, necessitating a need to build competency and trust between different parties.

### *Broadening the participation of young people*

The voluntary nature of citizen science raises important questions surrounding the unpaid nature of many CS projects, which negatively impact young people or socio-economically disadvantaged groups that cannot afford the demands on their time, and high costs for transport, accommodation and equipment costs. In some projects, a variety of compensation and payments such as reimbursements of expenses, small payments from indirect participation in project activities (e.g., for coordinating or providing equipment) or crowdfunded projects, as well as direct payments to participants, may be important to improve inclusivity [Haklay et al., 2021]. We urge project organisers to consider financial compensation for participants at the project planning stage however, we also recognise that the suitability of these approaches needs to be evaluated according to the resources and the social and cultural context of the project. Monetary compensation can be one way to overcome financial barriers for participation, but can also introduce biases, negatively impact volunteer motivations and compromise data quality [Asingizwe et al., 2020; Lawrence, 2006].

Our study, also identified a range of other ways to acknowledge and recognise volunteer efforts outside monetary benefits to sustain ongoing motivations to participate such as creating evidence of the knowledge and skills acquired through certificates, logged evidence of volunteer hours and accreditation through college and degree courses. Other suggestions included, acknowledging and celebrating the contribution of citizen scientists by providing rewards through social events. Therefore, at the start of a project, project organisers need to provide clear information on the type of compensation or reimbursements and how benefits or participants will be presented and communicated to prospective citizen scientists.

This study identified a lack of awareness of CS projects, as well as an understanding of the CS role, requirements of the project, level of support provided and benefits were key barriers to participation. Therefore, targeted promotion, advertising and marketing for recruiting people may raise awareness and understanding [Crall et al., 2017; West & Pateman, 2016]. This means creating visually appealing and informative advertisements that detail the purpose, requirements, support offered and benefits of the scheme for participants. In turn, targeted dissemination of advertisements may improve recruitment. Traditional approaches to recruitment such as by word of mouth or through social media channels are likely to recruit people similar to those already engaged. Therefore, accessing clear entry points into CS particularly for those with no CS experience, are sometimes crucial and facilitated through other institutions (e.g., schools, work, universities, churches, community groups) [Webber, 2011]. Therefore, tapping into relevant social networks such as student unions, universities, local community groups and workplaces may extend the reach of advertisements.

Our study also identified several recommendations for overcoming programmatic and organisational factors conditional to the management of a CS project. Enhancing inclusivity is important by creating opportunities for all regardless of prior knowledge, skills and experiences at the recruitment stage of a project. In these circumstances, adequate support needs to be built into CS programmes to provide training for amateur citizen scientists to build knowledge, competency and confidence in their role.

To overcome issues of lone working and to build a social component to the CS experience several suggestions included establishing a buddy system where more experienced participants mentor amateurs. Similarly, task force groups where volunteers work together on a task may also build team cohesion. Diversifying CS roles beyond target data collection was also identified to engage a wider population of young people with different knowledge and skills. Several suggestions included tailored digital roles (e.g., creating blogs, newsletters and videos documenting local experiences), public engagement roles (e.g., to disseminate project outcomes news) and desk-based roles (e.g., data entry, and analysis of survey data).

Following other studies our findings highlight importance of providing social opportunities for participants to interact with one other through online platforms [Asah, Lenentine & Blahna, 2014]. This could be achieved through WhatsApp, Slack and Yammer and used to share knowledge, address concerns and updates on project progress. Building an inclusive working environment by providing a welcoming and friendly environment was important, for example, several individuals suggested bringing a friend along to new CS events to build their confidence, particularly for those with no CS experience. Other ideas including building opportunities to share opinions and feedback on the project. Several CS projects have integrated participatory elements into the design of projects where young people express their ideas, interests through dialogue, face to face conversations and online forums [García-Holgado et al., 2020]. Collaborative and co-created projects such as these provides examples of how citizens can interact, feedback, share knowledge and learning from their experiences with scientists. CS projects that offer avenues for feedback can also build trust with contributors by sustaining ongoing motivation to participate [Tiago, Gouveia, Capinha, Santos-Reis & Pereira, 2017].

## Conclusions

Our results provide novel findings on the motivations, barriers and recommendations of factors that may enhance youth engagement in CS particularly, those with no prior CS experience, an often-unexplored group. Our findings show that recruitment strategies targeting younger people requires a multi-faceted approach to appeal to young people with different CS experiences particularly, in the exploration of what appeals to non-engaged groups. However, our small sample size and a lack of accounting for the diversity of projects that fall under the E-CS and NE-CS categories, may influence the diversity of personal motivations and outcomes identified by different groups. Therefore, these findings, may preclude drawing inferences about a larger population. Similarly, one of our focus groups (E-CS) was skewed toward females which may have introduced biases within the responses. Future sampling issues could be overcome by extending the advertisements for participants by identifying specific selection criteria over a longer time period to achieve the desired participant characteristics.

Nonetheless, our research identifies the importance of evaluating personal motivations, barriers and locally grounded recommendations from people with different CS backgrounds when developing new projects. Similar efforts to investigate motivations for participation, particularly among those with no experience of citizen science, should be conducted across different audiences in different age-groups and life-stages. This effort will help recruit specific target groups and develop retention strategies for ongoing projects. Project organisers must also keep in mind their specific project goals and protocols when designing recruitment strategies as there may be mismatches between the CS opportunities currently offered and the opportunities sought by people from different CS backgrounds. Creating or modifying CS projects and CS opportunities to match interests and sharing research implications of how to best overcome barriers to participation will enable project organisers to attract new audiences from diverse backgrounds.

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