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CHANGE – THE TRANSFORMATIVE POWER OF CITIZEN SCIENCE

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Abstract:

We are in a time of rapid change on multiple levels. Change can be seen as positive by one group and negative by another. As a result, different perspectives on any given change can draw completely different conclusions. In these proceedings we want to address different approaches to change from all kinds of perspectives within the realm of citizen science and participatory research.

We discuss both active, transformative change, and the observation of change monitored by citizen science in all kinds of disciplines.

We highlight the potential of citizen science to be a change maker in research and society, and as a tool to manage the change happening around us.

The proceedings "Change – The transformative power of citizen science" showcase a selection of topics that have been presented and discussed at the ECSA/ACSC 2024 double conference in Vienna and highlight the transformative power, citizen science can have.

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Change – The transformative power of citizen science

Editorial
The transformative power of citizen science

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Abstract

In these proceedings the growing and reflective community of Citizen Science actors give insights into their findings which were presented at the joint conference of Österreich forscht and the European Citizen Science Association (ECSA) in Vienna 2024. The conference key topic was *change*, since we face changes in various aspects, in nature and society as well in the way Citizen Science is executed and perceived. Enjoy reading and get guidance and inspiration for your further work in the field of Citizen Science.

Keywords: biodiversity research, open science, funding, innovation.

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Change as leading topic

Change was the leading topic of the joint conference of Österreich forscht and the European Citizen Science Association (ECSA). Integrated into the event was the celebration of already 10 years institutionalized existence of these two vibrant networks and catalysators. ECSA as institutionalization of joint efforts of different communities in different countries (Vohland et al. 2021), and Österreich forscht as bottom up community (Heigl et al. 2016).

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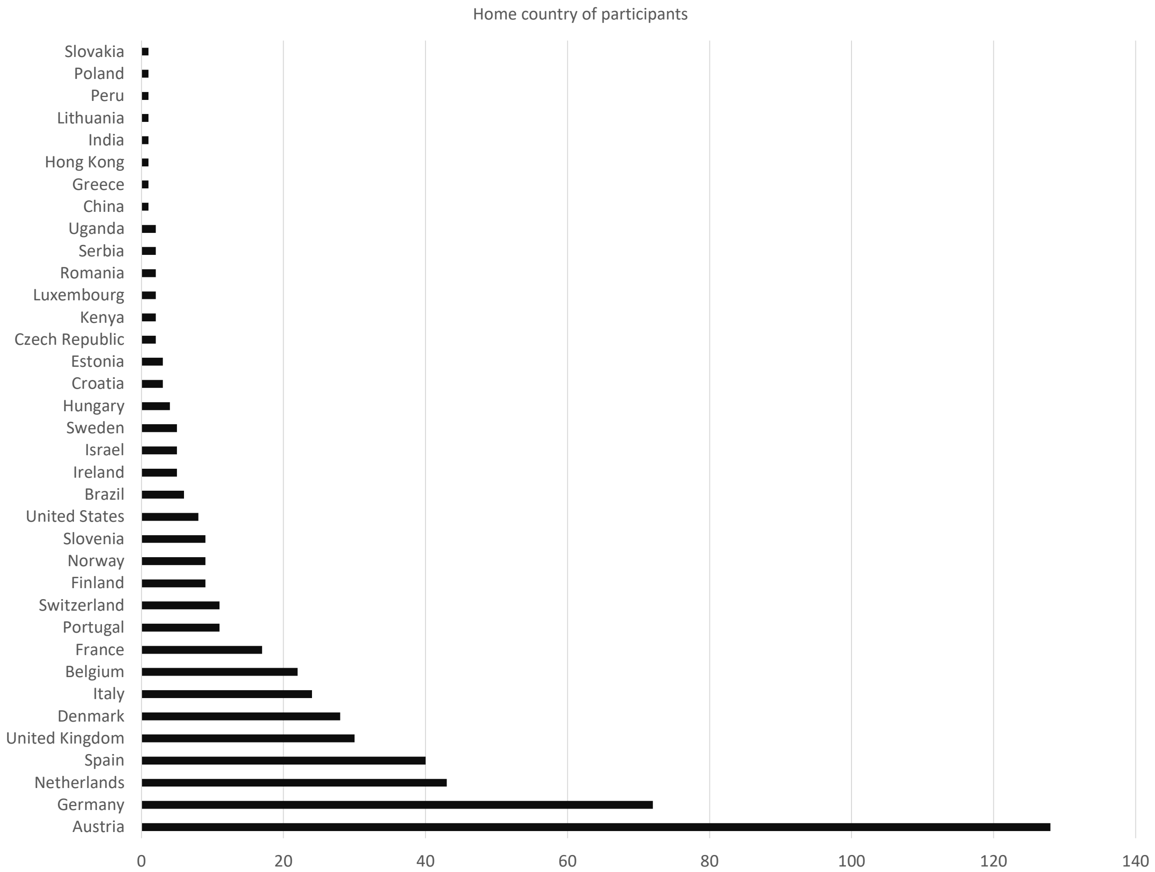

Figure 1. The country of origin of the participants.

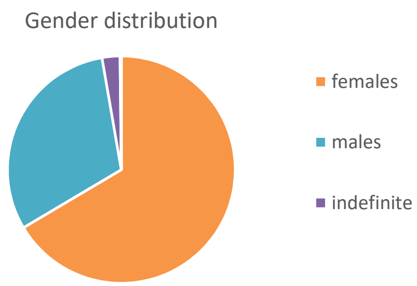

Figure 2. The gender of participants by self-declaration.

Change – for the better – that Citizen Science is linked to a positive change is the normative assumption behind all these activities. Especially now where we observe changes which frighten and upset us: the Big Acceleration with its consequences, the loss of biodiversity, weather extremes, lost habitats and wars in Europe. Citizen Science is seen as tool not only to support academic research but to increase ownership and self-efficacy as remedy against perceived and real faintness. This positive energy may be one explanation for the growth of the Citizen Science community. And indeed, the conference with its audience was beyond any expectation. In our funding proposal we assumed a number of 300–350 participants, but more than 500 from 36 countries (Fig. 1) representing mainly scientific institutions (Tab. 1), with a slight bias towards females (Fig. 2) registered and forced us to also explore the digital space. In this week in April 2024 we therefore celebrated contently the success of the large and growing Citizen Science movement which consists of so many persons and their networks, who are engaged in planning, running, financing, and evaluating Citizen Science.

Table 1. Type of institutions according to the affiliations of participants. Universities comprise all universities, scientific institutions all other research performing institutions. Museums and libraries are determined by self-nomination, NGOs comprise all non-governmental organisations, associations, etc.; companies, governance institutions, and funding organisations are clustered according to their mission, and one participant did not provide an affiliation.

Type of institution	Number of participants
University	193
Scientific Institution	71
Museum	41
Library	13
NGO	84
Company	47
Governance Institution	31
Funding Organisation	4
n.a.	1

Recent developments in Citizen Science

During the conference, we got knowledge of many different projects and approaches to initiate, detect and reflect change in the environment, in biodiversity, or in climate change impact. The areas initiate and enable changes and reflect changes comprised most of the contributions of the conference. New technical developments were proposed as well as the outreach to new communities to trace changes.

More social science-oriented disciplines provided increasing insights into historical, social, or economic interdependencies gained by citizen scientists, and explained how the different projects and approaches empower citizens in order to participate in our science-based society. Citizen Science is also increasingly reflected, for instance with regard to the reproduction of injustice (for instance with regard to access to digital Citizen Science tools, Aristeidou et al. 2024) or reproduction of colonial or hegemonial patterns (Austen et al. 2024; Kragh et al. 2024).

How Citizen Science can be used in schools was embraced by many contributors, for instance through programmes like “Sparkling Science”, funded by the Austrian Federal Ministry of Education, Science, and Research. Next to new knowledge gained for science and monitoring the kids gained insights into scientific working. But another aspect is extremely important: In schools, social segregation is less expressed than what we typically see in Citizen Science projects, a bias towards academically educated persons.

Impact assessment and evaluation of Citizen Science is a growing need not only for funders such as the European Union, but also for projects themselves as researchers want to understand if and how their projects met the intended goals or if they initiated change, as has been reflected by several workshops and presentations during the conference (e.g. Kieslinger et al. 2024).

Last but not least, the fast progress in information sciences during the last years allows to connect, visualize, and analyze data in a new dimension and follow the ECSA principles of Citizen Science (c.f. Robinson et al. 2018) with regard to openness.

Changing nature of Citizen Science

Looking back the last ten years, we saw Citizen Science changing from loose ideas and idealistic networks driven by enthusiastic volunteers to one pillar in the Open Science Strategy of the European Union, we consequently saw it changing from private initiatives to building blocks for the Open Science Policy in Austria or for European Funding Programmes such as Horizon Europe. Public funding in fact was an important driver of the success. When ECSA started, visionary institutions integrated the young association into their consortia. The contribution to the different projects then increased the epistemic and methodological capacity of ECSA while the overhead allowed to run the ECSA office which until today is hosted at the Museum für Naturkunde in Berlin, Germany.

In Austria, BOKU University not only hosted Österreich forscht at the beginning, but also gave Austria's Citizen Science platform a long-term perspective by providing tenured positions to its founders and an annual budget to further foster Citizen Science in Austria. Furthermore, the Austrian Federal Ministry of Education, Science and Research supported the annual Austrian Citizen Science Conference since 2015. Both allowed the network to grow and to realize essential partnerships, concepts and communities for the Austrian Citizen Science network.

The increasing importance and visibility also contain the risks of modification of Citizen Science from an expression of scientific independence to instrumentalizations, either as neoliberal approach for unpaid scientific work or putting co-benefits of Citizen Science such as scientific literacy or awareness raising to the front (Vohland et al. 2019).

Conclusions

This increasing significance impacts also the Citizen Science networks. They also change – or better broaden – from local associations to understand local environments to transboundary or even global initiatives relevant for Planetary Health such as the Mosquito Alert. Is the key interest to support Citizen Science research, i.e. new insights? Or is it in first place education, for instance STEM training? From international guests, economic power through the innovative potential of Citizen Science was expressed, perhaps similar to the European Union who sees scientific literacy as key asset for wellbeing. Citizen Science is also seen as an approach to improve environmental justice. So, Citizen Science is attributed a high transformative force (Austen et al. 2024).

Reciprocality, democratizing and co-creation are huge impact values. More discourses about the role of Citizen Science are urgently needed at different levels to clarify its functions for science and society.

Acknowledgement

The conference was possible due to the financial support of the Austrian Federal Ministry of Education, Science and Research. Additional support was provided by the city of Vienna, BOKU University, the Natural History Museum Vienna and the European Citizen Science Association. The Association of the Friends of the Natural History Museum Vienna supported the publication of the Proceedings. We also thank the large and dedicated teams helping to plan and run the conference, and namely Helga Auer as organizational master mind.

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Change – The transformative power of citizen science

Criteria for citizen science – a source of community empowerment or a barrier?

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Abstract

Citizen science (CS) initiatives are diverse, leading to a complex landscape of approaches and terminology. To address this complexity and foster a shared understanding, criteria were co-created with CS researchers, practitioners and citizen scientists to guide project inclusion on online CS platforms. At the ECSA2024 conference workshop, participants discussed the utility of these criteria, sharing experiences and reflections. The workshop employed a fishbowl exercise followed by a world café setup to delve into key topics such as project evaluation and progression, criteria and terminology application, and potential barriers to inclusion. Participants expressed caution regarding mandatory criteria, emphasizing the need for flexibility, particularly in the social sciences and humanities. While some criteria may enhance project communication and funding prospects, concerns were raised about the eurocentric nature and global applicability of the criteria. Despite limited familiarity and implementation of existing criteria, there is a growing understanding of their potential importance and usefulness within the CS community. Challenges remain regarding implementation processes and project exclusion concerns, but positive examples showcase the potential benefits of embracing criteria in CS networks and platforms.

Keywords: citizen science, criteria, ECSA2024, evaluation, inclusivity, online platforms, project repositories, terminology.

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Introduction

Citizen science (CS) comes in many shapes and forms, and a variety of different terms are used to describe this constantly evolving practice of engaging the public in scientific research. This complexity sometimes leads to uncertainty and confusion, both among researchers, but also in the interaction with other CS stakeholders, e.g., funders, evaluators, or potential collaborators. A way to address this challenge and move towards a shared understanding, is through the use of vignettes or characteristics (e.g. Haklay et al. 2021), principles (e.g. Robinson et al. 2018) or criteria (e.g. Heigl et al. 2020) to more clearly delineate what CS is. The ECSA Working Group on Citizen Science Networks has, over the last 3 years, co-created with CS researchers, practitioners and citizen scientists transparent and impartial criteria to be used as a guide for deciding if and when a project could be listed on online CS platforms, such as Österreich Forscht (www.citizen-science.at) or EU-citizen.science. Such CS platforms are often run by CS networks and aim to promote CS projects, facilitate CS stakeholder networking, and advertise CS-related events and news. Criteria can be partially amended or adjusted in a truly adaptive management approach by platform owners. If implemented, criteria have the potential to facilitate a system change on how CS networks collaborate, potentially facilitating acceptance of CS project listings across platforms. The criteria could also be useful for funding bodies, researchers and other CS stakeholders to inform their choices, evaluations, and decisions.

The goal of the workshop run at the ECSA2024 conference was to familiarize participants with the criteria developed and discuss how and where CS criteria might be: 1) a source of community empowerment; 2) useful in participants' work; and 3) seen as barriers and how to overcome such barriers. Thus, community empowerment was one of the core topics discussed, here seen as 3-fold: 1) the CS community who got involved in defining the criteria in the first place; 2) the CS community overall as implemented community-sourced criteria can enhance trust in CS; and 3) the local/regional/national CS networks (also communities) using, possibly after adapting to local conditions, the criteria, as it will strengthen their projects overall and again strengthen the trust in their projects and CS generally. We invited researchers, practitioners and other CS stakeholders to share their experiences with and reflections on criteria for CS and discuss how criteria could be most beneficial for CS projects, CS communities, and other actors involved, especially when applied to create shared understandings between researchers and other stakeholders.

Methods

After a brief introduction to the developed criteria, the 22 participants were invited to join discussions first through a "fishbowl" exercise with five chairs placed in the middle of the room and participants claiming an empty chair to join the discussion, sharing their own experiences, case studies and reflections on where and how criteria can most usefully be applied. The shared experiences and reflections were collected on a whiteboard and categorized into topics.

This was followed by a "world café" setup, where the three topics voted most important by participants were discussed, one topic per table. A facilitator was present at each table and participants could change tables at any time. A final wrap up session summarized the main results emerging from each table.

Results

Fishbowl

Participants initially shared their experiences on setting up or interacting with CS platforms, criteria, and decisions on projects to list, or their reflections on this. They reported using or considering using a variety of approaches, concepts and criteria (e.g., ECSA 10 principles, CS platform criteria), but it was difficult to decide which ones to use. Also, the timing of platform criteria implementation was discussed. Should criteria be implemented at the beginning of the platform setup process, or later when the platform is established, especially as some platforms have already been set up? Another topic was the time it takes for project co-ordinators to submit responses to criteria and platform coordinators to evaluate such submissions. Due to limited time available, criteria could be a barrier for submission of criteria responses by project coordinators. Likewise, further guidance from platform coordinators must be planned for and resourced, so this is available if needed by projects, and the evaluations of submissions must be resourced as well. Both of these time issues pose potential barriers to inclusion of some projects on platforms.

Concerns were also raised that strictly adhering to criteria could hinder consideration of future developments in the dynamic field of CS. Furthermore, the timing of project assessment was reflected upon. Should projects be evaluated at the beginning, during the project or after the project ends, if indeed it is time-limited? Should this evaluation be once or continuous?

After the fishbowl, participants voted to further discuss the topics of a) evaluation and progression of projects, b) which criteria and terminology to use, and 3) if criteria are a barrier and/or limitation to inclusion, at the three world café tables.

World Café: Evaluation and progression of projects

Participants felt that criteria should not be mandatory and that their application should be cautious. Participants mentioned that some good projects may be excluded from platforms, particularly those in the social sciences and humanities, where it is often more difficult to define what a CS project is. Also, some remarked that the criteria are very Eurocentric and cannot be applied worldwide. Participants considered that some criteria should be mandatory and others optional, i.e. that some criteria might be more important than others. Criteria could help projects be clearer in their communication about their CS approach. Use of criteria for evaluation purposes can be useful when it comes to funding projects. The discussion was very lively and participants felt that it should be continued as circumstances can vary depending on how, when and where criteria are implemented.

World Café: Criteria and terminology

Participants agreed that deciding on an appropriate terminology for "criteria" can be difficult and depending on the term chosen, it could cause barriers to inclusion, thus overlapping with the discussion in the third World Café. Potential terms discussed included "criteria", where some saw that term as too restrictive; "principles", where some saw that term as too high-level; and "guidelines", where some participants saw this term as too open. It was suggested to adhere and point to the ECSA ten principles as the foundation, though more in-depth "criteria" could be useful in setting standards and conduct evaluations, e.g. for policymakers and funders. There was general agreement that one term cannot cover all needs and a call to focus on "good practice" rather than strict rules.

World Café: Criteria as barrier or limitation to inclusion

Participants were critical of the use of strictly defined criteria, as such rigidity could deter people from even wanting to engage with CS platforms to get their projects listed. The wide variety of CS projects could also be a challenge for criteria, as relevance of criteria would depend on project goals. The criteria were seen as very academic and too Eurocentric, again possibly limiting their potential usefulness. However, some criteria, e.g. the ones on active involvement and mutual benefit, were suggested as useful for projects and thus being able to strengthen the implementation of projects. Criteria were also suggested to be beneficial for CS platforms as a sign of platform quality that projects had been vetted before being included for promotion on the CS platform.

Discussion

Very few participants in the room were familiar with the criteria developed by the ECSA CS Networks WG, and even fewer had applied them in practice. Apart from the Austrian platform experience using almost three times the number of criteria discussed at the workshop and from which the initial idea of using criteria originated, little experience has been gathered in this field. Conversely, most participants were not directly engaged in the management of platforms and, consequently, in the process of project selection, thus often the discussion revolved around the need for criteria, their usefulness or otherwise for particular projects, and on the "hard-to-define" concept of "citizen science". The variety of experiences and backgrounds among participants was surely a source of inspiration and enrichment, but at the same time added some complexity to the discussion, bringing a trade-off between the original aims of the workshop and the perceived uncertainty on the right way to approach the basic questions regarding use of criteria for CS platforms.

Conclusion

Many networks and platforms in Europe (with platform organisers participating in the WG) are hesitant to implement criteria or principles into their workflows, as there are still some open questions about implementation process and concerns over excluding some projects. Concerns mostly related to the time required on both the project and platform coordinators' sides, as well as the continuously evolving aspects of CS projects. Also, the criteria discussed were developed with a European perspective, possibly limiting their usefulness in other regions. These concerns highlight the need for CS platform organisers to carefully consider their national context and engage in dialogue with their national stakeholders, limiting barriers for inclusion, and ensuring opportunities are there to bring in voices that might otherwise not be heard. However, positive examples exist, e.g. Österreich Forscht, and the understanding for implementing criteria is increasing in the CS community.

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Change – The transformative power of citizen science

The promises of citizen science – fact or fake?

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Abstract

Despite its increasing popularity, not everybody is supportive of citizen science. Authors are critical of the promises that citizen science practitioners claim and challenge the role citizen science can play in the democratisation of science or in tackling societal challenges. They put the promises of citizen science under scrutiny and question that citizen science can increase trust in science among the public by participating in actual research. Some critics do not only deny the promises of citizen science, but even see a threat in it as it may jeopardize academic freedom or cement existing power relations.

Keywords: societal challenges, personal outcomes, social good, science-society relationship.

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Introduction

The promises of citizen science are as diverse as the topics and disciplines it encompasses. Citizen science is said to increase trust in science (EC 2020), democratize science (Irwin 1995) or empower participants. Thus, citizen science holds a "dense promissory discourse" (Strasser et al. 2019).

But what are (these) promises in citizen science and why do they matter?

A promise, in general language, is defined as a "declaration or assurance made to another person (usually with respect to the future), stating a commitment to give, do, or refrain from doing a specified thing or act, or guaranteeing that a specified thing will or will not happen" (Oxford English Dictionary 2024). From

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a psychological perspective, promises are "social contracts that can be broken, kept, or exceeded" (Gneezy and Epley 2014). Keeping a promise is viewed more favorably than breaking it. From a philosophical point of view, "promises are binding because the act of making a promise creates expectations in the promisee" (Patterson 1992). Therefore, the act of breaking a promise is considered morally wrong and deserving of criticism. In organizational studies, it has been shown that unfulfilled promises among employees lead to negative behavioral outcomes, such as less loyalty or lower performance and an increase in complaints (Fu and Cheng 2014). Therefore, promises are closely related to benefits, virtues and potentials and especially to expectations.

The aim of this research is to shed light on some promises that citizen science holds and criticism these promises attract. Criticism refers to "[t]he passing of judgement on a person or thing" (Oxford English Dictionary 2024). Another aim is to raise awareness among the citizen science community, especially researchers on how and why they may propagate prevalent promises.

Study approach

Presently, citizen science is hyped in Europe, fueled by the European Commission, various funding bodies, research institutions and governments. The promises citizen science holds are one cause for this push.

Promises

The promises of citizen science found in literature can be categorized according to the "greater democratization of science, better scientific literacy, and new scientific breakthroughs" (Strasser et al. 2019). In the following, these promises are subsumed under three categories: the benefits for society as a whole (the greater or social good), the relationship between science and society and personal benefits.

Social good

The promises guaranteeing benefits for an entire society are related to the advancement of knowledge (in science), to the creation of a healthy environment (McKinley et al. 2016) or to increasing well-being, such as public health (Broeder et al. 2018). Additionally, citizen science holds the promise to influence policymaking (Schade et al. 2021). Another promise related to greater social good is that citizen science can help achieve the Sustainable Development Goals (SDGs) by defining, monitoring and implementing them (West and Pateman 2017). Other promises related to tackling societal challenges by means of citizen science according to Chari et al. (2017) are "more robust, open, and democratic decision-making processes", the empowerment of communities as well as transformative change.

Criticism in this regard includes that citizen science cements power relations, contributes to the neoliberalization of science and platform capitalism (Mirowski 2017) instead of instigating real-world change.

Science-society relationship

Citizen science has gained increasing traction in the European Union, including in its funding schemes. The European Commission (EC 2020) states that citizen science "has the potential to improve research and its outcomes and reinforce societal trust in science" and increase "science literacy and confidence of the public in research", thereby highlighting the role of citizen science in improving the relationship between science and society. The democratization narrative is seen as a means to overcome "the elitist barrier between scientists and the public" (Strasser et al. 2019). Another promise is that citizen science can increase the public understanding of science (Bonney et al. 2016). Moreover, there is the promise that through acquiring scientific literacy the acceptance, support and uptake of science among the public can be improved. Furthermore, citizen science can generate knowledge in previously underexplored areas and expand the scientific worldview (Strasser et al. 2019).

Criticism centers on the implications of the democratization of science. First, the way how citizen science is implemented may even reinforce (and not challenge) "existing knowledge paradigms and associated power dynamics" (Tubridy et al. 2022) and patronize citizens instead of empowering them. Additionally, researchers may have hidden agendas and exert their interests on the participants (Mirowski 2017) instead of acting in the interests of society at large. Second, the democratization of science may jeopardize academic freedom (Mirowski 2017) as everybody would have a say in academic research. Third, democratization might mean that citizen science has to align with the life worlds of its participants.

Additionally, citizen science usually relying on the support of volunteers, can be seen as an exploitation of citizens. Could citizen science even deteriorate the science-society relationship and burn bridges, for example, in a case where academic findings do not align with the lived experience of the participants or when communities are abandoned after a project concludes? This raises ethical concerns about building relationships with participants only to potentially disappoint them when the project concludes.

Another criticism here is that academics might be seen as superfluous and that citizen science results in "the social dumping of paid professionals and the "Uberizing" of research" (Strasser et al. 2019). Moreover, studies on the science-society relationship have mixed results, for example, whether citizen science can increase trust between citizens and researchers (Bela et al. 2016).

Personal benefits

The promises related to an individual's benefit in citizen science (mainly focused on the participants and not the researchers) are the acquisition of disciplinary knowledge (Peter et al. 2019) or scientific skills (Gönner et al. 2023), such as data collection or reporting skills and increased (environmental) stewardship (Phillips et al. 2018). Additionally, changes in behavior or attitudes as well as new skills and enhanced self-efficacy (Peter et al. 2019) are personal benefits of the participants.

Criticism with regard to personal outcomes is based on studies that are inconclusive whether participation in a citizen science project results in a long-term change in behavior, attitudes or self-efficacy (Peter et al. 2019).

Keeping promises is difficult…

The citizen science community gives these promises to various actors, including funding bodies, the participants, academia, the public or policymakers. While there are studies demonstrating the potential of citizen science, they often face challenges in interpretation due to their small scale, contextual limitations, and project-specific focus. With regard to the socio-political impact, we see a "vision-reality gap for citizen science" (Gönner et al. 2023).

Moreover, there is a lack of standardized metrics to validate these claims. It is important that the citizen science community critically reflects on these promises and their propagation and urges caution against making overly sweeping claims. A means to assess whether a citizen science initiative kept its promises is the Citizen Science Impact Assessment framework based on five impact domains, i.e. society, environment, economy, science and technology and governance (Wehn et al. 2021).

The European Union and funding bodies contribute to heightened expectations of citizen science and promote these promises. Many funding schemes require applicants to outline the anticipated 'impact' of their projects. Some promises are overly broad, such as "increasing public understanding of science" or "democratization of science", making it difficult to determine if a project has fulfilled them. These (too) broad claims have also called critics on the scene contesting the role citizen science can play in the democratization of science or in tackling societal challenges. Some critics do not only deny the promises of citizen science, but even see a threat in it as it may jeopardize academic freedom (Mirowski 2017).

Therefore, Pandya et al. (2018) recommend that the citizen science community analyses the actual outcomes of their projects, for example through longitudinal studies to track changes in individuals' and communities' scientific knowledge, skills, attitudes and behaviors across different citizen science projects.

Conclusions

Citizen science holds a wide variety of promises related to the social good, the improvement of the relationship between science and society and personal benefits for both researchers and participants. This contribution serves as a word of caution against overhyping the potential of citizen science. Since the science-society relationship is at the heart of many of these promises, researchers should be wary of propagating promises that might be difficult to fulfil, as unkept promises can be highly damaging to this crucial relationship.

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Change – The transformative power of citizen science

The role of citizen science in public engagement with socio-scientific debates

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Abstract

Human societies face many challenges for which scientific knowledge is essential to gain a broader and in-depth understanding of the problems and possible solutions and alternatives. However, fake news, anti-science claims and misinformation unbalance much-needed public debates on socio-scientific issues. Conversely, failure to convey a clear and transparent message about science can also contribute to the emergence or growth of controversies. There is no simple solution to such a complex problem, but the introduction of collaborative and participatory approaches to research, as a way of involving the public in the production of scientific knowledge, can be a powerful strategy for promoting trust in science, while integrating a critical view on research work. We recently proposed a new concept, engaged citizen social science, which aims to provide a theoretical framework for deeper engagement of citizens with science. This concept is being tested in a HE-funded project that integrates social sciences and humanities in the development of a new biosensor technology. Biotechnology is a hot topic in socio-scientific debates, involving issues such as control, risks, access to data, democratisation of science or governance. By engaging in structured conversations with different publics, we are mapping these and other cultural and social perceptions, exploring dimensions of representation (ideas and cultural meanings about the technology) and identity (who the public is considering knowledge, proximity to the technology, and scientific information consumption). The results of these social dialogues influence the project's research agenda and the production of the communication outputs, thus also having the potential to influence scientific policies in this area. Here we present the preliminary results of this mapping and discuss our findings in relation to our dialogical strategy.

Keywords: engaged citizen social science, biosensors, public engagement with science, cultural and social perceptions.

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Introduction

Living in societies increasingly dependent on science and technology, science and society dialogues are essential to the functioning of contemporary democracies (Davies et. al. 2019). But a current scenario marked by fake news, anti-science claims and misinformation unbalances much-needed public debates on socio-scientific issues (Jonsson and Grafström 2021). Conversely, failure to convey a clear and transparent message about science can also contribute to the lack of public engagement on socio-scientific debates.

The introduction of collaborative and participatory approaches to research, as a way of involving the public in the production of scientific knowledge, can be a powerful strategy for promoting trust in science, while integrating a critical view of research work. This action mode is at the heart of citizen science, a growing field that aims to bring scientists and citizens together in the production of scientific knowledge (Irwin 1995; Vohland et al. 2021). These dynamics have important impacts on the scientific and the social communities, contributing to alternative models of knowledge production, promoting dialogues among the different members of both communities, and fostering a commitment to respond to or address socio-scientific questions (Trench 2008; Bonney et al. 2009; Kullenberg and Kasperowski 2016; Bonhoure et al. 2019; Campos et al. 2021).

We sought to incorporate citizen-science approaches in the research and communication of the Horizon Europe project BioAssembler (https://bioassembler.eu/). The project has an interdisciplinary approach and two major goals: 1) to develop a new generation of biosensors, and 2) to promote societal engagement about the impact of the technology. Despite being very present in people's daily lives, biosensing technologies are not widely discussed, and their development is linked to important debates in biotechnology, such as control, data privacy, democratisation and governance. Our interest, therefore, was to create a social dialogue that can feed both the project research and communication. In this paper, we present the preliminary results of the second goal—the creation of the project's communication outputs—which began by identifying the proximity of youth to science and their social perceptions and knowledge about biosensors.

Theoretical framework

The analytical and practical work described here is based on the concept of engaged citizen social science (Campos et al. 2021). As an advance in the understanding of citizen science, the concept addresses the inclusion of participatory and collaborative practices embedded in social challenges to favour the integration of non-scientific knowledge and other types of community-based knowledge. It is thus rooted in an idea of citizen science that is flexible, to accommodate other knowledge production systems, and dialogical, to create a two-way engagement with science: citizen engagement with science and scientists' engagement with society (Campos et al. 2021).

This vision is aligned with a growing body of research that demonstrate the importance to observe science communication as a process of (co)construction of meanings, which considers the experiences and identities of the public in creating connections with scientific topics (Davies et al. 2019). In the scope of

BioAssembler, this perspective is being used to co-create a visual dictionary of biosensor-related knowledge integrating contributions from scientists and citizens. However, given the complexity of the science behind biosensor's development, the first step was to comprehend who the public is considering their knowledge of biosensing technologies and consumption of scientific information, as well as their social perceptions around this technology.

Methods

This paper describes part of the citizen science approach to the social dialogue within BioAssembler, with students from two professional school classes in the city of Coimbra, Portugal. Two visits to their school were organized to 1) characterize students' interest in science and technology and their perception of biosensors and biotechnology and 2) discuss the concepts and questions related to biosensor's development and applications that should be integrated in the visual dictionary. Different methodologies were used, including a 13-question questionnarie that covered personal details, consumption of science information and knowledge of biosensors and biotechnology and two round-table debates. Students responded to the questionnaire and debated more general aspects of biosensors in the first visit. In the second visit, students discussed and revised the overall concept of the dictionary, contributing to its development with suggestions for new entries and for the writing style.

Preliminary results from the questionnaires

Sixteen students completed the surveys. 37,5% were 17 years old and 62.5%, 18 or older. Regarding gender, 56,25% identified as male, 31,25% as female, and 12,5% chose "another option". Concerning their consumption of scientific information, we were able to identify some results:

- the majority (75%) answered that they rarely search for information about science;
- most of the students revealed that they have some interest (43,75%) or almost no interest (43,75%) in science and technology, and only 12,50% said they had a lot of interest;
- as for the preferred medium to get information about science[1], the most popular choices were online (100% of participants), movies and documentaries (56,2%) and social media (50%);
- as for the most interesting formats for content about science[1], the most popular choices were video (100% of participants), audio (56,2%) and art and illustrations (31,2%);
- as for the motivations for consuming information about science[1], the most popular choice was curiosity and personal interest (56,2% of participants), followed by learning (43,8%);
- as for the barriers to engage in content about science[1], the most expressive reasons were the lack of examples and situations applicable to my reality (31,2% of participants) and the lack of interest in the topics (31,2%).

[1] These questions allowed multiple choices

The group was also asked about the terms biotechnology and biosensors.

- 68,75% considered that the term "biotechnology" was "not very familiar", while for 18,75% it was "very familiar" and for 12,50% it was "not at all familiar".
- as for the term "biosensor", 50% considered it "not very familiar", 43,75% considered it "not at all familiar", and 6,25% said it was "very familiar".
- concerning their perception of the impact of biotechnologies on society, most respondents said they could not form an opinion (62,5%), while 37,5% had a predominantly positive perception; none of the respondents said they had a negative perception.

Discussion

Engaged citizen social science (Campos et al. 2021) involves people actively participating in scientific research and data collection, focusing on social issues. This approach democratizes research by integrating local knowledge and experiences, enhancing the relevance and impact of studies on societal challenges, and empowering communities as key stakeholders in the research process. It also defies the boundaries between researchers and citizens, allowing the latter to interfere with the research process. But low familiarity to a given scientific subject can hinder citizen interest and/or engagement with the science (Frensley et al. 2017).

This preliminary data helped to understand the group's acquaintance and general feeling towards the technology. Responses hinted at which themes and examples might or not produce identification, providing a starting point and narrative strategies to address socio-scientific debates or complex messages. Data provided more substance to reflect on the potential of creative forms of public engagement with science and contributed to our understanding of the reasons behind difficulties in recruiting and keeping citizens involved in the research and communication processes, and confirmed the unfamiliarity with the topic of biosensors and biotechnology (Ikegwuonu et al. 2018). Being a citizen science-based co-creation process, the results obtained are being incorporated into the development of the visual dictionary. The citizen contribution for the development of the dictionary is expected to continue with other citizen groups.

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Change – The transformative power of citizen science

Changing for the better: starting to explore citizen science and the development of community resilience

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Abstract

This paper explores the transformative potential of citizen science (CS) in building community resilience during natural and technological disasters. Citizen science involves the engagement of non-professional scientists in scientific endeavors, providing invaluable contributions in data collection, enhancing community awareness, and building local capacities. The cooperative relationships fostered between citizens, academics, and governments are critical for creating informed, localized policies that resonate with community needs and foster resilience. This paper elaborates on the theoretical underpinnings, methodologies, and empirical findings of an initial study, offering first insights into how CS can be systematically integrated into resilience strategies.

Keywords: community resilience, citizen science, participatory methods, hazard protection, public policies, data collection, social capital.

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Introduction

The global rise in natural and technological disasters, exacerbated by climate change and urbanization, underscores the urgent need for effective disaster risk reduction and resilience-building strategies. As a result,

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there is the urgency to make disaster risk reduction and the promotion of resilience a core element in public policy, especially in the case of developing countries (Data Pop Alliance 2015). Resilience emerges both from top-down strategies at the state level and from bottom-up approaches at the local community level, which allow communities to plan and prepare for, absorb, and recover from disasters, adapting to new and diverse conditions (National Research Council 2012).

Community resilience refers to the ability of social entities to withstand, adapt to, and recover from adverse situations. It is increasingly recognized that resilience involves not just recovery, but also the capacity to learn from past disasters and adapt to future challenges (Folke 2006). Citizen science has emerged as a significant participatory approach that involves communities in scientific research, enhancing local knowledge and fostering collaborative problem-solving (Jordan et al. 2015). This paper critically examines the role of citizen science in augmenting community resilience, providing new perspectives on its potential for widespread application.

Methods

This study adopts a broad conceptualization of resilience, viewed as a dynamic process encompassing planning/preparation, absorption, recovery, and adaptation in response to disasters. Citizen science is integrated as a pivotal tool for empowerment and engagement across these stages, with varying levels of citizen involvement from passive data collection to active research design and decision-making (Haklay 2013).

A systematic literature review was employed, utilizing major databases such as Scopus and Web of Science, to explore the nexus between citizen science and community resilience. It is important to note

Table 1. Inclusion criteria used for article selection.

Inclusion criteria	**Scopus**	**Web of Science**
Keywords	Resilient/Resilience Citizen Science Crowd Science	Resilient/Resilience Citizen Science Crowd Science
Subject Area	Social Sciences Business, Management and Accounting Economics, Econometrics and Finance	Social Sciences Interdisciplinary Economics Management
Document Type	Article Review	Article Review Article
Language	English Portuguese	English Portuguese
Scopus Full Query Search		
TITLE-ABS-KEY ((resilien* AND ("citizen science" OR "crowd science"))) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ECON")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Portuguese"))		

the limitations associated with the methodology employed: the keyword search was restricted to a limited set of terms, which may not have captured all relevant studies, particularly those that use fewer common terminologies or synonyms not included in our initial list. Furthermore, by limiting our search to Scopus and the Web of Science, we excluded grey literature and other scientific outlets that might be extensively utilized by the citizen science community. The search was conducted following the PRISMA framework (Moher et al. 2015), aiming to encompass a broad array of studies without temporal restrictions. To identify relevant articles, keywords such as resilience, resilient, citizen science, crowd science were used. Table 1 details inclusion criteria used in the search. This approach enabled a detailed exploration of the roles and impacts of citizen science in resilience initiatives globally.

The keyword search retrieved 377 articles from the selected electronic databases, and applying the selected inclusion criteria the number was reduced to 35 articles. Following the removal of 2 duplicates, 33 articles were preliminarily assessed based on their abstracts and keywords. Subsequent evaluation led to the exclusion of irrelevant studies, narrowing the pool to 22 articles. Of these, one article was inaccessible, and 9 were later excluded for lacking clear information on the CS impact, resulting in 12 articles suitable for detailed analysis.

Results and Discussion

The analyzed articles showcase citizen science (CS) initiatives across various global locations, including Nepal, Puerto Rico, Brazil, Italy, the USA, and Australia. These initiatives focus on addressing natural environmental hazards such as floods, extreme heat, and volcanic activities. The level of citizen involvement in these CS projects ranges from basic crowdsourcing to more engaged participatory science approaches. The most common forms of participation noted were distributed intelligence, where citizens engage in simple data gathering and interpretation tasks, and participatory science, which involves citizens more deeply in defining problems, collecting data, and analyzing it with expert support.

The analysis did not uncover instances of extreme citizen science, hinting at a possible need for enhanced educational and training programs to enable more effective citizen involvement in complex data analysis and interpretation. This identifies a critical need for enhancing educational and training programs to enable effective citizen involvement in more sophisticated aspects of CS projects.

Also, the systematic review illuminated several key roles of citizen science across different phases of disaster management:

- **Planning and Preparation:** CS initiatives are crucial for collecting data in remote or understudied areas, thereby aiding in the development of early warning systems and localized preparedness strategies (Pandeya et al. 2021). This proactive involvement allows for better tailored emergency response strategies that are contextually relevant and scientifically robust.
- **Absorption:** During disasters, citizen science contributes to the collection of real-time data, which is vital for understanding community responses and adapting ongoing strategies to manage the crisis effectively (Zhao et al. 2021).

- **Recovery:** Post-disaster, CS helps assess the effectiveness of recovery efforts and gather community feedback, which is instrumental in refining resilience strategies (Stone et al. 2014).
- **Adaptation:** Citizen science also facilitates the involvement of community members in designing and implementing long-term adaptation strategies. This engagement empowers communities, enhancing their preparedness for future challenges and ensuring sustainable resilience practices (Hoffman 2020).

The main conclusions derived from the systematic review corroborate the significant impact of citizen science (CS) on disaster management across various stages, further underscoring the need for integrating these initiatives into broader resilience frameworks (Kliewer and Priest 2019; Sittenfeld et al. 2022). Enhanced engagement through citizen science not only garners local knowledge and community-generated data but also amplifies the policy relevance of such information, ensuring that resilience strategies are not only scientifically robust but also contextually relevant and supported by those they aim to protect.

Conclusion

Citizen science offers a valuable approach for enhancing community resilience by promoting a culture of preparedness and informed response. This paper emphasizes the need for integrating citizen science into broader resilience frameworks to ensure that community-led initiatives are effectively supported and leveraged.

This initial study identifies several practical implications for policymakers and disaster management practitioners. The implementation of citizen science approaches can lead to more informed, community-centered policymaking, thereby enhancing the effectiveness and acceptance of resilience strategies. Additionally, the development of citizen science projects can serve as a catalyst for building local capacities and fostering a culture of preparedness and innovation (Gray et al. 2017). Finally, future research could explore a deeper literature review or apply complementary methods, such as qualitative interviews or participatory action research, to further increase our understanding of citizen science practices and how they contribute to community resilience.

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Change – The transformative power of citizen science

Then and now: citizen scientists help assess the changing biodiversity of minnows in Austria

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Abstract

The minnows of the *Phoxinus* genus were long thought to be a single species, as even experts found it difficult to distinguish them by external features. In the last 20 years, however, their status has changed dramatically as molecular studies have revealed a high level of genetic diversity within this group of fish. Currently, more than 23 genetic lineages are known in Europe, of which 14 are recognised as valid species. In Austria, instead of one common minnow, studies have revealed at least four species, three of which are presumed native and one introduced. The Citizen Science project “Biodiversity of minnows in Austria”, funded by the Federal Ministry of Education, Science and Research as part of the “Sparkling Science 2.0” Programme, aims to collect and analyse the missing data to determine the number of minnow species swimming in Austrian waters. With the help of pupils from six different schools across Austria, fisheries associations and numerous independent fishermen, the minnows are being sampled extensively and their genetic lineages determined. Basic data on their habitat is also being collected using standardised forms. At the same time, the project team is analysing up to 200-year-old specimens from the fish collection of the National History Museum in Vienna to assess the rate of change in the minnow’s biodiversity. Our initial results confirm the native distribution of three minnow species in Austria and show several mixing zones between them, which may not be natural. This is therefore a study of change: on the one hand, changes in genetic diversity over time are evaluated. On the other hand, it highlights the changes that new methods are bringing to our scientific and general knowledge about biodiversity. One of the most dramatic consequences of human impact on our planet is the continuing loss of global biodiversity. What better way to experience these changes than by actively participating in a study designed to assess them?

Keywords: *Phoxinus* minnows, Citizen Science, museum collections.

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Introduction

The minnows of the *Phoxinus* genus are cold loving species inhabiting different kinds of oxygen rich waterbodies (Frost 1943). At the end of the 18th and up to the beginning of the 20th century, several species of *Phoxinus* were described, e.g., *P. marsilii* (Heckel, 1836) and *P. csikii* Hanko, 1922. However, as even experts found it difficult to distinguish them by external features, they were all synonymised under one species, *Phoxinus phoxinus* (Linneaus, 1758), the common minnow, whose distribution range included Europe and Asia. In the last 20 years, however, their status has changed dramatically as first some morphological studies (Bogutskaya et al. 2004; Kottelat 2007) and later molecular studies (Geiger et al. 2014; Palandačić et al. 2017; Palandačić et al. 2020) have revealed a high level of genetic diversity within this group of fishes. Currently, more than 23 genetic lineages are known in Europe, of which 14 are recognised as valid species (Palandačić et al. 2017; Denys et al. 2020; Bogutskaya et al. 2023).

In Austria, instead of one common minnow, studies have revealed at least four species, three of which are presumed native (*P. marsilii*, *P. csikii* and *P. lumaireul* (Schinz, 1840) and one introduced (*P. phoixinus*; Palandačić et al. 2020). However, a denser sampling and a more detailed genetic analysis are needed to determine the number of *Phoxinus* species in Austria, their distribution and the state the populations are in. Finally, when analysed, museum specimens up to 200 years old can help determine the changes in biodiversity of Austrian minnows.

The Citizen Science project "Biodiversity of minnows in Austria", funded by the Federal Ministry of Education, Science and Research as part of the "Sparkling Science 2.0" Programme, aims to collect and analyse the missing data to determine the number of minnow species swimming in Austrian waters. In addition to scientific goals, the project also foresees the transfer of modern methods and procedures of biodiversity research into the educational system. Among objectives is also raising awareness of issues such as biodiversity loss and the problem of introduced species.

Methods

With the help of pupils from six different schools across Austria, several cover fisheries associations and numerous independent fishermen, the minnows are being extensively sampled (Figure 1A) and their genetic lineages determined. For this purpose, sampling kits have been prepared, containing information on minnows,

1A 1B

Figure 1: Pupils working on different activities within the project; 1A collecting minnows at Purkersdorf, Lower Austria in June 2023; 1B counting the number of vertebrae and fin rays on a stained minnow.

standardised forms to collect basic data about the habitat, instructions for sampling and swabs to take DNA samples. At the same time, the project team is analysing the historical minnow specimens.

Upon receipt of the collected DNA samples, DNA is extracted using the Qiagen QIAmp DNeasy Blood and Tissue Kit (QIAGEN, Germany) according to the manufacturer's protocol. Cytochrome oxidase I (COI; so-called barcoding fragment) was then amplified by polymerase chain reaction according to the protocol described in Palandačić et al. (2017) and sequenced in one direction at Microsynth (Vienna, Austria). The raw sequences were visually inspected and aligned using MEGA 6.0 software (Tamura et al. 2013). To determine species, sequences were compared using a simple phylogenetic tree reconstruction analysis with the same software.

In addition to the scientific results, several field trips and workshops were organised for the pupils involved. After a theoretical introduction to minnows and their biodiversity, the students went out collecting, accompanied by the scientists involved in the project. They then learnt and carried out DNA extraction and analysis methods, with pupils in the last two years of the secondary school programme carrying out the species identification analysis and presenting the results in the form of a scientific talk or poster (Figure 2). Workshops for younger students included a more creative approach, preparing posters of the minnow food chain and colouring the minnow models to represent their hidden biodiversity. Finally, all students were able to work with stained minnows, which allowed them to count different skeletal features such as the number of vertebrae and fin rays (Figure 1B). To accompany the workshops, all materials were prepared also for the teachers and made available online.

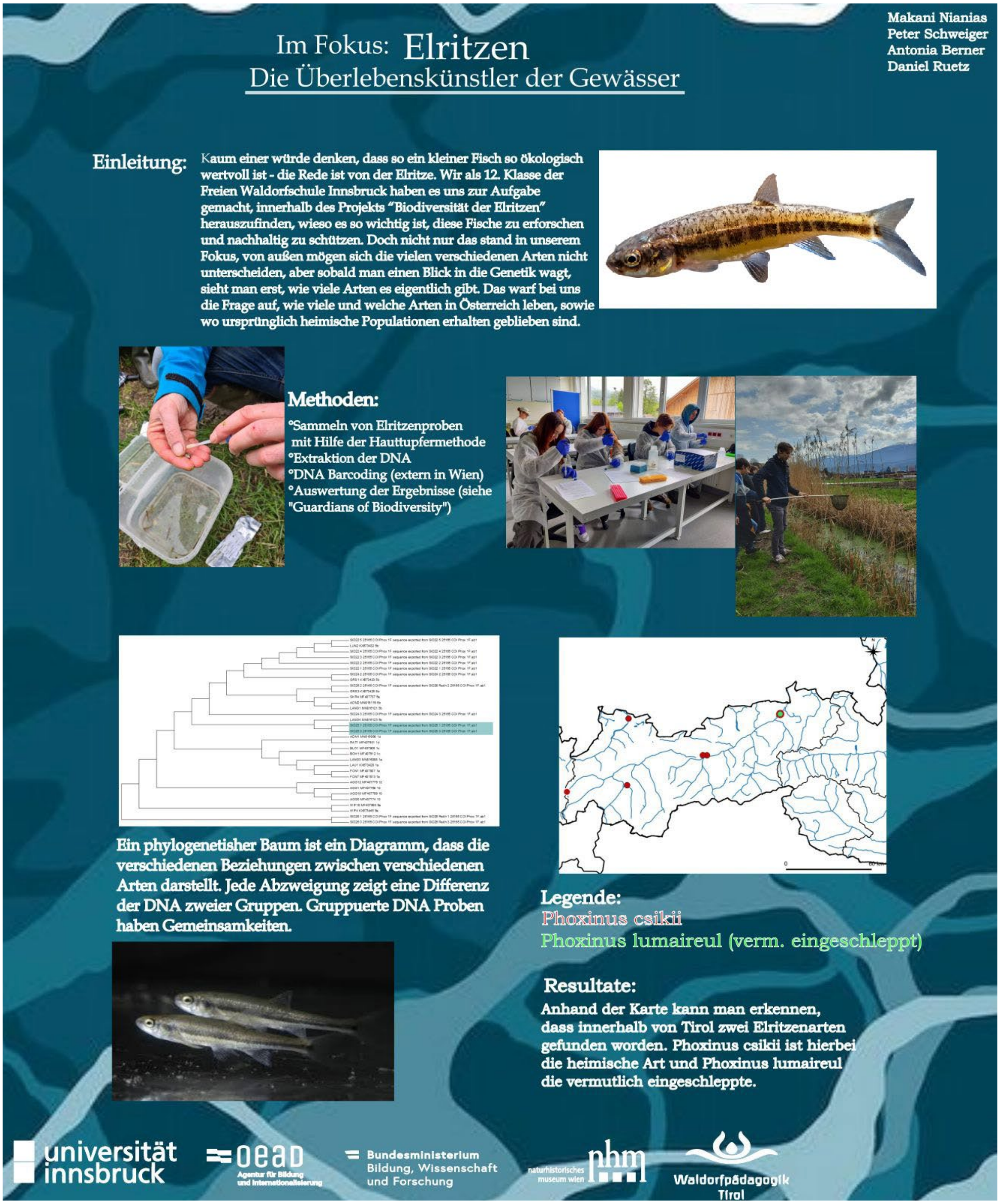

Figure 2: A scientific poster prepared by the pupils about their work on *Phoxinus* minnows. The poster includes all chapters relevant for presenting scientific study.

Results

In the first 1.5 years of the project, 174 fin clips, 91 swabs, 84 whole fish were collected and analysed. Of these 349 specimens, the pupils (accompanied by project scientists) collected 70 (20%) and the fishermen collected 155 (44%). The rest, 124 (36%) was collected by scientists and field biologists not directly involved with the project. This was another positive effect of the project, as even in scientific circles the biodiversity of the minnows in Austria was not known. The results confirmed the presence of three native and one introduced species in Austria. So far, the introduced species appears to be present only at two sites in Styria and at Lake Constance. Two of these populations, one in Styria and the one in Lake Constance, are a mixture of two species - one native and the other introduced. Further, mixtures of two native minnow species were also detected in several other areas, however these may point to the natural hybridisation zones.

Discussion

As shown by the results, future sampling should focus on the areas with less data (Styria, Carniola) and on possible hybridisation zones. The DNA samples already collected in the hybridisation zones should be analysed in more detail, not only to identify the species, but also to infer possible introgressions between species in these populations.

In summary, this project has enabled us to collect valuable data on the biodiversity of minnows throughout Austria. As all nine different federal states have different rules for obtaining collecting permits, fishermen were a crucial stakeholder in providing us with this data. Together with pupils, these two groups of citizen scientists have supported biodiversity research in Austria, while at the same time experiencing research first-hand. Thus, the project is helping to raise awareness of conservation and reduce scepticism about science. What better way to experience changes in biodiversity than by actively participating in a study designed to assess them?

Acknowledgment

This project (SPSC_01_021) is funded by Federal Ministry of Education, Science and Research and the Austrian Agency for Education and Internationalisation and its Sparkling Science 2.0. Programme. The collecting was performed with the help of cover organisations Landesfischereiverband Nieder Österreich, Landesfischereiverband Salzburg, Tiroler Landesfischereiverband, Verband der österreichischen Arbeiter-Fischerei-Vereine, Wiener Fischereiausschuss, Landesfischereiverband Steiermark. We would like to thank the editor Sven Schade and the two reviewers, Ulrike Sturm and Agostino Letardi, for the helpful feedback.

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Change – The transformative power of citizen science

Lichens and air quality: a new citizen science approach

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Abstract

Citizen science has been widely adopted in monitoring air quality by indexes of lichen diversity. Since the identification of lichens is challenging, volunteers are often involved in adopting simplified sampling protocols, which require identification at a higher level than the species, or the use of morpho-types, or colors. In Italy, a simple citizen science protocol for monitoring air quality with lichens by involving schools has been successfully tested, and will be replicated at the national level.

Keywords: anthropic pressure, biomonitoring, identification, schools, urban ecosystems.

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Lichens, air quality and citizen science

Epiphytic lichens have been used as bioindicators since the second half of the 20th century (De Wit 1983). They are also used in several citizen science efforts for assessing air quality (e.g. Counoy et al. 2023). A first relevant experience with schools was carried out in the UK during the ’70s (Gilbert 1974), followed by several experiences at different scales.

This study aimed at developing a replicable, cost-efficient protocol for monitoring air quality in an early warning, permanent network in Italy, involving (mostly, but not exclusively) high and junior high school students. Schools were selected as targets for the study since, being present everywhere in the country, they could provide ideal nodes for the network. Plus, hands-on participatory activities are particularly appreciated by students and teachers. The activity was supported by the Municipality of Verona, its Natural History Museum, the CariVerona Foundation, the Italian Association for Citizen Science, National Biodiversity Future Center, Botanical and Lichen Societies, and WWF.

Identification of lichen species

Lichens identification is quite a challenging task, especially for volunteers, since it often requires spot tests, and microscopic features. McMullin and Allen (2022) reported (from iNaturalist research grade records) a rate of correct observations of 59% for lichens which can be identified by macroscopic morphological features. The rate dropped to 7% and 5% when microscopic or chemical features were required. Munzi et al. (2023) reported an error rate of ca. 70% for iNaturalist observations for three towns, Palermo, Turin and Lisbon. The error rate of volunteers during the CSMON-LIFE project (LIFE13 ENV/IT/842) ranged from 14% for the very easy-to-identify *Xanthoria parietina*, up to 55% and 52% respectively for the easy *Flavoparmelia caperata* and *Evernia prunastri*, and 86% of the relatively difficult *Diploicia canescens* (Martellos et al. 2021).

Given these experiences, a protocol for monitoring air quality by means of epiphytic lichens with a citizen science approach should not require identification, at least at the species level.

The protocol

The monitoring protocol does not require the identification of lichens, but rather of “morphological functional traits” (Fig. 1a–d), defined as:

a) crustose lichens (two-dimensional thallus completely attached to the substratum with its lower surface, resembling a crust);
b) narrow-lobed foliose lichens (two-dimensional thallus attached to the substratum by means of small root-like structures, free at least at the margins; marginal lobes not wider than 3 mm);
c) narrow-lobed foliose lichens (same as b, but marginal lobes wider than 3 mm)
d) fruticose lichens (three-dimensional thallus)

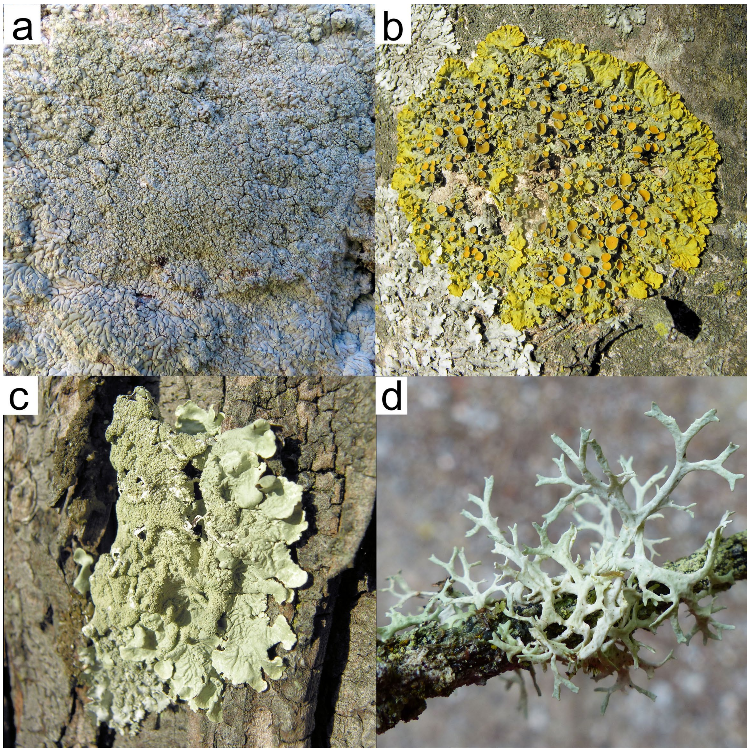

Figure 1. The four morphological functional traits: a) crustose lichens (as an example, a thallus of *Diploicia canescens*); b) narrow lobed foliose lichens (*Xanthoria parietina*); c) broad lobed folios lichens (*Flavoparmelia caperata*); d) fruticose lichens (*Evernia prunastri*).

The protocol requires the monitoring of survey sites with a radius of 50 meters. Starting from the center, 3 trees must be surveyed for lichens. The trees must belong to genera with a similar pH and texture of the bark (Hawksworth and Rose 1970). The protocol allows the surveying of *Populus nigra*, *Quercus* ssp., *Tilia* ssp., and *Ulmus glabra*. The trees should be isolated (at least 5 meters one from the other), without signs of mechanical or chemical disturbance, straight (inclination < 10°), not included in hedges.

Each tree's score ranges from 0 to 3, as follows: 0 – no lichens, or crustose lichens only; 1 – presence of foliose, narrow lobed lichens; 2 – presence of foliose, broad lobed lichens; 3 – presence of fruticose lichens.

Scores should be stored in a spreadsheet with the following columns: survey site number; address; coordinates; tree 1 score; tree 2 score; tree 3 score.

Volunteers must follow the following workflow:

1) identify a survey site, and report its data in the spreadsheet;
2) select the trees, according to the guidelines;
3) survey each tree for morphological functional traits between 100 and 200 cm from the base, and report the score in the spreadsheet;
4) take an image of each tree on the side with the higher-scoring morphological functional traits.

The surveying process (1 to 4) must be repeated for each survey site volunteers plan to investigate. At the end of the experience, the spreadsheet and the images are sent to a repository for validation and verification.

Results

The activity was carried out in Verona (Northern Italy), during a week (19–24 September 2023). Ten schools (junior and junior high), 14 classes and ca. 300 students monitored 176 sites and 528 trees.

All data were verified by expert lichenologists. Plus, 10% of the survey sites were resampled for verification, and no bias emerged.

The average score per site (sum of the score of each tree divided by the number of trees) ranged from 0 to 2.5. Considering the center of Verona only, it ranged from 0 to 1.67, demonstrating a higher anthropogenic impact. The distribution of the survey sites (Fig. 2) is uneven, concentrated around each school, hampering general considerations. However, lower scores were obtained in areas where vehicular traffic is more intensive, as expected, given the sensitivity of lichens to phytotoxic gases deriving from fuel combustion.

After the elaboration, all the data, along with a simple manual describing how they were processed and mapped, were returned to the schools, to allow replication of the activity.

This first experience provided relevant feedback, which led to the protocol's improvement, in order to make the data more informative.

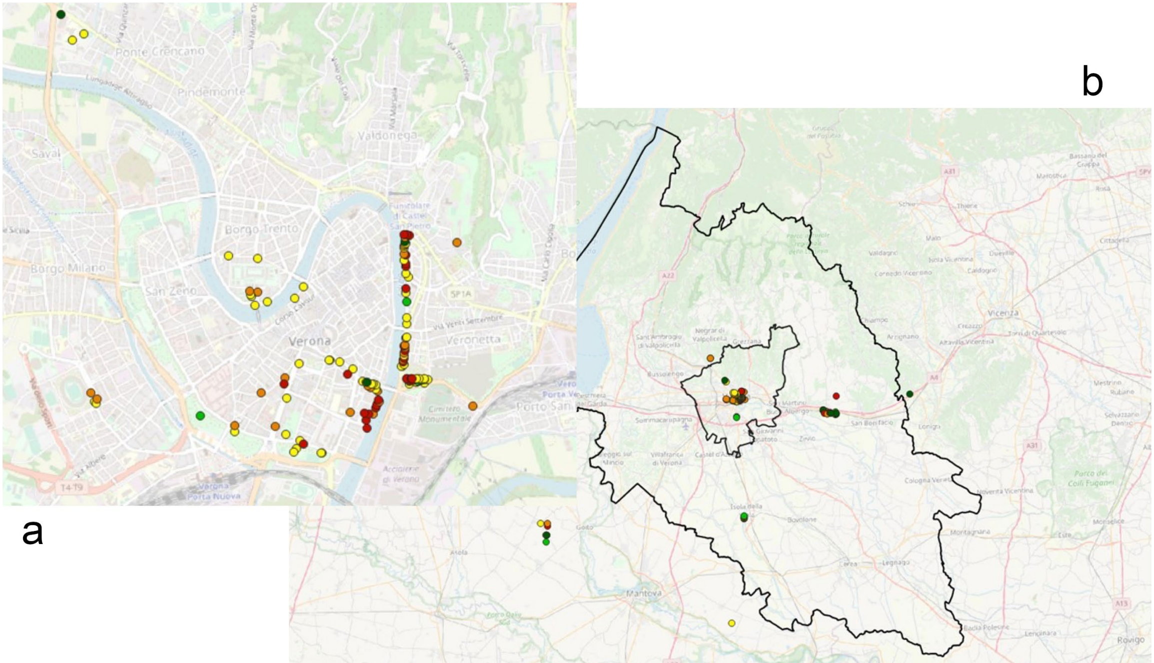

Figure 2. Survey sites. Depending on the score, the survey sites are colored in red (lower score) to green (higher score): a) magnification of the urban center of Verona; b) the whole study area.

As a consequence, the score is now: 0 – no lichens; 1 – crustose lichens; 2 – narrow lobed foliose lichens; 3 – broad lobed foliose lichens; 4 – fruticose lichens. Furthermore, volunteers are asked to report, in cases 1–3, also the coverage, i.e. the total area of the tree which is covered by lichens, providing a second score as follows: 1 = <5%; 2 = 5–25%; 3 = 25–50%; 4 = 50–75%; 5 = >75%.

Conclusion and future perspectives

The results demonstrated the feasibility of a sustainable, replicable protocol for monitoring air quality using epiphytic lichens as bioindicators involving volunteers in a citizen science approach. The protocol is a trade-off between how much informative the data are and the difficulty of the task which have to be performed by volunteers.

This experience was a first test. The protocol and the approach will be replicated at a national level between 2024 and 2025, thanks to the support of the Italian National Biodiversity Future Center (https://www.nbfc.it)

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Change – The transformative power of citizen science

The citizen science project “AmphiBiom”: a quest to mitigate habitat loss for the European green toad

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Abstract

We aim to understand the distribution and environmental drivers for the occurrence of the European green toad (*Bufotes viridis*) in Austria and create breeding habitats for it. Citizen scientists can use a custom smartphone application (AmphiApp) to record data such as the calls of anurans and photographic documentation. The records are validated by experts. To provide breeding habitats for green toads, we gave citizen scientists 300 small plastic ponds (1.20L × 0.9W × 0.4D m) to place on their land (garden, backyard). These citizen scientists will monitor their pond every two weeks for two seasons (March–August 2024 & 2025) for the occurrence of amphibians and their invertebrate prey. During the first two months, most pond owners have been highly motivated and have followed the monitoring scheme, despite the involved procedure, likely due to our active engagement with them (e.g., during the pond delivery by team members, emails, phone calls and messaging within AmphiApp).

Keywords: AmphiApp, amphibian, aquatic invertebrates, breeding ponds, conservation, frogs, observational data, toads.

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Introduction

Amphibians are among the most threatened taxa in the animal kingdom. Global change, including habitat loss and degradation, is one of the major factors driving the ongoing decline in biodiversity. Human-made habitats can mitigate the negative impacts for some species, such as the AmphiBiom project's target species, the European green toad (*Bufotes viridis*). These toads' primary habitats (steppes and wild river floodplains; (Stöck et al. 2008) are scarce in contemporary Europe; however, toads are still found in cities and suburban areas (Landler et al. 2023; Vargová et al. 2023). Due to the projected drier weather conditions, green toads could become increasingly dependent on human-made breeding sites. Thus, anthropogenic effects in particular, such as chemical pollutants and noise pollution, could impact this species. A large study in Switzerland found that providing breeding habitats alone can be an effective conservation measure for amphibians (Moor et al. 2022). In addition, citizen science can be an effective method to monitor amphibians in an urban context and to advance conservation of this endangered animal group (Lee et al. 2021).

The aims of our AmphiBiom project are to better understand the distribution of green toads in Austria, and to identify factors that contribute to their occurrences.

Methods

We collect amphibian distribution and breeding calls data through a dedicated mobile phone application (AmphiApp) developed specifically for the AmphiBiom project. It is advertised through the project website (www.amphi.at), public outreach events (e.g., podcast), and media work (newsletter, social media). Citizen scientists record all amphibian observations including species, location, breeding calls and pictures of the habitat where they observed the individual or the animal itself. The recorded photographs and calls in the app will provide us with new information about the distribution and possibly expand the known range of the green toad and other amphibians.

Furthermore, through media outreach we solicited volunteers throughout Austria to receive and monitor a small artificial pond to place on their property (Fig. 1). Interested people applied for the ponds and we selected them based on proximity to green toad occurrences, location characteristics and tried to stratify them in the green toad range. Finally, we selected 300 localities. All of which were asked to install and use our customized phone app. The citizen scientists maintain comparable conditions throughout (e.g., no plants, sufficient water level, lack of substrate; see Fig. 1), and check their pond every two weeks in March–August, 2024 and 2025). Monitoring uses AmphiApp to record all observed amphibians and the invertebrates present in the pond. Invertebrates collected using a small provided aquarium net that is moved through the pond twice describing the figure eight, placed on a white plate, photographed, and transferred to a plastic tube filled with 70% ethanol, to be identified by experts later.

Figure 1. An artificial pond used in the AmphiBiom project (dimensions: 1.20L × 0.9W × 0.4D m), with a coconut mat that allows animals to climb out. Photograph by Lukas Landler.

Results

So far, we can only report preliminary results as data collection has just commenced. Most people who installed ponds, do take part in regular monitoring. However, close contact is required with the citizen scientists, including continuous quality control. Apart from the pond initiative, we received about 6 times more picture-based recordings than breeding calls. We notice a bias for citizen scientists to record specifically green toads versus other species, although the application provides the option to record all Austrian amphibians.

In many cases, ponds have been initially colonized by mosquito larvae, water striders and mayflies. However, backswimmer bugs and water beetles were also reported, showing the slow but steady colonization of the established ponds. Luckily, the first amphibians were also recorded, starting with the smooth newt (*Lissotriton vulgaris* during the week beginning February 26, 2024), also including common toad (*Bufo bufo*, during the week beginning March 11, 2024), water frogs (*Pelophylax* sp. during the week beginning April 1, 2024), and our target species, the green toad (Fig. 2, during the week beginning April 1, 2024).

Figure 2. A green toad recorded by an AmphiBiom citizen scientist. Photograph by Sigr/AmphiBiom CC-BY 4.0.

Discussion

Our initial results support the notion that establishing even small artificial breeding habitats can be effective in providing new habitats for amphibians and associated aquatic insects. However, to guarantee high quality scientific results, close and constant contact with citizen scientists is required to validate that they maintain comparable conditions. Despite the broadly similar conditions in the ponds, the taxa recorded so far vary. Based on the sample pictures, most ponds appear to be inhabited by water striders; while some ponds are heavily colonized by mosquito larvae, others have almost none, maybe due to the presence of predatory water insects such as backswimmer bugs. The factors that cause these differences remain to be analyzed.

Picture-based recordings might be more frequent because of the typically nocturnal calling of many anuran species, while most citizen scientists are recording predominantly during the day. One may consider approaches where people are specifically asked to go out for call surveys in the evening to overcome some of the biases. Similar to other citizen science projects, effort among the application users is highly skewed (Wood et al. 2011), with a few users recording majority of the observations.

It is already clear that even such small ponds can attract amphibians and even encourage the breeding activity. The extent to which artificial small ponds can mitigate habitat loss might be challenging to measure, but would be an important subject for future investigations.

Conclusion

Citizen science initiatives such as AmphiBiom can be vital in rapidly obtaining distribution records over extended areas, collecting ecological information, and mitigating biodiversity loss due to human induced global ecological changes.

Acknowledgements

We thank all our citizen scientists participating in this effort to protect amphibians by collecting data and providing habitats for (semi-) aquatic wildlife. AmphiBiom is funded by the Biodiversity Fund of the Federal Ministry of Austria for Climate Action, Environment, Energy, Mobility, Innovation and Technology and Next Generation EU (project no. C321025).

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Change – The transformative power of citizen science

UrTrees: a mobile app to involve citizens in measuring urban trees

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Abstract

Trees provide essential ecosystemic services (e.g. stocking carbon or locally regulating temperatures) and play an important role in the resilience to climate change, especially in urban areas. Quantifying these services in cities is difficult because little information is known about each tree, and no allometric model yet exists for urban trees.

The UrTrees project calls the citizen to the rescue to help collect measurements and increase our knowledge of urban tree key features. Using the mobile app that we have designed, only a short video around the tree is necessary to approximate three key measurements: the tree height, its diameter at breast height (1m30 above ground) and the crown volume. No expertise in trees is required to use UrTrees, which has even been tested on children from 6 years old.

A 3-dimensional point cloud of the scanned tree is first derived from the video using Structure-from-Motion algorithms. Geometric models for the trunk and the crown are then fitted to the point cloud in order to estimate the key measurements.

Additionally, Pl@ntNet can be used to identify tree species. All measurements are stored in a database providing data for urban tree studies and feedback to the mobile app user. Efforts have been put into the mobile app user experience, with a scoring system, daily quests and point cloud interactive visualisation. Individual tree information collected through the app will be made freely available to the general public.

Keywords: citizen science, urban tree, 3D point cloud.

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Introduction

The urban landscape that is familiar to us is mainly made up of buildings, transport infrastructure and urban furniture. However, urban vegetation, and more specifically urban trees, are also major elements of these spaces since they offer a very wide range of ecosystem services (air filtering, microclimate regulation, reduction of noise, cultural and recreational appeal, socio-economic role) (Bolund and Hunhammar 1999; Wilkerson et al. 2018). For example, they play a dominant role in carbon storage or air circulation and appear as refuge zones for urban biodiversity. Their emotional and cultural value is also not negligible for human populations.

Quantifying these services is difficult because little information is known about each tree. Indeed, urban trees being different from trees in natural environments (regular pruning, soil composition, air pollution, etc.), the classical methods of foresters to obtain allometric models (Picard et al. 2012) do not apply to them. Therefore, an exhaustive inventory of urban trees and their characteristics is essential to better identify the ecosystem services they provide, in particular in the context of climate change (Rötzer et al. 2019). However, collecting this data is costly in terms of human and logistical resources, thus limiting the spatial and temporal dimensions of the studies carried out.

Related work

Citizen science has already been used for monitoring urban trees for various purposes (Goodenough et al. 2017). However, these studies also highlighted the heterogeneity of the success of these approaches and the variable quality of the data collected by citizens (Roman et al. 2017; Vogt and Fischer 2017). It therefore seems that simplifying the data acquisition protocols (in order to avoid the need to train participants) on the one hand, and retrieving the tree characteristics by non-human means on the other hand make it possible to increase the reliability of the collected data. The UrTrees project proposes a simple video acquisition protocol and a data processing pipeline that allows any citizen without any training to measure three key urban tree characteristics with only a smartphone.

Several applications on smartphones have emerged allowing to massively collect data on trees (Trees Count; Arboreal – Tree). However, this data usually remains closed and inaccessible to the public. Other solutions have been recently proposed to recover tree measurements from a video, e.g., (Ahamed et al. 2023; Wu et al. 2023). However, they are not fully automatic as they require some manual interaction for the scaling. In addition, some key features such as the tree crown volume are not computed.

Objectives and methodology

UrTrees calls the citizens to the rescue to increase our knowledge of urban tree features. The objectives are twofold. On the one hand, we aim at a better understanding of the urban trees growth and services, by mapping and measuring urban trees in order to adapt forest allometric models to urban environments. On the other hand, our goal is also to make citizens aware of their environment and ecosystem services provided by their neighbouring trees. To do so we have developed a mobile app (running on Android) that allows citizens to record videos of urban trees, as well as a data processing pipeline that automatically computes 3D measurements of recorded trees from these videos.

The mobile app

Screenshots of the mobile app are displayed in Figure 1. The instructions to record a video of the tree are very simple: the user only needs to keep the phone at her or his eye level and go around the tree with the trunk axis always in the centre of the video. We ask her or him to film vertical lines starting from the ground. No expertise in trees is required, and this protocol has been tested with children from 6 years old. Our experiments show that going around a bit more than half of the tree is enough, even in the presence of street furniture. Efforts have been put into the mobile app user experience, with feedback given to the user and gamification elements: the app includes a scoring system, reward points, levels to reach, and daily quests. On top of the computed tree measurements, the feedback includes the 3D point cloud of the tree that the user can visualize in augmented reality. Thanks to the Pl@ntNet API (Bonnet et al. 2020), in case the user also provides a picture of a leaf, flower or the bark, the tree species is also retrieved. In addition, marking the GPS coordinates of the tree will allow in the future the user to track the evolution of the tree measurements.

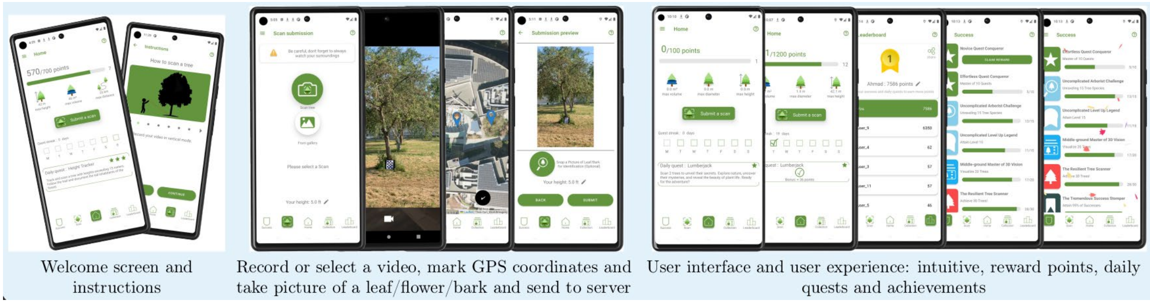

Figure 1. The UrTrees mobile app.

The data processing pipeline

A 3-dimensional point cloud of the scanned tree is derived from selected frames of the video using a Structure-from-Motion algorithm (Schonberger and Frahm 2016). Panagiotidis et al. have shown that such an approach allows to estimate tree height and trunk diameter at breast height (1m30 above ground) with accuracy similar to a LiDAR approach, even if this accuracy decreases with tree height (Panagiotidis et al. 2016). This 3D point cloud includes the target tree, but also unwanted elements for automatic measurements (noise, walls, urban furniture, neighbouring trees). It is therefore essential to segment the tree to be studied in the 3D data. We have integrated simple approaches to first remove points corresponding to vertical plane surfaces such as building walls or road signs and then isolate all the points belonging to the tree studied. It allows in particular to isolate a tree in a line from its neighbours. Finally, we compute a concave hull of the tree crown with guaranteed topology. Scaling is automatically computed using the user height and the vertical distance from the camera to the (automatically detected) ground, without any need of an additional element such as a QR code or a chessboard. We are thus able to estimate three key measurements: the tree height, its diameter at breast height and the crown volume. Others, such as the crown projected area on the ground, would also be easy to compute since we recover the tree crown, the trunk and the ground separately.

Limitations and perspectives

UrTrees is an ongoing work. As such, the measurements accuracy and robustness to various parameters have not yet been fully evaluated. Our initial tests show that the scaling error is less than 5% of the tree height. Individual tree information and measurements collected through the app are stored in a database and will be made freely available to the general public. Following the Principles of Citizen Science, we plan to make all UrTrees data Findable, Accessible, Interoperable and Reusable. We expect this data to allow to develop allometric models for urban trees. We would like to develop and interact with some user communities, for example in a local area or for a specific purpose such as green space management. Hopefully, their feedback can help us improve the project and go from simple data collection and “Distributed Intelligence” to “Participatory Science” (Sui et al. 2012).

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Change – The transformative power of citizen science

Co-creation for change: engaging urban community gardeners in the development of insect conservation interventions

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Abstract

Urban community gardens are socio-ecological spaces, in which the conservation of pollinator diversity in cities can be directly promoted through conservation gardening. However, there is a lack of insights into how practical knowledge of gardeners can be combined with scientific findings in order to develop evidence-based and practice-oriented guidelines for insect conservation interventions. In a co-creation process, we facilitated three workshops with community gardeners from Berlin and discussed research methods and results from four years of ecological research on the relationships between pollinators and garden features. Subsequently, we performed a qualitative content analysis to identify critical adoption barriers and learn from previous experiences of the gardeners. Our preliminary results revealed the gardeners' great interest in understanding the scientific process as well as their high motivation to integrate new information in their own knowledge. Therefore, we think that co-creation has high potential for initiating change as it includes relevant stakeholders at an early stage of the transformation process.

Keywords: bees, biodiversity stewardship, citizen science, conservation gardening, qualitative content analysis, social transformation.

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Introduction

Urban gardens are often discussed as a beneficial land use type for pollinators such as wild bees through providing sufficient habitat (Daniels et al. 2020). They are also socio-ecological spaces, in which the conservation of pollinator diversity can be directly promoted through conservation gardening (Segar et al. 2022). However, reliable data and evidence on the effectiveness of conservation interventions is difficult to retrieve and their application in practice is not guaranteed (Drossart and Gérard 2020). Involving key stakeholders like gardeners into the development of conservation strategies for pollinators in the city can be beneficial in that regard (Baldock 2020). By understanding adoption barriers, like social norms that hinder a disorderly looking gardening approach, and gaining insights into successful solution strategies out of the community, conservation interventions can become more relevant for practice (Gusto et al. 2023). However, there is still a lack of appropriate formats and insights into how these perspectives out of the practice can be combined with scientific findings.

Our work aims to close this gap through a co-creation process together with community gardeners in Berlin, Germany. Participation requires a high level of commitment from gardeners, but also harbors great potential for initiating social change (Skaržauskaitė et al. 2021). Here, we will show how we are linking the findings of four years of ecological research on the relationships between pollinators and garden features that we conducted in community gardens in Berlin and Munich, Germany (Neumann et al. 2024) with the practical knowledge of the community gardeners.

The co-creation process

In order to allow knowledge exchange between researchers and gardeners, we facilitated three workshops at the Museum für Naturkunde Berlin and two community gardens that have participated in our research in Berlin (Figure 1). The sessions took place in October 2023 and lasted each for approximately three hours including two breaks. The actual discussion time during each workshop was 154 minutes, 122 minutes and 115 minutes long. We invited all gardeners from the 16 community gardens that were part of our project in 2023 via email and signs posted in the gardens. We did not offer any financial or material incentives for participation. A total of 33 gardeners (n = 10, 13 and 10 for each workshop) out of 12 community gardens in Berlin (n = 7, 1 and 7) participated. The average age of the participants was 54 years with a wide range of ages, from 18 to 82 years old. The participants were active in community gardens for 1.5 months to 32 years with an average involvement of 6.3 years. Their age was slightly above the average age of the gardeners who responded to a survey in our accompanying research (Sturm et al. 2021), but still represented a variety of community gardeners of different ages and levels of gardening experience.

Each workshop included a presentation of our research methods as well as the discussion of results such as the positive effects of flower richness on solitary bee abundance (Neumann et al. 2024) and their significance for the practical implementation of pollinator-friendly interventions in community gardens. Participants were invited to ask questions, share their thoughts and engage with each other at

Figure 1. Example of workshops in which gardeners discussed conservation interventions

any time. Following our aim to co-create new knowledge, we recorded and transcribed the workshops. We conducted a qualitative content analysis by first inductively developing categories based on the research aim, coding of all material and further deductive dividing of the contributions into subcategories (Kuckartz 2012). All coding and development of subcategories was done by two researchers independently. The categories and codes were revised until both were satisfied with the classifications. Based on these results, we will develop a catalogue of guidelines for conservation interventions, which will undergo another feedback loop with gardeners prior to implementing and evaluating pollinator conservation interventions in the gardens.

Engaging with science

Transcripted contributions from the discussions were grouped into three categories: (a) "barriers" to the implementation of interventions, (b) "previous knowledge and experiences" around conservation interventions and (c) "questions and ambiguities". Here, we briefly present the preliminary results of the latter category as they underline the relevance of linking research and practice in the co-creation process (Table 1).

Table 1. "Questions and ambiguities" of participants from workshop 3.

Subcategory	Representative quotes
Reflection on research methods	So, you take them with you and identify them correctly so that you can really say what they are? Because there are almost 400 wild bee species, you can't identify them all in passing.
Further interests	I started to look more into the topic of wild bees and honey bees, whether they are competitors or not at what times or in what area.
Interventions	Yes, but that would also be interesting. So, what types of wood are good and also what age?
Feedback about their own garden and collaboration	So that's why I'm specifically asking if I can have a look at the individual results from the community garden, which I'd be very interested in, of course, in comparison to the other gardens.
Knowledge questions	Are there any nocturnal wild bees?

The participants critically evaluated the research methods and results presented and showed great interest in understanding how we, as scientists, work and reach our conclusions. By reflecting on the results and introducing topics beyond the scope of our ecological research, they tried to connect the new information with their own knowledge and interests. Furthermore, some participants immediately started to plan the implementation of interventions in their own garden. However, it can pose a challenge for researchers to support this high motivation with evidence-based recommendations, as the process of reviewing and publishing scientific findings can be quite lengthy. To synchronize processes, the open question on how to increase the pace of our research while at the same time remaining true to scientific standards needs to be answered.

Conclusion

Facilitating a co-creation process to develop insect conservation interventions can support reciprocal learning among researchers and gardeners. Gardeners showed great interest in the research and motivation to engage in pollinator conservation, which is consistent with previous research on self-reported motivation to participate in the project (Sturm et al. 2021). We simultaneously gained insights into barriers to the implementation of interventions as well as learned from the participants' knowledge. Therefore, we think that co-creation has high potential for initiating change as it includes relevant stakeholders at an early stage of the transformation process.

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Competing interests

The authors have declared that no competing interests exist.

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Change – The transformative power of citizen science

The Iliad digital twins of the ocean: opportunities for citizen science

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Abstract

In recent years, there has been growing interest in digital twins (or virtual representations) of the environment. Programs in the European Union and the UN are investing in digital twins, particularly those of the ocean (DTOs). While citizen science has been mentioned as a potential data source for digital twins, the full potential of citizen science in this context has yet to be fully realised. The Iliad project (https://ocean-twin.eu), funded by the European Commission, is developing a comprehensive set of digital twins of the oceans which are interoperable, data-intensive, and cost-effective. The project (2022–2025) brings together over 50 partners to demonstrate the technologies and methodologies required to develop DTOs. Citizen science and engagement play a pivotal role in the project, with the following goals: (a) exploring the potential for citizen science to contribute to digital twins of the oceans; (b) demonstrating how citizen scientists (and society more broadly) can benefit from digital twins. The Iliad team is currently working on over 20 separate digital twins of the oceans that fall into two primary categories: (i) environmental and ecological digital twins; (ii) engineering and industrial digital twins. Using the Iliad DTOs as case studies, lessons learned for citizen science are presented from the development of each digital twin.

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Within the field of environmental modelling, the concept of digital twins is gaining traction, with programmes in place to develop a digital twin of the Earth (Bauer et al. 2021). The term "digital twin" originally emerged within industry and described a system consisting of "a physical entity, a virtual counterpart and the data connections in between" (Jones et al. 2020, p.36). Whilst the concept is at an early stage of maturity within environmental science, initial examples are emerging. For example, a digital twin of the terrestrial water cycle has been developed for the Mediterranean region (Brocca et al. 2024). As with more traditional modelling, citizen science has been proposed as a solution to fill data gaps within digital twins (Bye et al. 2023). However, the potential of citizen science in this context may be limited by current data practices which can be lacking in terms of data licensing, documentation, interoperability and infrastructure (Bowser et al. 2020).

The Iliad project (https://ocean-twin.eu) is developing a comprehensive set of over 20 separate digital twins of the ocean (DTO), providing tools to explore, simulate, analyse and predict environmental processes and inform marine management (Bye et al. 2022). The project, which was funded by the European Commission through its Horizon 2020 research programme (grant agreement number: 101037643), runs from 2022 until 2025 and brings together over 50 partner organisations to demonstrate the technologies and methodologies required to develop DTOs. Citizen science and engagement play a pivotal role in the project with the following goals: (a) exploring the potential for citizen science to contribute to digital twins of the oceans; (b) demonstrating how citizen scientists (and society more broadly) can benefit from digital twins. Importantly, the value of citizen science is recognised to extend beyond just the provision of data. Incorporating citizen science into the development of digital twins has the potential to: increase public engagement and involvement in the topic of the digital twin; increase public awareness and education (including enhancing ocean and water literacy); increase public participation in decision making; and increase the societal relevance of the digital twins developed.

To illustrate the project activities, a short description of the citizen science elements of four of the Iliad DTOs are given below.

1. **Jellyfish swarm forecast, Israel.** Citizen science observations from the Meduzot project (Edelist et al. 2022) are combined with metocean parameters to develop an interactive forecasting tool for jellyfish swarms.
2. **Harbour safety, Varna Bay, Bulgaria.** A new citizen science app "I SEE SEA" has been developed to enable citizens to report coastal pollution, jellyfish swarms, weather changes and other unusual phenomena. Sightings are incorporated into a digital twin of Varna Bay which is used by vessels within Varna Port to minimise risk during adverse weather conditions or other risks to harbour safety.
3. **Oil spill monitoring, Thracian Sea, Greece.** Citizen observations (extracted from social media) are used to provide early warnings of potential oil pollution and are used to trigger and validate oil spill models.
4. **Cultural heritage monitoring, Israel.** An ongoing citizen science project engages interested parties and actors, including students, to report archaeological finds along the Israeli coast. Reports are validated, catalogued, and then included within an interactive digital record of cultural heritage sites.

The pilot digital twins developed within Iliad can provide a number of lessons learned for the integration of citizen science in digital twins across a range of marine topics and for environmental digital twins more broadly. Of particular importance is the availability and interoperability of citizen science data. To support this, the Iliad project is developing an Ocean Information Model (OIM) as a tool to provide full semantic interoperability within digital twins of the ocean (Zaborowski et al. 2023). A core principle of the OIM is to adopt common ontologies and establish alignment with other existing models in a modular approach rather than developing a new ontology from scratch. This modular approach also helps overcome challenges of creating a single model to cover several heterogeneous domains. A core, cross-domain layer defines terms relevant across all domains such as temporal concepts (adopting W3C OWL Time) and geographical/spatial concepts (adopting OGC GeoSPARQL). Domain-specific modules are then adopted. For example, the Iliad Jellyfish swarm forecast DTO connects to Darwin Core standards for biodiversity informatics and PPSR Core for citizen science. The OIM is available via a GitHub repository (Palma and Atkinson 2023) and in the future will be accessible on the OGC Rainbow server. To support further capacity strengthening around citizen science within the marine sector, the Iliad project has established a citizen science community within the UNESCO IOC Ocean Best Practices Repository (OBPS, Pearlman et al. 2019) The aim of the community is to provide a collection of marine-specific citizen-science best practices, manuals, guides, handbooks and other documents which ultimately can be adopted across Europe and beyond and are readily available for adoption by marine researchers (including those interested in developing a DTO).

To gain further insight into the opportunities and barriers for citizen science in the context of digital twins, the Iliad consortium is carrying out a series of semi-structured interviews with project leaders from each of the Iliad DTOs. So far, 15 interviews have been held including five DTOs where citizen science is already integrated, six with some potential for citizen science, and four where the project leader believes citizen science is not applicable. Each interview lasted around one hour and included questions covering: (i) the project leader's experience with citizen science; (ii) details about their DTO including data gaps and plans for validation; (iii) the social relevance of the DTO; and (iv) how citizen science could bring value to their DTO. Initial results indicate opportunities for citizen science through: promoting existing (or establishing new) citizen science standards to enable data to be more easily integrated into models; including citizens in discussions around contentious marine management decisions such as pollution or wind-energy; and engaging professionals such as fishers or energy technicians as citizen scientists, not just members of the public. Commonly cited barriers to citizen science include: issues of accessibility, particularly for sites far from the coast; lack of capacity within the DTO team to engage with citizens; lack of added-value over abundant sensor data; and issues of trust or lack of transparency, especially for more industry-based DTOs. Further outputs from the Iliad project, including the full results from this review, will be shared via the Iliad Marketplace (https://ocean-twin.eu/marketplace).

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Change – The transformative power of citizen science

"From sea to street": initiating change for stronger connection with our ocean

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Abstract

The Earth's vital ocean is constantly changing and is at risk due to pollution, overfishing, and climate change (Pörtner et al. 2022). Research highlights the importance of personal attachment to the sea in fostering responsible stewardship (Chawla 2020; Pyle 2003). In urban areas, opportunities for human-nature interactions are limited, making mediated experiences, i.e., indirect interactions a crucial tool for fostering ocean stewardship. Murals, a form of street art, are prevalent in many cities around the world (Schacter and MacDowall 2023) and have been suggested as tools to promote community engagement and raise environmental literacy and awareness (see Mattern 1999; Sanchez et al. 2020; Schneller and Irizarry 2014). Based on the lessons learned from the project "From Sea to Street", we hypothesise that murals evoke emotions, thoughts and memories, thereby shaping and strengthening people's connection to the marine environment.

Keywords: street art, murals, ocean literacy, citizen science.

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Citizen science for ocean conservation

The project "From Sea to Street'' (FStS) (June–December 2023) was a citizen science initiative co-developed by the authors, focusing on the intersection of street art, citizen science and ocean conservation in Spain, Latvia, and the Netherlands (IMPETUS 2023). Our international and multidisciplinary project team set out to decode the language of urban murals and how they shape people's relationship with the seas and oceans. In this context, we defined an ocean/sea-themed mural as a mostly large-sized painting on a publicly accessible wall of a building or other surface that features ocean/sea-related themes such as marine life, the marine environment, people's interaction with the ocean/sea, or cultural, mythological, and traditional elements related to the ocean/sea, created with the necessary legal permits (VU 2023).

Our approach consisted of three parallel pathways. First, we encouraged people to submit photos of mural artworks (N=54), along with information about the artist and location, via an online form or through social media. Parallel to that, we conducted a multilingual online survey (N=254). In both cases, participants were asked to share the emotions, memories, and thoughts that the murals evoked in them. Third, we interviewed and collaborated with artists and organised street art tours and community workshops in the project's focus countries: Spain, Latvia, and the Netherlands (Figure 1).

Figure 1. Snapshot of the project activities: a) interviews during the mural festival "Viladomar" in Rianxo, Spain (photo: Sophia Kochalski), b) guided street art tour by boat on the river Daugava in Riga, Latvia (photo: Edgars Šulcs), c) applying street-art techniques at the Street Art Museum Amsterdam in the Netherlands as part of the Interdisciplinary Community Service Learning course, Athena Institute, VU Amsterdam (photo: Tanja Warning).

Creating positive change together

The finding that marine-themed murals arouse interest, inspire, and stimulate thought was evident in the face-to-face discussions and in the open questions as part of the online survey. The type and intensity of the reactions depended on which mural image was shown to the survey participants. Figure 2 shows an example of a word cloud containing all reactions to a mural by the artist Tim Rodermans which portrays a jumping humpback whale in almost its true size (see: Whale – Fraunhoferstraat Amsterdam n.d.). The viewers were impressed by its size, beauty, and strength; it made them think of nature, freedom, and the environment.

Figure 2. Frequency of words based on the narratives provided for a mural of a jumping humpback whale. The larger the letters, the more frequently the words appeared; each word listed was mentioned at least twice.

For the same mural of the humpback whale, respondents were given a list of 18 discrete emotions from which they could select up to five. The most frequently selected emotions were intense positive emotions: elation (56%) and awe (52%). Many participants also experienced calmer positive emotions (amusement, 35%; contentment, 30%), as well as interest (35%) and surprise (20%). Only two of the 84 respondents viewing this specific mural chose the option that it evoked "no emotion" in them. The negative emotions that were available for selection (e.g., sadness, fear, anxiety, anger, disgust) were mentioned little/not at all (N<5).

The extent to which the project activities and the emotions, thoughts, and memories evoked by murals affect people's attitudes and actions beyond the moment remains an open question for further research. The possible relationship is exemplified here by a contribution from Puerto Rico, from where a picture of artisanal fishermen was submitted via the mural submission form:

"*The image echoes the struggle of the artisanal fishermen of the island of Culebra, Puerto Rico (...) It teaches me that together we can overcome great inequalities at key moments but that its unjust legacy (pollution from bombs) continues to require keeping the memory alive*".

Final remarks

Through our work, we support the statement made by McKinley et al. (2021): "*[t]here is a need to recognise the complexity of the emotional connections and the corresponding diversity of values (both monetary and non-monetary) that different audiences across Europe may have towards their aquatic environments*" (p.4). Street art (Thompson et al. 2023), particularly murals (Sanchez et al. 2020), holds this open-collaborative space to explore the human-ocean relationship.

With active citizen participation, the FStS project mapped and analysed murals, decoding which stories and emotions they evoke. While we successfully identified clear patterns for individual murals, expanding the participant base and reaching a broader audience would be desirable for future research. Additionally, the project has created a platform for exchange on marine science, art, and citizen science, which can facilitate further work.

Building on our project's insights, we emphasise the value of further expanding community engagement around street art and marine conservation. This can be done through educational activities, digital applications such as the SPOTTERON ArtSpots app (ArtSpots n.d.), or street art festivals, such as a mural tour organised in the context of "The Nature of Cities Festival" (TNOC 2024). Citizen science in particular can provide valuable approaches to not only generate data and knowledge, but also to facilitate and sustainably transform people's connection to nature.

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Change – The transformative power of citizen science

Designing (for) change: a taxonomy-based approach to project design

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Abstract
This paper presents insights into an ongoing research project, focusing on the application of a taxonomy for digital involvement projects to Citizen Science initatives. Extending the taxonomy to analog projects and conducting a survey on mit:forschen, this research aims to enable structured comparisons and insights into design patterns.

Keywords: citizen science, design taxonomy.

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Introduction

In the practice of Citizen Science (CS), projects are increasingly aspired to yield societal benefits. This includes endavours to democratize the scientific practice, foster learning, or promote social inclusion (Lewenstein 2022). However, the realization of transformative potentials hinges critically on the design of initiatives (De Albuquerque and Almeida 2020). Research underscores the significance of design dimensions, including communication and engagement modes or stakeholder relationships (De Albuquerque and Almeida 2020; Lewenstein 2022). Nevertheless, a structured approach to describe and evaluate these design dimensions remains absent. While numerous classifications exist detailing the degrees and forms of

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CS participation (Haklay 2013; Shirk et al. 2012), a comprehensive schema to guide project design is still lacking. Such a framework, however, is essential to facilitate structured comparisons between initiatives and foster dialogue among CS practitioners. Its application could ultimately guide project initiators in targeting their design to fit their purpose and realize desired benefits.

A suitable approach to structurally describe similarities and differenceses of a target domain is offered by taxonomies (Nickerson et al. 2013). While it would be an evident approach to develop a design taxonomy exclusively for CS projects, in this paper we argue, it may be more beneficial to adopt a broader perspective. The phenomenon of increasing demand for participation formats can also be seen in political and business practice. Thus, we propose the application of an existing taxonomy for (digital) involvement projects to CS, to enable structured comparisons within the CS field, while ensuring comparability with other participatory paradigms. In this paper we will present the theoretical foundations and methodological approach to the research project, highlighting potential challenges and benefits of a taxonomy-based approach to CS project design.

The DIP Taxonomy

In science, politics, and economics alike, the inclusion of lay people in formerly exclusive processes is gaining relevance. For citizens, various participation opportunities exist, particularly in the digital realm. While the field of science discusses this involvement as “Citizen Science” (Haklay et al. 2021), research on political participation examines the phenomenon of “E-participation” (Sanford and Rose 2007), and in the private sector, crowdsourcing processes are frequently mentioned (Estellés-Arolas et al. 2015). To better explore and classify participation projects across domains, Stein et al. (2023) aggregate these projects under the general term “Digital Involvement Projects” (DIPs) and develop a taxonomy of their key characteristics. They define DIPs as “projects that utilize digital platforms for the involvement of multiple external individuals in a defined participation process” (p.5) and derive, through an iterative process of theory and practice, 19 dimensions for describing DIPs (see Fig.1). The dimensions encompass sub-dimensions for the participation degree, the project’s implementation process, incentives, communication structures, project stakeholders, and project outcomes (Stein et al. 2023).

Although the taxonomy aims to analyze the design of participation projects across domains, potential advantages may emerge when employing it within CS: In CS research, numerous endeavors have been made to theoretically distinguish CS practices. Early frameworks by Shirk et al. (2012) and Haklay (2013) employ the level of participation as a basis for differentiation. More recently, scholarly attention in the field of CS has shifted away from rigid definitions, adopting a more open and inclusive approach, advocating for the recognition of the plurality within CS endeavors (Haklay et al. 2021). For practitioners and policymakers to benefit from this diversity of approaches it is indispensable to create more awareness for and an understanding of their design differences (Andersen et al. 2007; Haklay et al. 2021). Compared to theoretical definitions of participation types, relatively little scholarly attention has been devoted to making actual design decisions of CS projects tangible. To this end, we suggest the DIP Taxonomy could be used. Scholars such as Monzón Alavarado et al. (2020) and Moczek et al. (2021) have already contributed project reviews. Extending their work by applying the DIP

Dim-ension	Sub-Dimension	Characteristics				
Degree of Participation	D1 Extend of participation	Information sharing	Consultative	Democratic		
	D2 Participation offer	Single task	Multiple tasks optional	Multiple tasks mandatory		
	D3 Type of participation	Active-effort	Active-ressources	Passive		
Implementation of Participation	D4 Format	Digital	Analog/ digital (paralell)	Analog/ digital (sequential)	Analog	
	D5 Implementation	Asynchronous-web-based platform	Asynchronous-mobile application	Synchronous	None	
	D6 Structure of participation	Team work/ participation	Individual work/ participation			
	D7 Time requirements	High	Low	Self-selected		
	D8 Prerequesites	Domain knowledge	Domain-specific equipment	Assumes preconditions		
Incentives	D9 Incentives for participation	Self-related extrinsic	Self-related intrinsic	Impact-related		
	D10 Reasons for the participatory design	Acceptance & legitimation	Funding	Access and ressources	Value-based	Profit maximisation
Communication	D11 Direction of communication	One-sided	Two-sided	Multi-sided		
	D12 Suggestions feedbacked	Expert feedback	Crowd feedback	No feedback		
	D13 Community building	Yes	No			
	D14 Moderation	Crowd	Individual from crowd	Organization/ expert (intern)	Organization/ expert (extern)	None
Project Stakeholder	D15 Project driver	Crowd	Individual from crowd	Organziation/ expert	Equal partnership	
	D16 Project owner	Crowd	Individual from crowd	Organization/ expert		
	D17 Target group	Open	Restricted	Closed		
Gains and Outcomes	D18 Project outcome	Product	Knowledge	Decision	Sharing things	
	D19 Publicity of the outcome	Public	Accessible for the participants	Non-public		

Figure 1. DIP taxonomy according to Stein et al. (2023) with adaptions for analog projects.

taxonomy, we can increase the number of design dimensions under review, providing a more complete picture of project design.

Analyzing CS with the DIP taxonomy

To utilize the DIP taxonomy for analyzing the realm of CS two prerequesites must be met. First, we note, that although online CS is trending throughout recent years, there is still a large quantity of projects that operates analgogously. For the DIP taxonomy particularily the dimensions “Format” and “Implementation” (Stein et al. 2023), are exlusively focused on the digital realm. To not exclude the variety of analog projects, we adapt the DIP taxonomy by adding a characteristic “analog” or “none”. Second, building upon experiences from

Monzón Alvarado et al. (2020) and Moczek et al. (2021) a direct contact to the project initators may be beneficial to accurately describe projects according to the taxonomy's dimensions. Thus, methodologically, we conduct a survey using a web application (Stein et al. 2023), working together with the German CS Platform "mit:forschen", to reach a diverse set of CS projects.

Through our methodological approach we obtain project classifications that present a descriptive view on CS project design. Focusing on the distribution of projects onto the taxonomy we are able to evaluate homo- or heterogeneity of CS projects within the individual design dimensions while also differentiating CS from the design in other participation domains (e.g. through absence of design features). Furthermore, we use hierarchichal clustering methods to identify relations and patterns within the projects' design approaches (Kassambara 2017).

Conclusion

In this paper, we present insights into an ongoing research project focusing on a taxonomy-based approach to project design. Drawing upon a taxonomy for DIPs, we aim at making the design decisions in CS projects tangible. Instead of creating exlusive definitions of CS, our approach focuses on describing the design of projects identifying as CS and to ultimately identify potential patterns and clusters to be able to discuss CS in a more differentiated way. Adopting the broader perspective of the design of (digital) involvement across domains, ensures applicability and enables comparability also to non-CS projects. We believe that providing this structural basis to compare and discuss project design across the CS landscape is indispensable to advance our understanding of the societal benefit different CS projects can achieve.

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Change – The transformative power of citizen science

"Get on board with researchers": Life Conceptu Maris marine citizen science campaign

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Abstract

The manuscript provides an overview of the mid-term results of the citizen science campaign activities conducted within the Life CONCEPTU MARIS project (LIFE20 NAT/IT/001371) whose aim is to improve the conservation status of cetaceans and pelagic sea turtles by addressing information gaps, setting up an internationally agreed-upon approach for surveillance, and identifying appropriate conservation measures. It fosters a cooperative effort by engaging the scientific community, stakeholders, policy makers and citizens in a common effort to support biodiversity.

Keywords: awareness, biodiversity, cetaceans, ferries, Habitat Directive, marine ecosystem, monitoring, sea turtle.

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The Mediterranean Sea faces significant changes amplified by global warming and induced by anthropogenic pressures to which Cetaceans and Pelagic Sea Turtles are exposed.

The conservation status of CEPTU species is still considered data deficient for most taxa according to the last Habitats Directive Art. 17 Report (2013 – 2018) and the EEA Report (No 10/2020), which states that "*marine mammals (cetaceans) are among the species with the highest proportion of unknown assessments (over 78%)*". The data deficiency is mainly due to the fact that CEPTU species spend the majority of their life in remote offshore areas most difficult to monitor because of their extent, highly dynamic nature and the high costs involved in carrying out regular large-scale surveys that overcome socio-political borders.

In the frame of the LIFE Conceptu Maris project researchers and citizen scientists cooperate to monitor these species which serve as key indicators of ecosystem functioning and dynamics and of the integrity of the trophic web. At the end of the first year of the citizen science campaign approximately 315 citizens from 13 different countries had applied to the project. 154 of them have completed an online training and 82 have participated in training sessions onboard the ferries (Fig. 1) which operate along 17 routes in the Mediterranean Sea. All data are stored in the Capo Carbonara Marine Protected Area repository and will be available upon request.

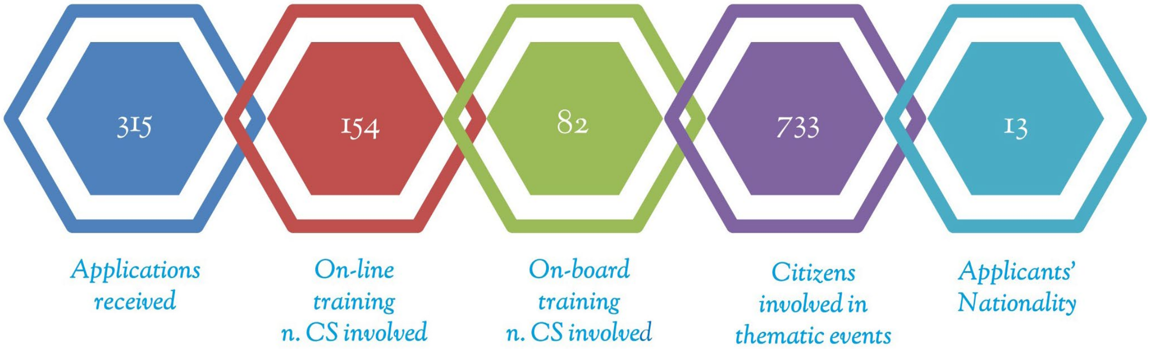

Figure 1.

Over the past decade, a multidisciplinary synergistic approach has been developed for the long-term monitoring of marine megafauna (e.g., marine mammals, sea turtles, sharks, manta rays, sunfish, sea birds) and addressing major threats (such as marine litter and maritime traffic) through coordinated efforts within several EU projects (e.g., Medsealitter, ABIOMMED, Impel MTT). This approach, which uses ferries as platforms of opportunity and floating laboratories for research purposes, is extended to citizens trained according to standardized protocols, through appropriate measuring tools (binoculars, GPS, range stick), and identification sheets for species recognition, ensuring the quality of data collected by citizen scientists.

Before boarding, citizens attend a two-phase training course: an online theoretical introduction (video training course) to the visual monitoring protocol and species identification methods; and a practical phase on-board with the experienced researchers, whose constant presence ensures the collection of validated data. The training material is created using simple and intuitive terms and images, since the end-users do not have a scientific background. On board, the four observers (experts and citizens) position themselves on the wings of the command bridge initially observing with the naked eye (Fig. 2). During the campaign's first call, citizens have contributed to gathering 809 sightings of sea turtles, 1751 sightings of cetaceans, for a total number of 265 surveys and 59,428.40 Km of effort.

Figure 2.

The Citizen Science activities of Conceptu Maris play a significant role in driving change with strong scientific, policy and societal value. Scientific value is enhanced by gathering data to generate a better understanding of CEPTUs conservation status. The current engagement of citizen scientists ensures the continuity of monitoring activities in the long term, gradually forming expert observers capable of collaborating with researchers, who alone would not be able to ensure the sustainability of monitoring activities. Citizens will also be acknowledged in future scientific publications based on data collected during the monitoring session.

Citizens are also able to autonomously report sightings of CEPTU species through the App “Marine Ranger” (Life DELFI, LIFE18 NAT/IT/000942). All citizens involved in the media campaign are informed about the conservation action by the project’s media channel and the newsletter.

The value of Citizen Science extends beyond scientific understanding. The high-quality data collected together with citizens will be processed using standard metrics developed by the project to assess the conservation status of CEPTU species. This data will be integrated into a decision support model co-designed with policymakers, who are permanent members of the project’s Advisory Board. Citizens play a fundamental role in facilitating the initial phase of this process aimed at defining scientific solutions to support the implementation of European biodiversity policies.

A societal value is also achieved by raising awareness of environmental issues related to the project among the general public, and citizens directly involved in monitoring activities. In order to reach out to the general public, a comprehensive media campaign was launched, including a dedicated project website page (visited by 7,234 people between 2023 and 2024), newsletter, social media networks (reaching around 210,000 individuals through Instagram and Facebook), press releases (resulting in over 90 Conceptu Maris articles and press citations), participation in radio and TV programs, and 18 thematic events (involving 733 attendees). The onboard experience leads citizens to a clear understanding of the current challenges facing marine species and ecosystems. One of the most valuable societal results of the Conceptu Maris Citizen Science campaign is the establishment of a community dedicated to the conservation of cetaceans and turtles. This has helped to strengthen the connection between marine ecosystems and people and has generated a sense of belonging, motivating individuals to adopt new perspectives and strive for a new ecological balance.

Guidelines for Citizen Science involvement in the visual monitoring of CEPTU aboard ferries have been developed to offer a methodological approach, advice and practical guidance for establishing a Citizen Science programme for recruitment and training on-line and on-board.

The involvement of citizen scientists in marine conservation remains limited, particularly concerning CEPTU monitoring. Nevertheless, the Conceptu Maris project is dedicated to bridging this gap by actively enhancing citizen engagement in monitoring efforts, extending beyond the project’s duration.

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Conceptu Maris Project: https://www.lifeconceptu.eu/

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Change – The transformative power of citizen science

Young volunteers on Zooniverse: exploring the relationship between participation and background characteristic

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Abstract

This study explores the participation patterns and demographic characteristics of young citizen scientists engaged in online citizen science through the Zooniverse platform. By analysing log data from 242 participants and survey responses from 64 individuals, the research sheds light on the contributions and behaviours of these young volunteers. Key findings highlight the significant engagement of young participants, each contributing to various projects and demonstrating consistent activity on the platform. Surprisingly, demographic factors like age and gender showed no significant association with participation levels. However, confidence in using the platform positively correlated with increased engagement, emphasising the role of self-efficacy in fostering participation. Additionally, systematic participation was linked to higher project contributions, underscoring the importance of structured engagement. The study highlights the need for targeted strategies to empower young individuals to contribute meaningfully to scientific research while promoting inclusivity and engagement across diverse demographics.

Keywords: young volunteers, Zooniverse, participation.

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Introduction

Participation in online citizen science benefits young people's science learning and empowers them to take action and engage with science meaningfully (Herodotou et al. 2022). This study explored the participation and background characteristics of young citizen scientists on Zooniverse, highlighting their potential and the impact they can make. Understanding volunteer contribution, including young participants, and tracing their participation behaviour can enable scientists and project coordinators to make decisions about a project and platform design by adjusting the technology, content or engagement techniques (Skarlatidou et al. 2019).

This study was part of the LEARN CitSci project, an international research project studying how young people (aged 5–19) learn through participating in citizen science. Zooniverse is a citizen science platform that enables crowdsourced research in many disciplines (e.g., astronomy, ecology, biology) and via many projects. Volunteers contribute by classifying, annotating, drawing, and ranking images and illustrations or transcribing diaries and texts.

Methods

Log data from 242 Zooniverse young participants were used to calculate metrics indicating their participation and contribution levels. The participation metrics, as described in Aristeidou et al. (2021), included how active young volunteers were in days (activity ratio), how long they have been linked to Zooniverse overall (relative activity duration), the time they spent on Zooniverse tasks (task devotion), and how systematic (with regular intervals between visits) they were in joining the platform (participation periodicity). Additional contribution metrics looked at young volunteers' daily submissions (project contribution) and overall submissions (overall contribution).

A survey (n = 64) also collected data on participants' demographics and relevant information. The final aggregation of the collected survey data included gender (male, female), age (integer), previous experience with online science-related activities (yes/no), and confidence levels in using the platform (scale with high/low/no confidence). These variables were of interest due to studies on adult citizen science participation identifying gender and age imbalances (e.g., Pandya and Dibner 2019). Some variables were excluded from the inferential analysis due to low numbers (e.g., n <5, binary gender).

Similarly, science capital (e.g., previous experiences with science) (Archer et al. 2015) and efficacy in technology (Howard et al. 2016) have been shown to explain diverse participation levels in various science learning contexts. Ethical approval was obtained from The Open University Human Research Ethics Committee (reference number: HREC/3003/Herodotou), and participation was voluntary.

Statistical analyses were conducted to calculate the participation and contribution metrics and assess the degree of association among the metrics. These included descriptive statistics and non-parametric tests. The latter involved Spearman correlations to test any associations between participation and contribution metrics and Mann-Whitney tests to assess the relationships between participation or contribution metrics and survey information as described earlier.

Results

The analysis revealed significant contributions among young participants on Zooniverse, with a remarkable total of 237,727 contributions spread across 233 projects. Each participant contributed to 1–105 projects, showcasing diverse interests and involvement. Young citizen scientists demonstrated a relatively low activity ratio, being active on Zooniverse for about two out of ten days they were linked to the platform. On a daily average, they submitted 12.5 contributions, investing approximately 9.5 minutes on Zooniverse tasks, indicating a dedicated commitment. However, these findings are interpreted with caution, as the sample group involved a few super-users (i.e., contributing more than the average). Interestingly, the study found no evidence of systematic participation.

Further analysis showed that an increase in confidence in using Zooniverse correlated positively with extended overall duration and enhanced task contribution, suggesting that confidence plays a pivotal role in fostering continued engagement and active involvement in scientific endeavours. Furthermore, findings indicated that a more systematic approach to participation on the platform resulted in increased project contributions. This underscores the importance of structured engagement and methodical involvement in achieving meaningful outcomes within the Zooniverse community.

Contrary to initial expectations, factors such as age, gender, and prior engagement in online science-related activities were not significantly associated with increased participation in Zooniverse. This suggests that the platform offers a wide-ranging environment where individuals from different backgrounds can actively contribute to scientific research, irrespective of demographic factors. More information about the young people's activity on the platform can be found in Herodotou et al. (2022).

Discussion

Considering the practical implications of the findings on young people's participation in online citizen science is essential. One notable takeaway is the positive correlation between confidence in using Zooniverse and both increased duration of engagement and contributions. This aligns with previous research in other contexts, indicating confidence and efficacy in technology as crucial in fostering engagement and active participation (Howard et al., 2016). However, it's critical to recognise the existence of the digital divide, which may hinder some young people (or even adults) from fully participating due to a lack of digital skills or access. To address this issue, initiatives should be implemented to support these individuals, such as offering tutorials and clear instructions to help them feel confident navigating the platform and contributing meaningfully to scientific endeavours.

Furthermore, systematic participation emerged as a key factor in driving increased contributions to Zooniverse projects. To capitalise on this insight, strategies can be implemented to make participation more engaging and enjoyable for young citizen scientists. For instance, incorporating gamification elements, such as achievements and rewards, into a citizen science platform can enhance motivation and maintain interest. Offering short, focused tasks and interactive platforms can make the experience more interactive and compelling.

Moreover, fostering a sense of connection to the project and its outcomes is essential for sustaining young people's engagement. Providing recognition for their contributions and facilitating direct communication with scientists can help them feel valued and invested in the research process. Leveraging their social connections by encouraging group activities at school or through social media platforms can further enhance their sense of belonging and motivation to participate.

Collaboration with schools and youth organisations presents another promising avenue for promoting systematic participation in citizen science. Integrating citizen science activities into educational curricula and extracurricular programmes can expose young people to scientific inquiry and provide them with structured opportunities to engage with real-world research projects. By partnering with educational institutions and youth organisations, citizen science initiatives can reach a broader audience and foster a culture of scientific curiosity and collaboration among young people.

Conclusion

In conclusion, by implementing targeted strategies to enhance confidence and systematic participation, online citizen science platforms like Zooniverse can empower young people to become active contributors to scientific research while also addressing barriers to participation and promoting inclusivity and engagement across diverse demographics.

Acknowledgements

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Change – The transformative power of citizen science

Stakeholders' motivations for supporting environmental citizen science

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Abstract

Citizen science is moving from traditional scientist-public partnerships to larger multi-partner enterprises engaging new sectors of society. For citizen science to recruit and retain stakeholders, it is essential to understand what motivates partners to facilitate projects. Twenty-six people from 10 different stakeholder groups in the UK were interviewed about their personal and organisational motivations for supporting environmental citizen science. Template thematic analysis revealed five key motivational themes: (1) business-centric, (2) participant-driven, (3) scientific, (4) personal and (5) environmental motivations. These findings suggest that stakeholders have a range of motivations that go beyond the dominant narrative of science and the environment.

Keywords: citizen science, collaboration, motivations, partnerships, stakeholders.

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Introduction

Different groups of stakeholders may bring different skillsets and knowledge to citizen science (CS). Therefore, recruiting and sustaining partnerships with a broad diversity of stakeholders is valuable for developing CS projects and increasing project outputs. This paper defines stakeholders as individuals

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and organisations who facilitate or fund projects or use the data produced. As many stakeholder groups voluntarily support CS, it is critical to understand their motivations. Compared to the literature on citizen scientists' motivations (e.g. Ng et al. (2018) and Tinati et al. (2017)), there is limited research investigating stakeholder motivations (Geoghegan et al. 2016). Previous studies have evidenced that CS stakeholders have a range of motivations, including improving knowledge, contributing to science, informing conservation, providing education and improving partnerships (Elferink 2023; Geoghegan et al. 2016). This paper contributes to this topic by examining the motivations of UK environmental citizen science (ECS) stakeholders.

Methods

This study utilised online semi-structured interviews between April and July 2021 using Microsoft Teams. ECS stakeholders working in a UK-based organisation were recruited via targeted emails, snowball sampling, listservers and social media. All stakeholders signed consent forms and completed screening surveys before participating in the research.

The results are taken from a wider ongoing qualitative project to examine stakeholders' perceptions and understanding of ECS (Wilson 2022). The results presented in this paper focus on the 26 interviewees' answers to the question: "What first motivated you and/or your company to support ECS?" Interviewees were encouraged to provide an answer as both an individual and as a representative of their organisation. The interviews were recorded and transcribed using orthographic transcription.

Template thematic analysis (described in King (2012)) was conducted in NVivo (release 1.5.1) by the author. Words and sentences were organised hierarchically into themes, factors and sub-factors. First, sections of text that relate to a topic were grouped into factors or sub-factors. Second, several factors with broadly related topics were placed into themes. A code-confirming approach was used to check reliability. An independent qualitative researcher reviewed the themes, factors and sub-factors (codes) for a small sample of the data (4 interviews). At the end of the review, there were no disagreements about the codes or their definitions.

Results

The interviewees represented 10 stakeholder groups (see Table 1). Table 1 displays the five themes identified from the analysis of the interview transcripts and the factors discussed by four or more interviewees. A full coding template is found in supplementary materials 1.

Business-centric motivations

Three factors are discussed within the theme business-centric motivations. First, resources, particularly financial resources, were seen as important to relieve financial restraints and to improve funding opportu-

Table 1. The five motivational themes (bold), their definitions, and associated factors discussed by four or more interviewees (*italicised*) are presented in the table. The stakeholder groups who discussed the themes and factors are indicated with a tick (✓).

Theme/*Factor*	**Definition of the Theme**	**Type of stakeholder***									
		A	**BE**	**P**	**EE**	**F**	**Gov**	**NGO**	**RC**	**ST**	**O**
Business-centric Motivations	Motivations related to the advantages received by the organisation or company.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Resources			✓	✓		✓	✓	✓	✓	✓	
Novelty		✓	✓				✓				✓
Publicity				✓						✓	✓
Participant-driven Motivations	Motivations associated with providing benefits to the citizen scientists.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Engagement		✓		✓	✓	✓	✓	✓	✓		✓
Education			✓	✓	✓	✓		✓		✓	✓
The environmental citizen		✓	✓	✓	✓	✓	✓	✓			✓
Scientific Motivations	Motivations associated with the scientific outcomes of a project.	✓	✓			✓	✓	✓	✓		
Data and scientific advancement		✓	✓			✓	✓	✓	✓		
Personal Motivations	Motivations related to benefits stakeholders (the interviewees) gained.	✓	✓	✓		✓		✓		✓	
Career-driven			✓	✓						✓	
Enjoyment				✓				✓		✓	
Personal interest		✓		✓						✓	
Environmental Motivations	Motivations linked to the environment.		✓				✓	✓	✓		

* Type of stakeholder: A = Academic; BE = Business employee; P = Practitioner; EE = Environmental educator; F = Funder; Gov = Government employee; NGO = Non-governmental organisations/charities; RC = Records centre; ST = School teacher; O = Other.

nities. Second, interviewees were motivated by the potential publicity that may come from supporting ECS including winning awards and increasing memberships:

> "*...with schools, it's the publicity now that comes with it (ECS)... We've had three awards...*" – School teacher 4.

Third, interviewees discussed the novelty aspect of ECS. For example, its use in new sectors or subject areas and the use of new technology.

Participant-driven motivations

Three factors are noted within the theme participant-driven motivations. Interviewees wanted to engage citizen scientists in the natural environment, their CS project or a specific organism:

> "*...(ECS is) an excellent way for getting people involved in physically being out and about in the marine environment...*" – Environmental educator/Practitioner.

Interviewees stated that the education of citizen scientists was rewarding, a way to share their passion for the environment and improve ECS participants' knowledge and awareness. The factor "the environmental citizen" contained the sub-factor's connection to nature, inspiring people about the environment, giving people ownership of the natural world, raising awareness of environmental issues, promoting environmental behaviours and empowering participants.

Scientific motivations

One factor, collecting data and advancing science, was present in the theme scientific motivations:

> "*...citizen science kind of combines, for me, my desire to share the excitement around Natural History but also derived data to get a greater understanding of our natural world*." – Academic 2.

Personal motivations

Three factors are present within the theme personal motivations. Enjoyment was discussed as an important motivator:

> "*I love it and actually a (place name) particularly is a delightful place to do citizen science...*" – NGO 1.

This was linked to the factor "personal interest", where stakeholders discussed wanting to share their passion for the environment and CS topic. Career was also an important motivator, and included being able to publish results and teachers thought ECS was beneficial to their students.

Environmental motivations

Although environmental motivations are not divided into factors (because no factor was discussed by four or more interviewees) they should be considered important. Factors present in the other themes, such as collecting environmental data and improving environmental attitudes, overlap with this theme.

Discussion

This research has identified that stakeholders have a range of motivations, which supports previous research by Elferink (2023) and Geoghegan et al. (2016). Five key motivations were identified within this paper, (1) business-centric, (2) participant-driven, (3) scientific, (4) personal and (5) environmental motivations. The diversity of motivations uncovered is noteworthy, as whilst scientific and environmental outcomes are often the focus of CS publications (Follett and Strezov 2015), this research suggests that stakeholders are driven to support ECS for reasons beyond the dominant narrative of science and the environment. These findings are valuable for the recruitment and retention of important partnerships.

This research recruited a diversity of stakeholders to provide a general overview of their motivations. However, stakeholders are not homogeneous and motivations may differ between stakeholder groups. It is advised that future research on motivations focuses on singular stakeholder groups. Recent research on specific CS stakeholder groups includes Aristeidou et al. (2022) work examining teachers' motivations. It is advised that consistent methodologies be used when investigating the motivations of different stakeholder groups to allow for direct comparisons to be made in the future.

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Ethics statement

Full ethical clearance was provided by Loughborough University (reference: 2021-4933-3719).

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Change – The transformative power of citizen science

Participation and citizen science with young people – the u³Green participation framework

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Abstract

Discussions about the quality of life in cities also emphasize urban green. This is underlined by increasing urbanization and climate change impacts and it requires the appropriate implementation of urban green. Essential to this is a fundamental understanding of how different social groups use urban green and what requirements they place on it. Young people are a particularly challenging social group. This refers to their needs for urban green, which are different from those of adults, and the difficulties in getting them to participate and share their needs. However, which forms of participation are most suitable for young people? What youth-specific results regarding urban green can be achieved through appropriate participation? These questions are being investigated in the project u³Green, whose aim is to develop a youth-centered data collection app, analyze the data collected using this app, and communicate the analysis results to stakeholders. In u³Green, a participation model was developed that combines different participation formats and methods, and thus provides new insights into the use and needs of young people regarding urban green.

Keywords: geo-participation, child-friendly cities, the youth, urban planning.

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Introduction

Quality of life in cities has been increasingly discussed. The reasons for this are the need for (more) livable urban spaces, reduced environmental pollution, and tackling climate change challenges. Here, urban green

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significantly contributes to quality of life in cities (Carrus et al. 2015). Despite its importance, urban green is in growing competition with other urban uses, such as traffic, commerce, industry, and housing. Appropriate attention and measures are required to (better) consider urban green in urban planning (Boulton et al. 2018). For this, a fundamental understanding of how citizens use urban green and the demands they have is crucial. However, the uses and needs of urban green typically vary among different social groups. For instance, urban green usually plays a more important role for the youth than adults. One reason for this is that young people need easily accessible urban green for playing, sporting activities, meeting friends, and relaxing. To implement urban green in line with the demands of young people, it must be considered that they have demands on urban green that differ from what adults consider relevant and what adults consider important for young people (Hennig and Vogler 2016; Zhou et al. 2016).

Now, to learn about the relationship between people and urban green to support the implementation of (more) livable cities, citizen science and participation play an important role. This also applies to young people for whom the use of participatory methods, i.e. citizen science, is a promising approach to designing urban green that is actually suitable for them.

Although young people's participation offers numerous advantages, they are considered a difficult target group in terms of involvement (Aristeidou et al. 2021). Therefore, it is necessary to select and combine suitable participation methods. But which possibilities exist and can be used to support the appropriate involvement of young people that meet their needs? How can these aspects be optimally combined in the context of a participation framework? What youth-specific results regarding urban green can be achieved using a particularly developed participation framework? These questions are being investigated in the project u³Green (https://u3green-zgis.hub.arcgis.com; 10/2022-09/2025). u³Green aims to develop a youth-centered data collection app that allows youths to contribute their personal views on urban green, including infrastructure and characteristics. Such data are considered an important means of supporting the development of (more) livable cities for young people. In u³Green, the youth not only contributes data on urban green, but also participates in the creation of the data contribution app and the data analysis. To support this, a participation framework was created to fully involve young people in all development steps and tasks.

Methods

The design of a specific participation framework in u³Green is based on several steps using different methods (Figure 1): getting to know the target group in detail, identifying appropriate possibilities to support user involvement in different project tasks, selecting and combining appropriate possibilities for youth involvement, and assessing and optimizing the participation framework created.

Understanding the characteristics of young people is crucial for the development of the participation framework, which serves as a basis for further work steps: identifying and evaluating user involvement possibilities, selecting and combining possibilities that build up the framework to appropriately involve young people, and evaluating and optimizing the created participation framework. Literature and Internet

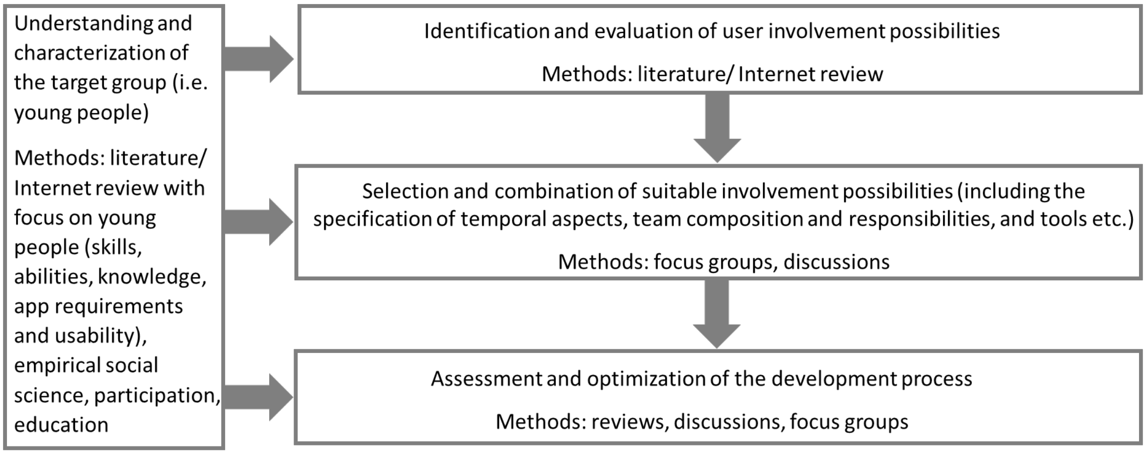

Figure 1. Creation of the u[3]Green participation framework

review was used to gain the required knowledge about young people and identify suitable possibilities for their involvement. Expert focus groups conducted allowed the selection and combination of possibilities to involve young people in the development process, as well as the evaluation and optimization of the created participation framework.

Results

The resulting development process focuses on involving young people in the development of the u[3]Green project solutions (data collection app, data analysis including visuals and geovisualization tools). The process is characterized by a combination of an appropriate design approach and a process model that applies different methods to engage the youth (Figure 2).

Thus, it is characterized by the design approach of strong participatory design (user input is solicited and decisions are made by the people involved in the process). Further, the prototyping model was applied: By creating and discussing various prototypes, the characteristics of the product to be developed can be collected and refined. This forms the basis for delivering the final solution.

The u[3]Green participation framework centers on the following tasks equal for the creation of all three u[3]Green solutions: The gathering of the initial characteristics always relies on information from literature and Internet review. To close knowledge gaps identified, the Metaplan method is applied, and the information obtained is, if needed, assessed and ranked using the Q-method (step 1; Vogler et al. 2023). In step 2, the initial characteristics are used to develop prototypes using the parallel design method (several groups of young people develop solutions in parallel). By discussing these prototypes, additional characteristics can be obtained (step 4). These are combined into a single prototype (step 5), which is further refined using the station discussion method. These insights allow the implementation of the final solution, which is tested (e.g., cognitive walkthroughs, focus groups) and optimized (step 6).

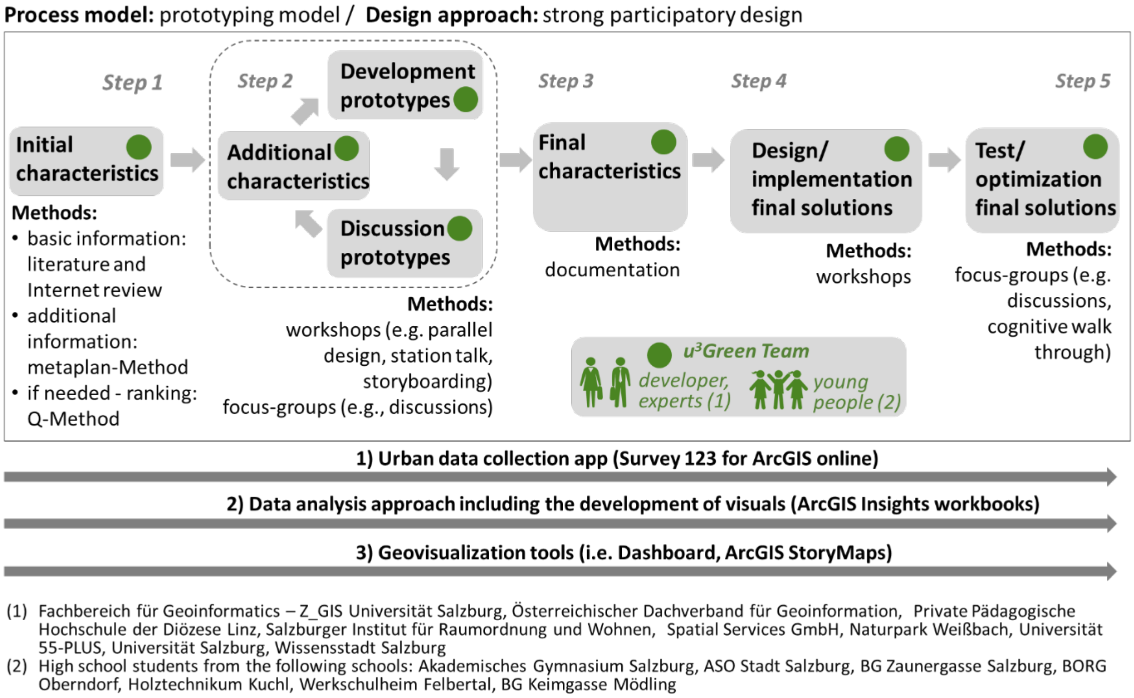

Figure 2. Schematic development process using the u³Green participation framework regarding the development of the u³Green solutions: urban green data collection app, data analysis with visuals, geovisualization tools

As part of the participation framework, young people are involved using various methods in connection with different participation formats (Figure 2): interactive in-class workshops in school (step 1), short-term internships (4 days; step 2), and long-term internships (6–8 months; step 1–5).

Conclusion

The u³Green participation framework presented here has already been used successfully to fulfill the project goals (development of data collection app, data analysis including the creation of visuals) and will also be used to reach the still open project goal (creation of geovisualisation tools). However, through the participation of the youth based on the particularly developed participation framework, we obtained results on young people's use of and demands for urban green. This refers to the relevance of urban green, which is particularly related to walking (including the provision of seating) and the importance of safety and the feeling of security (lighting, open space, e.g., in connection with lawns) and cleanliness. Even if the implementation of the described participation framework is time-consuming and intense, it can be considered a fruitful approach to involve young people in participatory and citizen science initiatives to match their needs and interests.

Acknowledgments

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Change – The transformative power of citizen science

CROPS: changing the scale of citizen science towards the transnational level

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Abstract

Citizen science has become a proven method across a range of scientific disciplines, able to collect new and complementary data which enhances and adds context to existing scientific methods. By upscaling to a transnational level, citizen science could collect, analyse and exploit a vast amount of data across Europe and beyond, achieving a higher impact through creating a multinational community of citizen scientists. However, many citizen science initiatives start at a small-scale, facing technical and practical challenges when attempting to upscale to a wider level, with current EU mechanisms not providing the support or resources required to assist their effort. The CROPS project (crops-cs.eu) will evolve the EU Research & Innovation system so that it can support the transition of citizen science from small-scale to a Europe-wide level, changing it towards a modern, open-science approach. CROPS consists of four activities: (i) appraisal of existing citizen science, their activities and their suitability for upscaling; (ii) creation of protocols and guidance for the upscaling of citizen science, replicating and building on best practice that exists; (iii) providing guidance regarding practical considerations such as open data sharing, sustainability, RRI and diverse funding opportunities; and (iv) development of transnational citizen science communities, including establishing societal coalitions and prospective citizen science champions to raise awareness of the potential of citizen science when addressing Horizon Europe EU Mission goals.

Keywords: upscaling, assessment, interoperability, sustainability, society, open science, citizen science.

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Introduction

In the past decade, the advance of modern-day digital technology has made the world a more connected place resulting in a surge of citizen science (CS) projects. Supported through either traditional funding systems (Horizon 2020: Science with and for Society for instance) or as part of larger initiatives, CS activities have made a significant scientific contribution in creating new and complementary datasets that enhance existing methods (Fraisl et al. 2020). This contribution goes beyond the science addressed, having the potential to impact on a number of societal needs and foster open, inclusive, and democratic science approaches (Wildschut 2017). As such, citizen science has been touted as method to support larger frameworks, for instance in providing data, public engagement, and the societal changes needed to make the Horizon Europe EU Mission goals achievable.

However, whilst existing support mechanisms have proven adequate for the needs of larger CS initiatives, they have not proven suitable for all. Many citizen science activities are small-scale and experimental, and with current financial processes not well adapted to their needs, have failed to upscale over the longer term. The effect of this is exacerbated as such projects are often those that can have the greatest societal impact, lending themselves to consider broader, EU Mission needs. Furthermore, whilst the potential of citizen science towards bridging the gap between science and society is well-known, it can be difficult to fully realise in a measurable way. Despite demonstrating the will to do so, CS practitioners often do not fully appraise their activities' full impact beyond the science involved, due to a lack of expertise, supporting resources, and time (Sprinks et al. 2021).

The aim of CROPS is to recognise the potential of citizen science activities' up-scalability, and invest in their long-term sustainability. It will help CS projects learn from the success of other initiatives that have already upscaled, and provide support kick-starting their own journey. Tools, guidance and best-practice resources will be assimilated from existing research, and openly disseminated to CS activities and their communities in order for them to fully realise their potential in bridging the gap between science and society.

The CROPS Concept

To achieve the CROPS vision of ensuring the next generation of CS activities fully realise its potential at a transnational level, with shared objectives targeted towards EU Mission goals, the following conceptual approach has been developed (Figure 1):

At its roots, the CROPS concept is fed by learning from the best-practice of existing citizen science projects that have successfully upscaled beyond their original scope. Experiences and knowledge from existing initiatives will be used to inform a thorough screening process to identify CS projects with the potential to upscale to a transnational level. CROPS will support the growth of CS activities that have been identified as suitable for upscaling to a transnational level. It will do this by adapting and utilising existing tools that have been developed through previous EU and other projects and activities. Protocols and strategies relating to communication, stakeholder engagement, training resources, mobilisation of funding, data management,

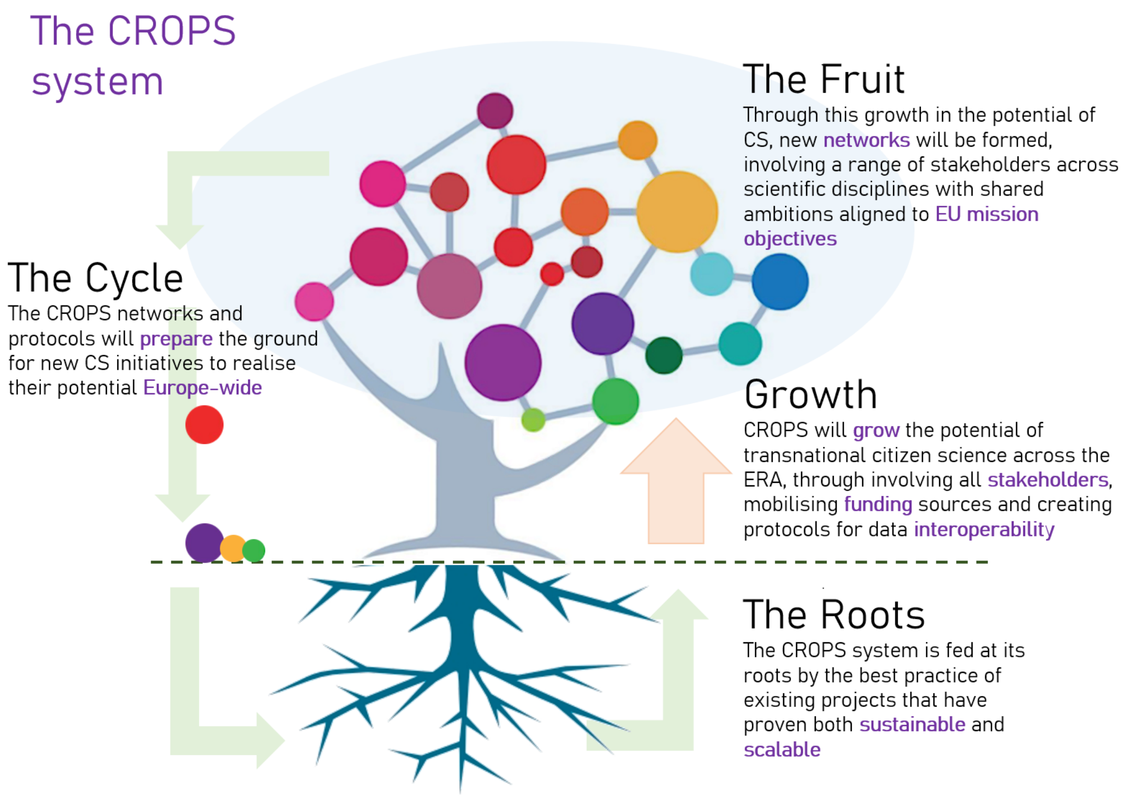

Figure 1. The CROPS concept and approach

and design will be developed as part of a user-centred process. The fruit of the CROPS concept, resulting from the screening and support actions and more specifically the user-centred, multi-stakeholder approach taken, is the creation of transnational CS communities and societal coalitions. Shared spaces will be created in conjunction with existing platforms such as EU-Citizen.Science to foster the creation of communities linked with each of the EU Missions, helping to foster alignment of actions and their objectives.

CROPS Methodology

The cornerstone of CROPS will be assessing scalability potential of citizen science projects and selecting those to focus on more in-depth accordingly. To do so, CROPS will be informed by an established framework developed by Ideas for Change and the JRC to understand and subsequently guide efforts in this way (Maccani et al. 2020), and also by subsequent work expanding on this method (Radicchi et al. 2023). In its nature, the upscaling phenomenon entails an initial citizen science project, initiative, action or intervention in a given context and its replication (in its entirety or of some of its parts) in another context where some or all parts of the original project are adopted. The framework therefore draws upon three relevant theories: i) adoption of innovations, ii) diffusion of innovations (Rogers et al. 2008), and iii) the concept of infrastructure from the Participatory Design discipline. The framework has been tested empirically and includes nine enablers for scaling citizen science projects or interventions. These can be divided into three clusters: (1) intrinsic elements of a given citizen science initiative (i.e. elements about the initial intervention to be scaled); (2) elements supporting the scaling process; and (3) level of alignment with the target context. In summary, the framework outlines nine empirically and theoretically grounded constructs that, if in place, foster scalability of a given citizen science intervention.

Informed by this methodology, CROPS will evaluate projects in terms of their scaling potential based on: (i) Elements intrinsic to the original project – proof of value, ease of understanding and level of openness in terms of resources and governance; (ii) Elements, when appropriately addressed, enable and substantially support the upscaling process – development and dissemination of narratives and consistent communication, existing community and champions, and potential for knowledge sharing and transfer of resources; and (iii) Alignment of the original citizen science initiative with other potential target contexts across the ERA (specifically the EU missions) – legal alignment, alignment of matter of concern (considering all quadruple-helix stakeholders), and alignment of social values (compatibility with the ethical values of the target context).

Conclusions

The CROPS project has ambitious plans in identifying CS activities suitable to upscale to the European level, and in creating transnational spaces and societal coalitions to share knowledge and foster alignment towards the EU Mission goals. Due to the broad types of CS covered, and the large number of projects engaged by CROPS actions, there is a risk that project support and communication becomes disparate in nature. To prevent this, the support and guidance offered by CROPS will be designed not only to be top-down, but also peer-to-peer in nature. The communities and coalitions created will be designed to be places of shared learning, formed through community events, workshops and online shared spaces, allowing projects and their associated communities to learn from each other.

Acknowledgement

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Change – The transformative power of citizen science

VifAdept project: participatory research on grapevines to adapt wine production to climate change

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Abstract

Vifadept is an on-farm data collection project. It has its origins in the VitAdapt (for Vitis Adaptation) research project (Destrac-Irvine and van Leeuwen 2016), which provided the basis for creating a network of plots on which winegrowers participate in climate change adaptation by experimenting with new varieties in cooperation with researchers and the wine industry.

Keywords: grapevine, climate change, adaptation, new varieties.

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A climate change context

Everything started after the 2003 heatwave, when winegrowers raised their concerns about climate change with the interprofessional council of Bordeaux wines (CIVB). After discussions to develop adaptation strategies, the VitAdapt research project was launched in 2007 to study the response of a wide range of grape varieties to climate change in Bordeaux, France.

Among various adaptation levers to climate change, varietal diversity is an available and suitable tool to adapt vineyards. Effectively, more than 6,000 grape varieties are listed worldwide, but only 33 account for half of the world's vineyards. In France, 10 varieties account for 70% of the surface area and only three varieties (Merlot, Grenache, Ugni blanc) account for 30% (OIV 2017). This situation is linked to the history

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of the grape growing areas and the production under Appellations with their specific authorized grape varieties. Another reason is the ever-growing share of varietal wines in the market. For varietal wines, the name of the variety acts like a brand. Because consumers only know the names of a limited number of varieties, growers tend to plant only well-known varieties like Chardonnay and Cabernet-Sauvignon.

Faced with this loss of use of natural diversity, the researchers wanted to assess the potential of grape varieties to respond to climate change, in particular by experimenting with varieties coming from hot and dry regions.

The VitAdapt research project, advantages and limitations

The VitAdapt project, implemented by Bordeaux researchers, represents an extensive phenotyping study of 52 different grape varieties over a long period of time. The project is based on an experimental setup with vines planted in 2009 on the same rootstock, with five repetitions to neutralize the effect of possible soil variability. The objective is to study the response of reference varieties from Bordeaux and varieties from different origins: France, Spain, Italy, Greece, Portugal, Bulgaria and Georgia. After more than 10 years of study, a database was established with a wealth of information concerning the adaptation and the behavior of this large range of varieties. The VitAdapt project showed a wide diversity of responses between the 52 varieties and the necessity of multi-year monitoring to characterize the varieties.

However, this research project was carried out on a single site with a single type of soil and cultural practices. The second step was therefore to develop on-farm research to test grapevine varieties on farmers' fields under variable environments and management conditions compared with those of a research plot. Moreover, considering the farmer and his local conditions means appreciating the perception and knowledge that farmers have of their own farm (Stroud 1993).

Ways of involving the farmer in the research process

To support research into the contribution of plant material to adaptation to climate change, a national directive was published (Directive INAO–DIR–CNAOV–2023- 01). Since 2018, the law authorizes winegrowers in the Appellations to experiment with new Varieties of Interest For Adaptation purpose (VIFA) under some conditions: maximum 5% of the surface area, 10% of the blend, 20 varieties (10 red, 10 white) and a 10-year evaluation period with a possible 10-year extension. Each Appellation should define a list of varieties to test.

The "Bordeaux" and "Bordeaux-Supérieur" Appellation (50% of Bordeaux vineyard with more than 53000 ha) used the results of the VitAdapt project to select six new varieties to be introduced into its specifications in 2019. For each Appellation, the results produced by the project were a valuable resource for making an informed choice.

The authorization to cultivate these six new varieties on Bordeaux AOC vineyards offers the opportunity to co-construct knowledge with winegrowers by monitoring the behavior of new varieties in a network of on-farm trials and characterizing their potential in response to the expectations of the INAO (National Institute of origin and quality) and the various actors in the appellations.

Experimental conditions and the VifAdept project's contribution to on-farm trial management

For the duration of the experiment (10 years renewable), these plots have to be monitored using standardized protocols and centralized management of the data produced. This monitoring, which winegrowers may find fastidious, could limit the involvement of professionals in these initiatives. This is why we proposed the VifAdept initiative (for VIFA deployment) to support winegrowers in this experiment and encourage them to take an active part in adapting their vineyards to climate change.

This project, which associates scientists, winegrowers, professionals and wine growers' associations, has allowed us to create a network of production plots in different pedoclimatic contexts (with different rootstocks and on different soil types). To enable the monitoring and production of reliable data on this network, research protocols have been adapted, leading to the development of new data acquisition tools.

One of the most important parameters studied on the farms is phenology, a highly effective marker for establishing and validating climate models. Under the influence of climate change, the three main phenological stages of the vine (budburst, flowering and veraison, i.e. the onset of ripening) occur significantly earlier. This has a major impact on vine-growing conditions, leading us to reconsider the way the vineyards are managed. Knowledge of the phenology of vineyard plots enables winegrowers to adapt their vineyards and their practices to changing climatic conditions.

To support the requirements of the VIFA experiment, improve and facilitate the acquisition and supply of phenology data, and then encourage and facilitate phenology notations by winegrowers involved in the newly created plot network - and beyond - we are currently developing a very easy-to-use and fully accessible tool. This work complements a published methodology for phenology monitoring (Destrac et al. 2019) and consists of PhenoVit, a free smartphone application and its associated website. Smartphone technologies offer great potential for participatory agricultural research and large-scale data collection. Dehnen-Schmutz et al. (2016) quantified and explored farmers' use of smartphones in Europe and assessed the potential of smartphones for farm-based participatory research. They showed that farmers have sufficient access and knowledge of the technology, as well as enthusiasm for participation in citizen science, which formed the basis for developing our application. This enthusiasm was also justified since involved winegrowers also volunteered to participate in the development of the specifications for this application on phenology. Based on the concept of ApeX-Vigne (Pichon et al. 2021), this tool uses an image recognition system. The aim of the application is to provide a simple tool for winegrowers and technical managers to facilitate the collection of phenological observations. It will automatically calculate the dates of phenological stages, georeference phenological observations and automatically transfer phenological data to a database on a server to facilitate future analysis and sharing of this data. This database is essential for modelling the behaviour of new varieties and simulating their development in different terroir and climate scenarios.

This innovation, intended for a large community of end-users, will help to further investigate climate-vine interactions. It also informs professionals about the importance of assessing phenology and teach them how to implement notations, for optimizing risk management in the vineyard and adapt grape varieties and practices to changing climatic conditions.

In conclusion, the VifAdept project encourages and supports winegrowers in their active participation to adapt their vineyards to climate change, by advancing our knowledge of new varieties and support the industry as it considers the grape varieties of the future.

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Change – The transformative power of citizen science

Boosting biodiversity in school grounds: a theory of change

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Abstract

The National Education Nature Park aims to involve every nursery, school, and college in England in enhancing the biodiversity on their site, whilst supporting young people's wellbeing, pro-environmental behaviours, and green skills. Young people gather environmental data using citizen science research, and then through collaboration and collective decision-making, they design and implement their own nature recovery actions. But will this participation in community and citizen science lead to behaviour change and environmental action, and how can we build participants' sense of agency to take environmental action through our programme? Here, we present our Theory of Change for the Nature Park and the design features of the programme that connect participation in citizen science with achieving two crucial types of change - environmental change in the form of biodiversity gain, and the behaviour change that underpins it.

Keywords: biodiversity, community science, education, environmental science agency, theory of change

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Introduction

Biodiversity – the range of species, habitats, and ecosystems in an area - is in a state of decline both globally and in the UK (Burns et al. 2023; IUCN 2020). Concurrently, many children spend little time outside in nature with potentially detrimental effects on health and wellbeing (Chawla 2020). The Dasgupta Review (Dasgupta

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2021) argues we have failed to engage with nature sustainably and calls for an urgent transformation of our systems, particularly education. England's educational estate (the land occupied by all nurseries, schools, and colleges) is estimated to cover 514 km² (Department for Education 2021). By better integrating nature into school areas, we can increase biodiversity while increasing the health and well-being of children and young people, and educational outcomes. The National Education Nature Park (Hazell and Clarke 2024) aims to involve every nursery, school, and college in England in enhancing the biodiversity on their site, whilst supporting young people's wellbeing, pro-environmental behaviours, and green skills. The programme focuses on building young people's sense of agency to act and supporting them in gathering the data they need to make informed decisions about enhancing their learning spaces for nature, and for themselves.

Methods

Unlike most projects which tend to be linear, the programme guidance is not prescriptive but suggests a five-step cycle for participants (Fig. 1). Educational settings first map their sites' boundaries, habitats, and biodiversity using iNaturalist (iNaturalist 2024) and digital tools developed by Esri UK. This forms a baseline for schools to identify spaces to improve for nature and people, and to implement projects to enhance their sites. Using these digital tools, they will monitor these changes, and reflect on and celebrate their achievements. Activities are planned and delivered by educators, supported by learning resources developed by the

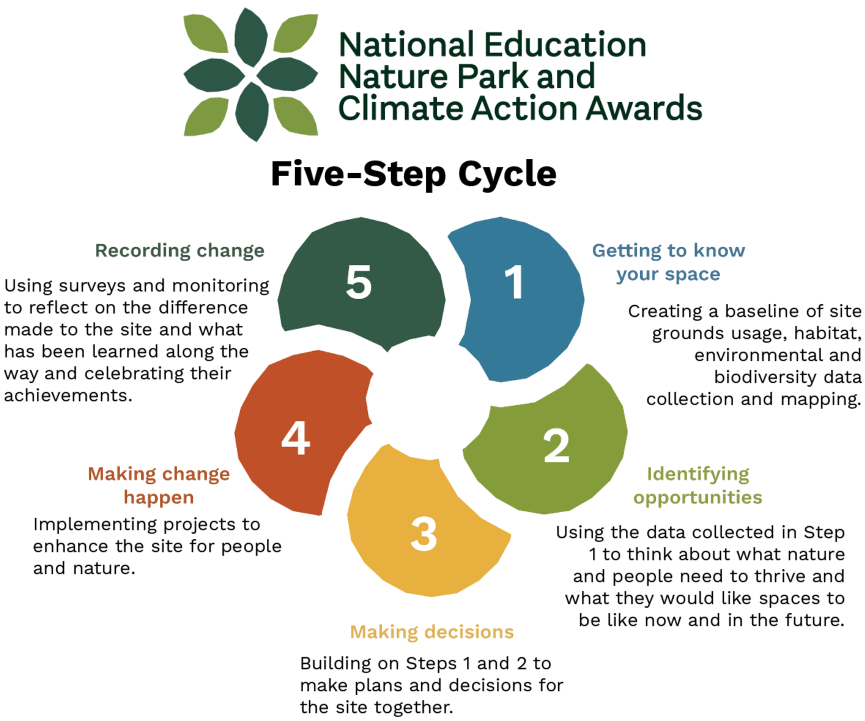

Figure 1. The National Education Nature Park Five-Step Cycle.

Nature Park team, and are intended to involve the whole school. By embedding pro-environmental activities within the programme itself, we hope for stronger outcomes.

Theory of Change (ToC) approaches were first developed in the US to evaluate complex community initiatives but are increasingly being used in the UK to evaluate policy initiatives (Sullivan and Stewart 2006) To guide the evaluation of the programme the team developed a ToC based on an academic literature review, the Dasgupta Review (Dasgupta 2021) and feedback from the delivery team and programme funder. The ToC connects the design, input and activities of the project to the expected outcomes.

As we evaluate the Nature Park, we will test and refine the connections between these different elements of engagement and outcome. Methods to evaluate the Nature Park and its alignment with the ToC include quantitative data collection, case studies and teacher surveys. An external evaluator will make case studies of ten educational settings per year to understand how they perceive the programme and how they have implemented it.

Results and discussion

Since its launch in October 2023, more than 3,200 educational settings have registered for the Nature Park, including 11% of all primary and secondary schools in England as of June 2024. So far, over 100 participants have mapped their baseline habitats, and new wildlife areas created include ponds and green walls.

The Theory of Change (see supplementary material) suggests the activities within the Nature Park, including lessons on biodiversity, community science, and engagement activities will achieve an increase in biodiversity, promote pro-environmental behaviour, and enhance overall well-being. It is anticipated that, by spending more time in nature, young people will feel more connected to nature, and this predicts increased wellbeing (Capaldi et al. 2015; Mayer et al. 2009; Pritchard et al. 2020; Richardson et al. 2021) and pro-environment behaviour (DeVille et al. 2021; Mackay and Schmitt 2019). We have also designed the programme for children and young people to develop an identification with environmental science, roles within it, and a sense of agency to enact change, using the Environmental Science Agency (ESA) framework (Ballard et al. 2017a).

Based on the strength of evidence gathered some aspects of the ToC may be confirmed, while others may be rejected, leading to adjustments. Although we know that community science can lead to multiple research and conservation outcomes (Ballard et al. 2017b), the connection between doing research through community science and taking nature recovery actions is still not well established, so this is one of the key linkages in the Theory of Change that will be tested.

Conclusion

In conclusion, the Theory of Change offers a promising framework for evaluating the Nature Park and assessing which activities could enhance knowledge of biodiversity, green skills, and nature connectedness. In the context of a Planetary Emergency, leveraging the vast numbers of people participating in citizen science will be crucial for driving them towards meaningful action. Understanding which activities effectively inspire this action is essential for maximising the impact of these efforts.

Acknowledgements

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Change – The transformative power of citizen science

How to include schools in citizen science health studies: Practical experiences and lessons learned

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Abstract

STEAM education is gaining increasing significance in science education and educational policies throughout Europe as it aims to equip young learners with relevant skills and knowledge to tackle global challenges effectively. But educators often encounter difficulties in engaging students, particularly in subjects like statistics, biology, and chemistry. Integrating citizen science activities into project-based learning could serve as a valuable tool in igniting students' interest in these subjects. Such initiatives may even inspire students to pursue academic careers in these fields. But when researchers approach schools to collaboratively conduct scientific studies they face manifold challenges, like limited motivation to participate or the need for adaptation of the scientific study to school curricula. When it comes to organizing citizen science health studies in schools, the challenges become even more complex due to the importance of data protection. These obstacles and potential solutions were discussed in the ECSA 2024 workshop, where we brought together 31 researchers and practitioners from schools, science, pedagogy, and medical research in the 1,5-hour working session. We identified important issues and good practices related to the motivation of schools, the link to curricula, ethical challenges and the issue of impact assessment.

Keywords: citizen science, education, health, medical, school, STEAM.

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Introduction

STEAM education is an integrative educational approach that fosters pupils' interest in science, technology, engineering, arts and math as it develops a range of important skills like critical thinking and science literacy. To develop fluency with STEAM, research suggests that engagement in authentic science experiences is required as we must do science to learn science. Thus, the active engagement of pupils in citizen science activities can considerably contribute to STEAM education. Some citizen science projects intentionally integrate learning goals with broader project objectives, with scientists and educators crafting collaborative activities to foster scientific education. Other citizen science activities can be adapted or repurposed for learning, where pupils engaged in scientific endeavors benefit from background information and material, and learning takes place less intentionally.

Intentionally planned or even as a "by-product" of collaborative research activities, citizen science has proven to generate important learning outcomes (Schaefer et al. 2021; Kumar et al. 2023; Fattal and Heejung 2023). By intertwining science subjects, arts, and citizen science activities, educators can facilitate not only the transfer of knowledge but also foster a deeper understanding of the interdisciplinary connections between different subjects. Students are encouraged to apply their learning to real-world problems, reinforcing the relevance and transferability of their education.

However, when researchers approach schools, they face challenges related to the planning and implementation of the participatory research approach and assessing its impact. Therefore, we organized this workshop at the European Citizen Science Conference 2024 to support mutual learning and experience exchange among the 31 participants of the session.

Methods

The method of our workshop altered individual reflections with a collaborative harvesting and discussion of individual experiences. We opened the session with a short presentation of the EU-funded project InChild-Health that involves schools and children from 6 to 13 years in a citizen science health study and introduced some of the key challenges we are facing in our work. This input presentation was followed by an individual reflection of challenges faced in the participants' projects and working situations, noted down on post-its. These thoughts were presented to the plenary, the post-its grouped to challenge clusters and discussed together.

In the next step we focused the discussion on sharing concrete solutions to the encountered challenges. All participants could contribute with their good practices and experiences, noted them on post-its and added them to the challenge clusters. The outcome of this workshop was a rich map of challenges and solutions of how to involve schools in citizen science health projects.

Results

The following challenge clusters and solutions have been identified by participants.

Motivation of schools, teachers, and parents to participate

The challenge is how to get schools enthusiastic to participate in a citizen science project when they have a full program already. Especially teachers need to be motivated to participate but are very often overwhelmed by their teaching obligations and demanding school curricula. Also, parents need to give their consent for their children to participate in research activities.

Solutions:

- Approach schools very early and talk to directors and teachers to understand their needs and expectations; learn from the contextual factors and tune your research activities to the necessities of the school.
- Co-design and pre-test every information material with teachers, pupils and parents.
- Manage expectations and communicate very clearly the outcomes and limits of the study.
- Offer teachers to get involved but also be prepared to do a lot of activities with your own team to unburden teachers.
- Emphasize the fact that pupils very often benefit from external practitioners and researchers who involve them in problem-based, hands-on learning activities.

Including citizen science activities in the curricula

The challenge is how to link citizen science activities to school curricula and do a proper scientific study without requesting tasks that are too difficult or demanding for students. This challenge also links closely to the motivation of participation.

Solutions:

- Make yourself acquainted with the current school curricula and relate your activities very concretely to them.
- Approach schools with different citizen science modules, that allow teachers to choose between different degrees of involvement. E.g. in InChildHealth the citizen science module “Air Quality Checker” takes only two hours and provides basic information and hands-on activities related to indoor air quality and mitigation measures. While the module “Air Quality Researcher” lasts around eight hours and students can explore the air particles in their classroom, define a research question, collect data on bacteria and fungi, and analyze them together with the researchers.
- Involve the teachers already in the first step of co-designing the science activities and the data collection methods.
- Do pilot-testing of your procedures, adapt protocols to the pupils’ skills, think of data quality measures early on.

Doing a proper impact assessment

The discussion focused on what evaluation instruments are well-suited for pupils of different ages and how not to be too demanding in collecting evaluation data.

Solutions:

- Involve students in more creative ways to present the outcomes of their work, e.g. doing a video or presenting the results on self-made flip-charts.
- Organize peer-to-peer interviews and focus groups that can also be held for students to get direct feedback on the process.
- Use gamified approaches and digital tools
- Co-design and pre-test your evaluation material
- Empower teachers to play a role in evaluation

Addressing complex GDPR and privacy issues in health studies

The challenge discussed was how to deal with complex and time-consuming ethical procedures and what to do if the project activities change in participatory projects. Also, the documentation of the citizen science activities and comparing and keeping track of data of individual students while being GDPR conform were issues mentioned.

Solutions:

- Build teams with someone who knows about the ethical procedures well, run through the ethical procedure early to get permission to do your research and file an amendment if things change.
- Ask students to do the documentation of the activities and invite schools to promote the activities, then you can refer to the material created by students and school personnel.
- Let the students choose their own anonymous ID, which will be used by them whenever they contribute data.

Discussion

As the results have shown, the workshop offered space for rich discussion amongst participants and there are clearly challenges regarding the involvement of schools in citizen science studies. Most of the challenges and solutions are not specific to health studies but apply to citizen science in general. Only the complex GDPR issues and the challenge of handling the very sensitive health data of minors come very specifically into play when we do participatory research in schools related to health and medical topics. The variety of issues raised led to the four challenge clusters, related to the motivation of participation, the linking to school curricula, evaluation challenges and ethical considerations. These were discussed in more detail and triggered the mutual exchange of potential solutions. We could identify good practices for all the challenges and the informal feedback from participants was very positive to take some of the learnings to their own work with and in schools.

Conclusion

In the end, participants collaboratively worked on current challenges and strategies for doing citizen science health studies in schools. The intensive discussions and the interest expressed by most participants clearly revealed that there is a need for a more dedicated exchange about the topic and follow-up workshops with some of the participants may help to find more practical solutions for the future.

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Change – The transformative power of citizen science

"I am more confident to talk about death now". Students' response to the citizen science project SoKuL

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Abstract

In the citizen science project "Storytelling about caring cultures at the end of life. Students and citizen scientists are doing research in intergenerational and intercultural exchange (SoKuL)", students (n=6) reported in qualitative interviews and focus groups on their learning experiences in the project.

The students were able to gain varied and sustainable experiences. As a result of their participation in the project, they perceived personal development, which they describe as valuable for their internship and their future profession in elderly care. This concerns the development of an attitude that makes it easier to deal with and address the topics of dying, death & mourning and a learning process in conducting dialogues.

The in-depth learning experiences of the participating students illustrate the interventional nature of the research project. The participation of citizen scientists as co-researchers not only serves the advancement of knowledge in sciences. Their participation in the project was accompanied by a transformative learning process.

Keywords: citizen science, end of life, palliative care, participatory research, storytelling, transformative learning.

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Introduction

October 2022 was the launch of the citizen science project “Storytelling about caring cultures at the end of life. Students and citizen scientists are doing research in intergenerational and intercultural exchange (SoKuL)”. We cooperated with the School for Elderly Care in the “Caritas Ausbildungszentrum für Sozialberufe” in Vienna. In the beginning of the project, we performed workshops and storytelling cafés with one class of this school. Over the course of the project, a core team of six students was formed for more intensive joint research work and other citizen scientists, mainly older people, were involved as contributors in storytelling cafés. By December 2023, 13 storytelling cafés on the topic of the end of life had taken place at various locations (nursing homes, museum, library, etc.), with between 7 and 32 people taking part. The students took on different roles in the storytelling cafés. They could spend the required time during their training period, any additional time was rewarded with a small amount of money. The other participating citizen scientists received no financial compensation.

Within the citizen science discourse (Eitzel et al. 2013), the SoKuL project can be located in the tradition of participatory action research (Hockley et al. 2014). This goes hand in hand with an understanding and the intention that (participatory) research processes intervene in social systems and thus change them. We understand the learning processes initiated through participation in the project as transformative educational processes in the sense of resonance pedagogy, a concept of learning by doing (cognitive, physical and emotional) (Beljan 2019; Rosa 2021).

The aim of this study is to reflect on and systematically record the learning experiences in relation to the project topic *care cultures at the end of life* and the *storytelling café method* from the students’ perspective. What resonance experiences did students have as a result of participating in the project? What did their participation in the storytelling cafés change for the students?

Methods

In December 2023, five students from the core team received a training on interviewing and consequently interviewed each other about their experiences in the project and in the storytelling cafés. They conducted qualitative semi-structured interviews. In addition, two focus groups (n=5/n=6) were held in December 2023 and January 2024, where, as in the interviews, the project and storytelling café experiences were reflected upon. The interviews and focus groups were recorded, pseudonymised, transcribed verbatim and analysed thematically by the researchers (Clarke and Braun 2006).

All of the participating students are completing their second education. They are between 30 and 52 years old, four of them are female and two are male, half of them are migrants.

Results

The students were able to gain varied and lasting experiences, particularly through their participation in the storytelling cafés.

> "*What surprised me so much was the really very private, intimate stories that were actually told. (...). I was very touched. And that will stay with me forever, yes, it does something to you, the experience*" (AS/FG5, 11).

They could perceive changes in themselves as a result of participating in the project, which they describe as valuable for their practical training and their future profession in elderly care. They feel "*more confident to talk about death now*" (AS/I4, 91). This concerns 1) the development of an attitude that makes it easier to deal with and address the topics of dying, death & mourning and a 2) learning processes in conducting dialogues.

1) Dealing with dying, death and mourning

Participation in the project encouraged the students' personal engagement with the topic of end of life.

> "*I heard a lot of stories in the storytelling café, I also told a lot myself (...), maybe it was difficult to address the topic at the beginning. It got better as time went on. I feel good in this project and have developed well, really being able to deal well with these situations at the end of life (...) for me personally*" (EL/I5, 14).

The attitude that the participating students have a more open approach to the topic of dying and death is perceptible. They increasingly find themselves in situations where they talk to someone about it, whether it is a nursing home resident, a relative or a colleague.

> "*Everything that has to do with death is something that tends to be marginalised in our culture. And you don't really know if you're allowed to talk about it now. Or when you see that someone is dealing with it, is sad, is worried. I have to say, I've lost my fear as a result. So I deal with it more openly. Very openly now, actually. And that's what the project has done to me*" (SJ/FG5, 20–22).

By listening to a variety of stories about the end of life in the storytelling cafés, the students learnt about many different ways of dealing with dying, death and grief, which is perceived as an enrichment for their professional activities.

2) Conducting dialogues

The importance of listening was very much emphasised as an aspect that could be taken away from the storytelling cafés, especially for their work with the elderly. "*I first have to listen and look before I can help*" (TS/FG4, 119). However, this aspect is not taken for granted in everyday working life.

Another important aspect is described by the students as allowing emotions, enduring silence and not judging.

> "*What I take away is that silence is also a form of communication, and in the internship, when I talk to people, I allow their feelings. And I don't have to comment on anything, just take it, and yes. I've learnt that*" (AS/FG5, 47).

Discussion and Conclusion

The in-depth learning experiences of the participating students illustrate the interventional nature of research projects (Ukowitz and Hübner 2019). The participation of citizen scientists as co-researchers not only serves the advancement of knowledge in sciences. Their participation in the project was accompanied by a transformative educational process that is reflected in the students' changed practices.

The storytelling café on the topic of the end of life with subsequent reflections is not only a social science survey method, but also proves to be a suitable method for acquiring the necessary skills in palliative care. The required specific attitude and conducting dialogues are skills that cannot be acquired purely cognitively. They require spaces of experience and resonance (Rosa 2022).

In the course of the storytelling cafés, encounters at eye level and a non-judgemental framework proved to be both a conducive learning environment and favourable in the collaboration between scientists and citizen scientists. The storytelling café is particularly suitable as a citizen science method, as it promotes mutual understanding, initiates change and learning processes and generates knowledge at the same time (Pichler et al. 2023).

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Change – The transformative power of citizen science

Students as citizen scientists on social media: how do learners evaluate science communication on TikTok, Instagram and YouTube?

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Abstract

As part of the Citizen Science Awards in Austria, the project "We Talk About Science" explored how students interact with and assess science communication on Instagram, YouTube, and TikTok. Over three months in 2023, 21 school classes recorded 3,654 instances of science communication content. The study found significant differences in students' abilities to critically evaluate this content, influenced by platform type and gender. Instagram posts received lower evaluations, and boys rated posts on Instagram and TikTok more negatively than girls. These findings highlight the need for educational initiatives to improve students' critical analysis of science communication.

Keywords: science communication, social media, secondary school.

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Introduction

Scientific communication, i.e. the communication of scientific content to laypeople, has become an important aspect of scientific activity. Understanding science contributes to participation in society and is a prerequisite for making informed decisions and being able to actively participate in society (Davies and Horst 2016).

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However, the latest Eurobarometer shows declining trust in science and interest in science (European Commission 2021). It has already been shown for adults that the use of online sources can strengthen professional knowledge and trust in science (Huber et al. 2019) and enables informal learning in this area (Lundgren et al. 2022). The communication of scientific knowledge and science is also increasingly shifting to social media (Könneker 2020). Given that young people spend a significant amount of time on social networks (saferinternet.at 2024), they can also be considered as a target group for science communication.

The Sparkling Science project 'We Talk About Science' aims to study students as a target group for science communication by enabling them to communicate knowledge themselves. The goal is to develop criteria for effective science communication with students. In 2023, as part of the Austria-wide "Citizen Science Award", school classes logged and rated science communication content from their social media consumption. The collected results were discussed in-depth with selected classes to better understand students' consumption of such content (see Majcen & Spitzer in this proceedings).

Methods

Given this context, our research questions seek to explore how students experience and evaluate scientific communication in their everyday lives on popular social media platforms:

- **Focus 1:** What forms of scientific communication do students encounter in their everyday lives on familiar platforms such as Instagram, YouTube, TikTok, and other social media?
- **Focus 2:** How do students evaluate these science communication products?

Entire school classes participated in the award, with no restrictions on the choice of social media platforms. Participants could use multiple platforms and submit contributions from any of them. Students logged posts they identified as science communication, providing a screenshot, link, topic, and brief description. They then evaluated the posts based on attractiveness, technical accuracy, and scientific quality using a 4-point Likert scale. We hypothesized that students rarely encounter science communication posts in their everyday social media feeds, so we allowed targeted searches for posts. This implies that our conclusions are limited to the posts identified and evaluated by students. The main aim of the project was to assess the quality of the science communication content as perceived and critiqued by the students.

Results

Between April and July 2023, 21 school classes from 13 different schools across Austria participated in the project. A total of 3,654 protocols were compiled, offering insights into the consumption of science communication products (see Table 1).

Table 1. Description of the sample

sex	N	%
female	2776	76,6
male	721	19,9
diverse	127	3,5
total	3654	100,0

Most posts were recorded on Instagram, TikTok, and YouTube. Facebook, X, Telegram, and other platforms were used significantly less and played a minor role in the overall sample. To get an insight into popular accounts, accounts with the most submitted protocols were ranked. Table 2 lists the 10 accounts with the most logged posts across the three most frequently used platforms.

Table 2. Top-10-Accounts

	Instagram			TikTok			YouTube		
	Account	**N**	**%**	**Account**	**N**	**%**	**Account**	**N**	**%**
1	orf.at	94	8,3	jjchemistry	80	7,4	Biologie - simpleclub	96	9,4
2	abi2med	36	3,2	wissensbert	68	6,3	musstewissen Chemie	72	7,1
3	ericlagadec	26	2,3	nss3221	24	2,2	Dinge Erklärt – Kurzgesagt	61	6
4	physikcoach_robert	24	2,1	space.generation	21	1,9	Chemie - simpleclub	60	5,9
5	Doktor-wissenschaft	23	2	astroocomet	19	1,7	Lehrerschmidt	58	5,7
6	mrwissen2go	22	1,9	Rhombenikosidodekaeder	19	1,7	maiLab	54	5,3
7	zeitimbild	21	1,9	raysherifi	18	1,7	Physik - simpleclub	50	4,9
8	Deutschesgesundheitsportal	19	1,7	sciencefunn	18	1,7	100SekundenPhysik	31	3
9	quarks.de	19	1,7	lord_of_the_stars	17	1,6	wissensbert	25	2,5
10	Visionpflege	19	1,7	niklaskolorz	17	1,6	Vsauce	24	2,4
				Tamuphysastr	17	1,6			
	total	303	26,8	total	318	29,4	total	531	52,2

Instagram features three accounts—"orf.at", "zeitimbild", and "quarks.de"—operated by public broadcasters. These accounts do not appear in the top 10 on TikTok, where the content primarily focuses on astronomy. The content from the accounts on YouTube is predominantly categorized within the explanatory video sector.

It's not just the most popular accounts that vary depending on the platform. There are also clear differences in the evaluation of the contributions. Due to the high proportion of female students, the evaluation was carried out separately. Figure 1 displays the evaluations by female students, with average ratings consistently high, ranging between 3 and 4, indicating that the contributions were viewed very positively. For enhanced visualization, only areas 3 and 4 are displayed on the y-axis.

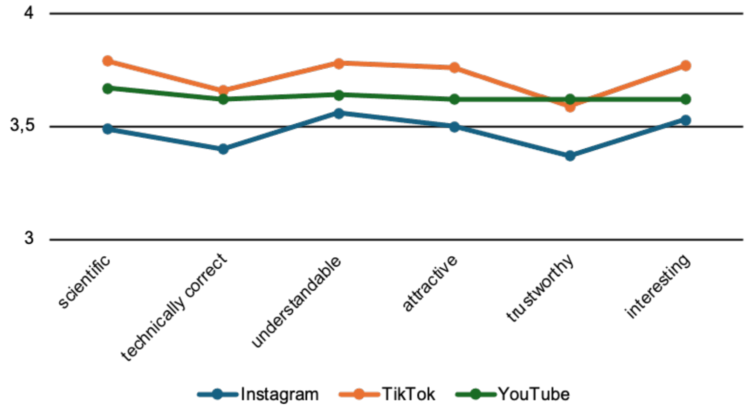

Figure 1. The figure displays the female students' evaluation of posts on the platforms Instagram, TikTok, and YouTube, using a 4-point Likert scale (ranging from 1 = completely disagree to 4 = completely agree). For improved readability, the y-axis is not shown in its entirety.

An ANOVA revealed significant differences in the evaluations across platforms. The evaluations of the contributions by the male students are as positive as those by the female students (Figure 2).

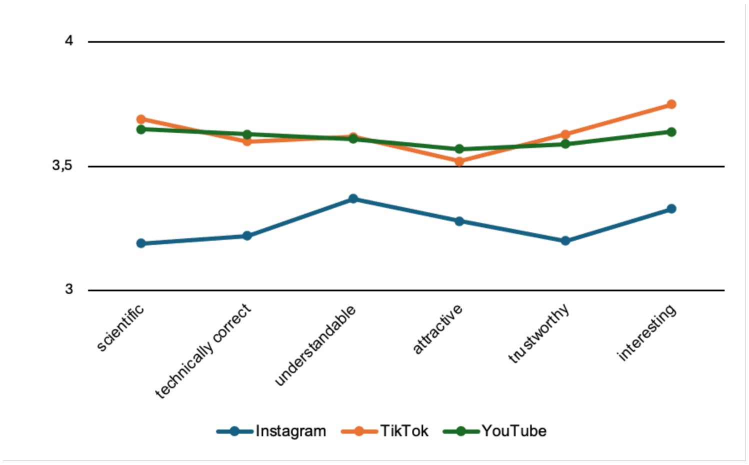

Figure 2. The figure displays the male students' evaluation of posts on the platforms Instagram, TikTok, and YouTube, using a 4-point Likert scale (ranging from 1 = completely disagree to 4 = completely agree). For improved readability, the y-axis is not shown in its entirety.

Instagram are rated significantly lower than posts on TikTok or YouTube. In contrast, no significant differences were found between posts on TikTok and YouTube. Supplementary unpaired t-tests revealed that boys rated posts on Instagram and TikTok significantly more negatively than girls but no significant difference was found for logged videos on YouTube.

Discussion

The top 10 accounts list reveals differences in content consumption across platforms. Public broadcasters are prominent on Instagram but absent in TikTok's and YouTube's top 10, where explanatory videos dominate. Students rated contributions highly for scientific quality and technical accuracy, deeming them trustworthy. Despite data variability, incorrect markings were ruled out, suggesting students submitted high-quality entries. Without a given definition of science communication, students logged posts based on personal interpretations, leading to discrepancies with established definitions. Some ads and entertaining posts were incorrectly categorized as science communication. This indicates a deficiency in students' ability to assess content accurately. Instagram posts were rated significantly lower, with notable gender differences in evaluations of Instagram and TikTok posts. The reasons for the less favorable evaluations of Instagram posts are unclear.

Conclusion

Our study provides insights into how students evaluate science communication posts. Notably, posts on Instagram are rated significantly lower than those on TikTok and YouTube. The results also suggest that students lack a uniform definition of science communication and the necessary skills to independently assess such content. Given the increasing presence of science communication on social networks, there is a clear need for science education to enhance students' assessment skills.

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Change – The transformative power of citizen science

Citizen science on bikes in museums and schools: being part of mobility change research with the senseBox:bike

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Abstract

Bikes and bike friendly cities are becoming the core theme of mobility change. In the presented projects we apply and investigate data-driven and participatory approaches to enable changes in bike-friedly policy and city infrastructure. Together with Futurium - house of futures - and several fablabs we co-designed a participatory approach to empower citizens to be part of the mobility change in Berlin. 30 citizens participated in the senseBox:bike workshop, built mobile senseBoxes to measure environmental phenomena, distance of surpassing cars and road or bike-lane quality. Some of the citizens collected mobile data for over 2 years, which was published as open data on openSenseMap and visualized in an interactive "living exhibit" in the Futurium Lab. We organized an intermediate lab meeting with some of the participants to discuss feedback, usability and the software of the protoypical device and re-co-designed the senseBox:bike to an open source product for mobile bike data collection. After two years we are meeting the citizen scientists again at Futurium and interview them about motivations, obstacles, experiences in the project. We adapted the approach with an more educational focus and designed workshops for five schools in Essen, evolving the participatory approach: the students work in the local quarters of the city, they build, program and mount the devices to their bikes, they conduct data collection and analysis, and then get into dialogue with local politicians, following the spatial citizenship approach.

Keywords: citizen science, mobility change, sensors, environmental monitoring.

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senseBox – a citizen science toolkit for everyone

A microcontroller, environmental sensors, a (graphical) programming interface, and open educational resources – that's all it takes to conduct IoT (Internet of Things) projects around environmental and climate protection with learners and interested citizens. This is demonstrated by a kit that combines these components in conjunction with citizen science: the senseBox. The data collected with the individually configured smart measuring device can be published and shared on the openSenseMap, an open environmental data platform. Thus, the DIY kit suits educational institutions and citizen scientists. Furthermore, a new variant – the senseBox:bike – can advance the transformation of data-driven mobility change.

senseBox:bike – Participation in mobility change

Bikes and bike-friendly cities are becoming the core theme of mobility change. In two pilot projects focusing on citizens in a museum (Futurium in Berlin) and schools (in Essen), we apply data-driven and participatory approaches to enable changes in bike-friendly policies and urban infrastructure. With the senseBox:bike cyclists collect data about the bicycle infrastructure while riding. This data on vibration, speed, and proximity to other road users can ultimately provide information about potholes and potential danger spots in traffic, among other environmental phenomena as temperature and air quality.

Berlin: Co-Designing the senseBox:bike with citizens

Research has shown that involving citizens in urban development processes can increase credibility, trust, and commitment to implementing such policies (Empel 2008). On their bike rides through the city, cyclists face various health risks (Apparicio et. al. 2016). Among others, air pollution may have severe effects on health and should have implications for urban planning. Nevertheless, particulate matter measurements are rarely carried out on a mobile basis at the position of cyclists but rather at a stationary position at the side of the road.

Another option for mobile data collection on the bike is the openBikeSensor. It offers a semi-automated solution for recording violations of the minimum takeover proximity. OpenBikeSensor uses an ultrasonic proximity sensor to measure the proximity to passing cars when the cyclist presses a button (e.g. in Hauenstein et al. 2023). However, it can be challenging to trigger the device reliably in hazardous traffic situations, which may result in stress and data loss.

Taking these challenges into account, together with Futurium and several Fab Labs we co-designed a participatory approach to empower citizens to be part of the mobility change in Berlin resulting in the prototype of the senseBox:bike.

30 citizens ("recruited" through social media channels of Futurium and senseBox) participated voluntarily in the senseBox:bike workshop at Futurium (Fig. 1), where they assembled, connected, and pro-

grammed the senseBox:bike, so each participant had their own device capable of collecting continuous mobile data on:

- proximity of surpassing road users
- road or bike-lane quality (measuring vibrations & bumps)
- Temperature and relative Humidity
- Fine Dust ($PM_{2,5}$ und PM_{10})
- Speed

The gathered data was published as open data on openSenseMap.org and visualized in an interactive “living exhibit” in the Futurium Lab. The participants were free to use the senseBox:bike for as long as they wanted, resulting in three types of participation of approximately same size:

- users, that only participated in the workshop and never used the senseBox:bike again
- users, that used the senseBox:bike on an irregular basis and only for up to 6 months after the workshop
- regular users still (more than two years after the workshop) using the senseBox:bike while commuting and in leisure time

Figure 1. Impressions from the senseBox:bike Citizen Science Workshop at Futurium. Credits: berlin-event-foto.de

After a year of use, we organized an intermediate lab meeting at Futuiurm. We invited all participants to share feedback on the usability and experience with the prototype. Only a few regular users appeared, bringing valuable feedback: from usability issues in the assembly process to ideas for hardware improvements and even contributions to the open-source code concerning location privacy issues.

Finally, after two years we conducted qualitative interviews with each one of the three different participant types about motivations, obstacles, and experiences for the project.

On the one hand, the regular user was motivated to actively contribute to its improvement. The other users stated that the process of attaching the box to the bike was too troublesome and that the box's own weight of half a kilo contributed to it not being used as often as intended. They added that they did not fully understand the process of acquiring and uploading data, which is why the box was not used or used less frequently.

The limitation of the first prototype in daily use was clearly its ease of use. The results underline the importance of accessibility and understandability of technology-driven citizen science projects. With the experience and feedback from the Futurium, we adapted the approaches of workshop and hardware to reach a different group of citizens: young people.

City of Essen: Young people engage in urban development processes

Young people often exhibit creative thinking and unconventional problem-solving approaches, showcasing the potential to disrupt traditional thought patterns. This attribute proves particularly advantageous in the context of urban planning, which is known for its complexity and time-consuming nature. Participation in urban planning is deemed a prerequisite, fostering communicative dialogues between local stakeholders and experts. However, participation processes frequently exclude young generations (Kogler 2018). At the same time, approaches to the involvement of young people receive a significant amount of public attention (Bruselius-Jensen et al. 2021).The project "Essen auf Rädern - Young People Develop Concepts for Cycling in the Ruhr Metropolis using Digital Geomedia" (funded by the German Federal Foundation for the Environment, DBU) addresses this issue.

Thematically, the project aligns urban planning with the ongoing mobility transition, particularly cycling. Essen, as highlighted in the ADFC city ranking of 2022, currently lags behind in sustainability-oriented mobility transition among cities with over 500,000 inhabitants. Consequently, significant changes are imperative for the city (ADFC 2022).

Technology-wise the project builds up on the Futurium experience by improving the usability of the hardware and software of the senseBox:bike and making the assembly, mounting and data collection process much simpler and safer (Fig. 2).

Methodologically, the project adopts the spatial citizenship approach, which outlines the skills and willingness of young people to actively engage in spatial decision-making in society through the competent and reflective use of technology (Gryl and Jekel 2012). Taking this guiding principle into account, project weeks at five secondary schools in Essen were designed and implemented. Specifically, the

Figure 2. Collecting data with the senseBox:bike

students a) collect spatial data on cycling infrastructure and environmental phenomena in their respective school districts with the senseBox:bike, b) analyze this data from their unique perspectives, c) present their findings to the public and politicians, and d) actively engage in societal discourse. Collaborating with stakeholders from academia and local initiatives, the data and the measures derived from it are processed (in data visualizations, maps) for the public and local politicians. This database, emphasizing data-driven objectification and evidence, provides a tangible voice to young participants in the discourse.

Conclusion and future work

The two examples provided have exemplified great interest and opportunities, but also challenges in expanding bicycle infrastructure based on data, in collaboration with citizens of different ages. Therefore, the projects are being transferred to additional cities - both within Germany and internationally. The BMBF-funded project "atrAI bikes" involves citizens from Münster and Sao Paulo working with a improved senseBox:bike, where AI-approaches will lead to better data quality and data analysis within a distinct bike-data-platform.

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Change – The transformative power of citizen science

Changing knowledge and attitudes through citizen science at schools

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Abstract

Improving scientific literacy among elementary and high school students is crucial. Here we report the learning outcomes of three Brazilian school initiatives that incorporated citizen science: 1. A cocreated one aimed at investigating biodiversity in a school garden; 2. A collaborative one focused on the phenology and life cycle of angiosperms; and 3. A collaborative initiative aimed at reducing food waste in schools. There is evidence that the initiatives promoted learning, such as: 1. Scientific content knowledge (life cycle of angiosperms, sustainable eating); 2. Procedural skills (asking productive questions; formulating clear and concise hypothesis; collecting precise and accurate data; drawing conclusions); 3. Improved self-efficacy for science; 4. Attitudes (reducing food waste, observing plants more frequently).

Keywords: angiosperms, curriculum competencies and skills, learning outcomes, productive questions, science literacy, sustainable eating, types of citizen science.

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Introduction

There is an urgent need to promote scientific education in Brazil. PISA results show that students in Brazil scored, in average, less than those from countries of the "Organization for Economic Co-operation and Development" in mathematics, reading and science (OECD 2022).

By engaging students more closely in scientific practice, citizen science can foster diverse individual learning outcomes that enhance participants' scientific education, such as scientific content, process and nature of science knowledge, skills, interest in science and the environment, self-efficacy, motivation, pro-environmental behaviours, and attitudes (Phillips et al. 2018; Wyles and Ghilardi-Lopes 2023).

Objective

To showcase individual learning outcomes from Brazilian school initiatives that integrated citizen science.

Methodology

All case studies were Brazilian (São Paulo State) public school initiatives that utilized citizen science protocols and implemented inquiry-based teaching-learning sequences (IBTLS) aligned with the skills and competencies outlined in the Brazilian curriculum (Table 1).

Table 1. Case studies, their respective number of steps and students involved, locations, type of citizen science, learning objectives, and learning assessment instruments used.

Case study / study/ Number of steps / Number of students / Location (city)	**Type of citizen science** (Shirk et al. 2012),	**Learning objectives**	**Assessment instruments**
Investigating the Biodiversity in School Gardens / 13 steps / 96 students / elementary school in São Caetano do Sul	Co-created and with a question-first approach (Parris et al. 2023)	**Concepts**: define biodiversity and citizen science, describe the work of scientists (steps 1–4, lecture-based and dialogued classes) **Skills**: elaborate questions (steps 5–8), design a study, collect, submit and interpret data, communicate results (steps 9–13)	**Questionnaire (pre and post)**: "Biodiversity is…" "Citizen science is…" **Student's research diary**: What scientific question(s) do you think we can ask about our school garden?

Case study / study/ Number of steps / Number of students / Location (city)	**Type of citizen science** (Shirk et al. 2012),	**Learning objectives**	**Assessment instruments**
Phenology of Trees / 8 steps / 37 high school students / São Paulo	Collaborative	**Concepts**: define phenology, pollination, and the phases of angiosperms life cycle; relate fruiting, pollination, and life cycle (steps 2 and 8) **Skills**: formulate hypothesis (step 1), observe the phenology of trees (steps 3–7), represent the life cycle on a poster (step 9), submit and interpret data, and draw conclusions (step 10–13) **Interest in science and botany** **Self-efficacy for science**	**Panel** constructed by students, with the stages of the life cycle of angiosperms. **Questionnaire (pre and post)**: What is pollination and why is it important? (After participating in the project) How often do you observe/notice the plants in your home and/or street? Are you interested in studying (more about) plants? Imagine that you must collaborate in scientific research on plants at school. Scientific research has several stages. On a scale of 1 to 5, indicate how well you would be able to carry out each stage of this research: 1. formulate hypotheses for a problem question, which the research will attempt to resolve; 2. collect data from observations, experiments, etc.; 3. organize and analyse collected data; 4. reach conclusions, checking whether the hypotheses were correct or not **Class activities:** Write a sentence using the terms “fruiting”, “pollination” and “life cycle” **Data collection forms**
From Waste to Sustainability / 8 steps / 153 fifth-grade students of 10 schools / São Bernardo do Campo	Collaborative	**Concepts:** sustainable eating, food waste impacts **Skills:** data collection (food waste weighing for 5 days) and submission, communication of results **Behaviour**	**Questionnaire (pre and post):** When we DON'T waste food, what are we taking care of? **Data collection forms** (g of food waste/person.day)

Results and discussion

The three IBTLS promoted learnings, evidenced by the data collected, reinforcing the importance of school citizen science for the development of scientific literacy and citizenship of students (Bonney et al. 2016).

“Investigating the Biodiversity in School Gardens”

For the open question “Biodiversity is”, correct answers increased from 2.1% in the pre-questionnaire to 92.7% in the post-questionnaire. Similarly, comprehension of the concept of citizen science increased (from 6.2% to 79.2%).

The 21 groups of 4–6 students formulated 135 productive research questions (out of 201), such as "How many different types of spiders are there in the school garden from April to October 2022?". Productive questions stimulate activities that lead to scientific inquiry, fostering the development of scientific research practices. These questions are essential for promoting science as an active process in classroom education (Jelly 2001).

The findings of the students' investigations were compiled and published in an e-book. Additionally, records were submitted to iNaturalist (https://www.inaturalist.org/projects/biodiversidade-do-jardim-da-emef-dom-benedito).

"Phenology of Trees"

In total, 14 hypotheses were produced for the problem presented in the first step (Supplementary file 1).

Most students understood the life cycle of angiosperms and 54% of students correctly defined and cited the three phenophases (foliage, flowering and fruiting). Only 26% of students were able to correctly relate fruiting, pollination, and life cycle, placing fruiting and pollination as life cycle events and explaining that one depends on the other to occur.

There was no significant change in the interest of the students in science and botany.

There was an increase in students' average self-efficacy for science ($z = 6,41$; $p < 0,05$) and 30% of the students reported they started observing plants more frequently (reduction of plant blindness, according to Wandersee and Schussler 1999).

Data was submitted on Anecdata (https://www.anecdata.org/projects/view/1061).

Data on phenology of trees presented an average accuracy of 75% (SD 23%) and an average precision of 80% (SD 19%), like other published works (e.g., Fuccillo et al. 2015).

"From Waste to Sustainability"

A noticeable change in student behaviour (albeit short-term) was observed, with an average 70.4% reduction in food waste across all schools.

Data was submitted on Anecdata (https://www.anecdata.org/projects/view/1125).

Furthermore, students demonstrated an enhanced understanding of the multifaceted nature of food waste. For instance, when asked what we are taking care of when we DON'T waste food, students provided answers such as "people who are hungry," "rivers," and "the economy," illustrating their recognition of the social, environmental, and economic dimensions of sustainability (Purvis, Mao and Robinson 2019).

Conclusion

The results demonstrate that citizen science initiatives in the participating schools effectively promoted learning outcomes, including knowledge of scientific content, skills in scientific inquiry, self-efficacy, and behaviour.

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Change – The transformative power of citizen science

Scrolling through science: exploring secondary school students' consumption of science communication on social media

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Abstract

In recent years science communication has changed drastically, driven by the rise of social media. To date, there is an enormous amount of content available online that offers potential for informal learning opportunities for school students if it is effectively integrated into their social media habits. In this study – which is part of the Sparkling Science project "We Talk About Science" – we worked with two secondary school classes and analysed on which platforms science communication is perceived and how it is evaluated. Afterwards, the experiences and consumption habits of the students were explored in group interviews. Many students were surprised by the amount of content that is already available on social media, as they had previously consumed hardly any or no science communication. Also, the submitted content was rated highly in terms of its comprehensibility, interest, attractiveness and trustworthiness. However, science communication was not or only barely integrated into their daily social media usage, indicating that the content does not meet their demands yet.

Keywords: science communication, social media, informal science learning.

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Introduction

Nowadays, students are turning increasingly to social media platforms like Instagram, TikTok, and YouTube for information (Belova et al. 2022; Feierabend et al. 2022). Some studies have already examined the strategies and criteria employed by students to assess the credibility of scientific content on social media (Belova et al. 2022; Kresin et al. 2024). However, the general role of social media in disseminating scientific information for students and their consumptions habits of scientific content remains poorly understood. Mass media, especially social media, may serve as a potential source for informal science education, which could assist young people in acquiring scientific knowledge. Accordingly, the aim of this study is to explore whether and where students consume scientific content on social media.

Project Overview

This study is part of the contributory citizen science project "We Talk About Science" which aims to explore student's perspectives on science communication. Starting with a competition, the students mainly took part in data collection. Over four months, they collected data about and evaluated scientific content in their digital environment. Two participating classes were particularly committed to this competition and were therefore asked for their experiences and views regarding science communication in social media. After the summer break, a recap was held to assess the medium-term effects of participating in the project. Once the results were analysed, the participants discussed and interpreted the findings. We incorporated different principles of Citizen Science (ECSA 2015). In addition to data collection and discussion by students, they also played an important role in gaining new perspectives on science communication. Students were given feedback and insights into their data as well as in scientific work and processes. However, it has to be noted that the students were both research subjects and participants in this study. Altogether, participation enhanced the students' awareness of science communication and science in their everyday lives, and we gained new scientific knowledge about science communication for students.

Methods

42 Students, all female, completed digital log sheets for each content including general information, a screenshot and a brief evaluation using a 4-point Likert scale to assess comprehension, design, interest and trustworthiness.

To deepen our understanding, eight semi-structured-group interviews with 24 students were conducted to facilitate a discursive dialogue focusing on their experiences and consumption habits and how these changed after participation. All interviews were audio recorded and transcribed. Summarizing content analysis was undertaken to determine key experiences and perceptions (Mayring 2022).

Results and Discussion

A total of 1,750 digital log sheets were successfully completed. The submitted content was mainly found on the platforms TikTok (45.2%) and Instagram (43.6%). YouTube (3.5%) and other platforms (7.7%) were used rarely. Figure 1 shows the mean values of science communication content in terms of the descriptions easy to understand, attractive, interesting, and trustworthy. The submitted content was rated very highly in these areas. Students offered potential explanations for this high rating. They indicated that they often submitted only the "good content" and that they found it interesting because it was new to them.

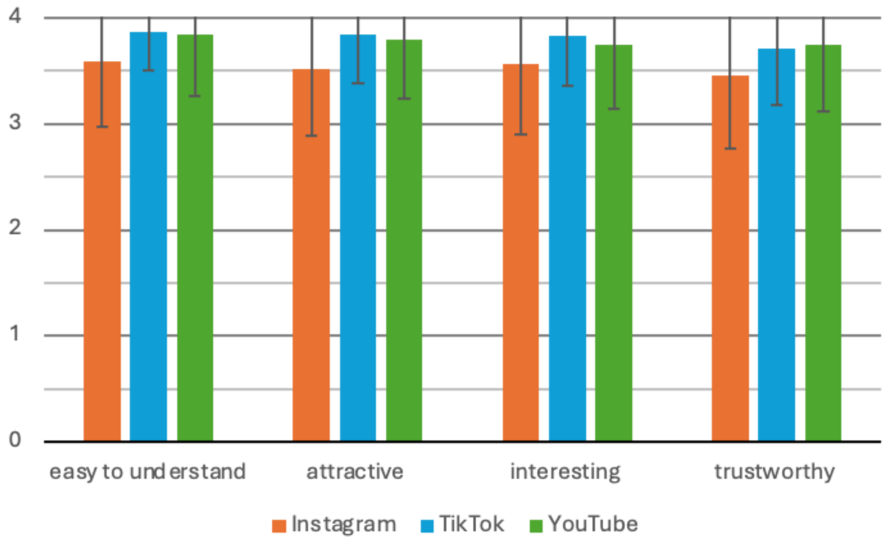

Figure 1. The figure displays the mean values and calculated standard deviations for each assessment for "easy to understand", "attractive", "interesting", and "trustworthy", as rated on a 4-point Likert scale.

The content analysis of the interviews revealed that most students had consumed little or no scientific content on social media prior to the contest. Some were even positively surprised by the extent of scientific content available on social media.

> *It wasn't that hard to find something and that surprised me, because I thought it is somehow hidden, the good stuff. But if you put in the right things, a lot of things came up and that surprised me in a positive way.* (BHS3,18; translated from German by the first author)

Besides positive aspects, the students also addressed the negative aspects of social media, such as advertising or fake news.

> *And what I've also noticed is that there's quite a lot of advertising in these facts. So there's always a link or an advert at the bottom, yes, I really noticed that. I wouldn't have expected that.* (BHS3,6; translated from German by the first author)

This may contribute to the students' general lack of trust in these platforms. Especially TikTok is classified as untrustworthy in the conducted interviews very often. This stands in contradiction to the information in the log sheets, where students rated content from social media as highly trustworthy. A possible reason for this discrepancy might be that students have a high level of trust in science (Krüger et al. 2022), which might explain the high level of trustworthiness concerning the scientific content submitted in the digital log sheets. In contrast, in the interviews, they didn't evaluate the content but the platforms in general.

Content that students remember or enjoyed consuming often has a connection to their everyday lives or is perceived as beneficial. Topics related to health, medicine and diseases as well as space and universe are frequently mentioned.

At last, the students reflected their consumption. When interviewed, most students stated that they now see more scientific content on their social media due to their changed algorithms. Many of them also reported that they watch some of it in their free time. Unfortunately, this effect did not last long. Three months later, after the summer break, the students reported in the recap that they no longer received any or only very limited scientific content on their social media feed. The students interpreted this by stating that the competition motivated them to consume more scientific content, which they found both interesting and engaging at the outset. Once they spent more time on certain topics, their thirst for knowledge was satiated. Additionally, both the topics and the structure of scientific content were found to be to similar, which made it boring and tiring to consume this content over an extended period.

Conclusion

Prior to participation in this study the students did not consume much or any science communication content on social media. Upon taking part, they were surprised by the wide variety of content that was already available. They also rated most of the content as trustworthy, easy to understand, interesting and attractive. Some scientific content was even integrated into their daily consumption habits. In our follow-up we found declining consumption of science communication content. This indicates that science communication on social media might not be tailored to the participating students. Further testing of how more suitable content should look like might prove interesting. Also, future studies will have to continue exploring what kind of science communication students perceive and how they evaluate it.

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Change – The transformative power of citizen science

Transforming research and public libraries into catalysts for citizen science

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Abstract

This paper reports the outcomes of an interactive workshop held at the ECSA2024 Conference in Vienna, focusing on the evolving role of libraries in supporting and advancing citizen science initiatives. Participants examined libraries as proactive stakeholders in citizen science, detailing their potential as catalysts and knowledge brokers. Key discussions include the need for dedicated library staff roles, specialized training, and enhanced connections between public and research libraries for resource sharing. The workshop also explored alignments between open science and citizen science, emphasizing community engagement through locally relevant projects to boost public participation and impact. Overall, the workshop underscored the critical role libraries play in the ecosystem of citizen science, providing strategic and operational insights for their enhanced involvement.

Keywords: citizen science, libraries as catalysts, knowledge brokering, community engagement, open science.

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Introduction

In a world experiencing swift changes due to technological advancements, environmental challenges, and societal shifts, the conventional roles of libraries and research performing organizations are in flux. Kaarsted et al. (2023) delved into European research libraries' understanding and application of open and citizen science, unveiling profound awareness but scant enactment in services and infrastructure. Key barriers are resources, funding, and policy constraints. To counter these, strategic enhancements in partnerships, institutionalization, and policy frameworks are vital. In this paper, we report the findings of an interactive workshop conducted at the ECSA 2024 Conference, which focused on exploring the opportunities and challenges for both research and public libraries to engage in, and potentially become catalysts for, citizen science.

Though existing research on the roles of research libraries and public libraries in citizen science is limited, it clearly indicates that these institutions play a significant role by offering a comprehensive suite of services designed to enhance project initiation, execution, and collaboration (Kaarsted and Overgaard 2018; Ignat et al. 2018; Kragh et al. 2020; Cigarini et al. 2021; Martek et al. 2022; Kaarsted et al. 2023):

- Research libraries may assist researchers in securing funding by identifying potential opportunities and aiding in the creation of citizen science grant proposals. This financial support is vital for the sustainability and expansion of citizen science projects.
- Furthermore, research libraries can utilize their existing competencies by managing research data for citizen science projects, adhering to FAIR Data principles and GDPR regulations, which highlights their commitment to data integrity and privacy.
- They can play a crucial role in facilitating project management and coordinating volunteer efforts, ensuring smooth and efficient project progression.
- Research libraries as well as public libraries are also key in communicating project updates and systematically evaluating ongoing projects, which helps maintain transparency and measure impact.
- Beyond administrative and evaluative tasks, research libraries and public libraries act as community hubs by organizing and hosting events that engage citizen science participants and attract the broader public. These events foster community spirit and stimulate public interest in citizen science.
- Finally, they focus on cultivating and expanding networks. Leveraging their institutional positions, research libraries connect with a broad spectrum of stakeholders both within and outside their research organizations, thus enriching the citizen science ecosystem and enhancing collaborative opportunities. Moreover, public libraries are strategically positioned to bridge the gap between researchers and local communities, facilitating meaningful exchanges and partnerships.

Method

This 90-minute workshop featured panel contributions, breakout group work, and an ideation session, all designed to equip participants with a deep understanding of the challenges and opportunities involved in integrating research and public libraries into citizen science. Attendees were encouraged to develop tangible, operational solutions to these challenges.

Specific objectives were to underscore the urgent evolution required by research libraries to champion citizen science; to identify unique services and resources that research libraries can furnish to propel citizen science forward; and to collaboratively formulate innovative strategies, ensuring research libraries' pivotal role in the citizen science ecosystem.

During the preparation of this abstract, the authors used ChatGPT 4.0 to enhance the readability and language. After using this tool, the authors reviewed and edited the content. They assume full responsibility for the content of the article.

Results

In this section, we report the results of the work that was done in the breakout groups and during the ideation session.

The breakout groups engaged deeply with the current challenges and opportunities that research libraries – and public libraries – face in becoming pivotal agents for citizen science. The discussions were structured around five key questions, designed to prompt reflection on the evolving landscape in which these libraries operate. The ideation session followed up on this activity in challenging the participants to come up with ideas for research libraries in becoming active citizen science participants. These are our summaries of the input received from the participants:

- **Significant cultural, social, and technological shifts affecting research libraries today:** Among these, the increasing demand for accessibility by researchers, the challenges of providing training data for AI models, and defining standards for what constitutes good and bad data were highlighted. The discussions underscored the reality that capturing the attention of researchers and the public is becoming more demanding. This necessitates that libraries enhance their communication strategies to effectively promote their services. A noted tension exists between the specialized demands of citizen science projects and the generally broad focus of research libraries. This tension calls for libraries to evolve from their traditional passive roles to adopt more proactive stances in seeking collaborators and initiating project ideas.
- **Current collaborations between libraries and citizen science projects:** Participants highlighted the evolving roles and expanding opportunities for libraries to engage more deeply with their communities. These collaborations have led to an increase in research activities, outreach efforts, and community building. Professional development programs for librarians were emphasized, equipping them with the skills necessary to support and lead citizen science projects. This training could include writing guidelines for library involvement in such projects, ensuring that librarians are well-prepared to handle the complexities of these initiatives. Through various outreach activities and engaging students and the public, libraries could become pivotal centers for community engagement in citizen science projects.

- **Ensuring impact in citizen science projects through library collaboration:** Participants agreed that citizen science projects represent a unique intersection of community involvement and scientific research, where ensuring meaningful impact beyond academic metrics is a fundamental goal. Research libraries, with their extensive networks and deep knowledge of assessment, play a crucial role in maintaining the focus on impact throughout such projects. To maximize the effectiveness of their involvement, libraries first need to define what constitutes relevant impact and determine whom it benefits.
- **Identifying stakeholders in citizen science:** Participants recognized that citizen science projects engage a broad spectrum of stakeholders, each contributing unique perspectives and resources. For libraries, the challenge lies in effectively identifying and understanding the diverse roles these stakeholders play, which is crucial for the success of any citizen science initiative. However, this also presents a significant opportunity: by engaging these varied groups, libraries can foster a more inclusive and collaborative approach to scientific research. This not only enriches the research process but also enhances the quality and applicability of the findings, making the results more relevant and beneficial to a broader community.

Discussion

The final discussion of our workshop focused on the broader implications of the groups' contributions, delving into both strategic and operational considerations for libraries engaged in citizen science.

- **Libraries as active research entities:** Libraries are increasingly recognized as research-performing institutions. As such, they should actively participate in defining policies related to citizen science. This involves advocating for the comprehensive integration of citizen science's core principles across all facets of their operations and outreach. Libraries are positioned to champion these pillars, ensuring that their potential as catalysts for citizen science is fully realized. The Citizen Science Knowledge Center at the University of Southern Denmark (SDU), hosted by the university library, exemplifies how research libraries can serve as active research entities in citizen science. This center is a collaborative hub, which facilitates knowledge sharing, enhances public engagement through education, and supports community-based research practices. The center has initiated several citizen science projects in collaboration with researchers, covering a diverse array of topics including public health, cultural heritage, biodiversity monitoring, and e-garbage collection.
- **Enhancing library support and staff development:** The discussions suggested that libraries could designate specific staff members as points of contact for citizen science projects, ensuring dedicated support and smoother project integration. It was proposed that such roles should be formally integrated into project budgets to ensure their sustainability. Additionally, the training of library staff via methods such as Massive Open Online Courses (MOOCs) on citizen science could enhance their capability to support these initiatives effectively. The training provided by the Office for Open Science and Schol-

arship at University College London (UCL) serves as a notable example. The Office has partnered with FutureLearn to offer a series of short online courses. Additionally, the EU-Citizen.Science platform functions as an online resource for sharing knowledge, tools, training, and resources related to citizen science. A stronger connection between public and research libraries was also recommended to foster mutual learning and resource sharing.

- **Strategic implementation and community engagement:** Strategies should further intertwine open science with citizen science, enhancing the efficacy and reach of both. For example, LIBER's Open Science Roadmap underscored the importance of strategically connecting open science and citizen science to enhance the efficacy and reach of both initiatives (Ayris et al. 2018). LIBER advocated for research and national libraries to lead in citizen science by leveraging their position as champions of Open Science. The CeOS_SE Project (Citizen-Enhanced Open Science in Southeastern Europe Higher Education Knowledge Hubs), led by LIBER, aimed to empower academic libraries in Southeastern European countries to develop further as knowledge hubs by upskilling staff when it comes to the connections between OS and CS (Dakić and Trotovac 2023).
- **Libraries as knowledge brokers:** Libraries should also function as knowledge brokers, mapping existing resources and stakeholders, and facilitating connections between researchers, librarians, and other stakeholders around specific project ideas. This role is vital in leveraging libraries' unique positions within the research and community ecosystems. The UCL Office for Open Science and Scholarship and the SDU Citizen Science Knowledge Center exemplify libraries that serve as brokers of knowledge and network facilitators. Both institutions have coordinated training and knowledge-sharing events, bringing together researchers engaged in citizen science or participatory research projects to exchange best practices and experiences, thereby supporting others within their universities to do the same.
- **Building knowledge infrastructures:** In terms of infrastructure, libraries should provide robust Research Data Management (RDM) and FAIR Data services (Hansen et al. 2021). Organizing internal workshops and training sessions can bolster staff expertise and engagement. Libraries can enhance community engagement by focusing on projects that offer significant community value. Methods such as participatory sessions for needs assessments, the creation of advisory boards, and conducting focus groups can deepen community involvement and ensure that library services meet the actual needs of their users. Lastly, establishing libraries as both conveners and brokers of information and creating bespoke models for information delivery can greatly enhance their role in citizen science.

The workshop concluded that libraries, by stepping up as proactive participants and facilitators in citizen science, can significantly impact both the scientific and community landscapes. This expanded role not only capitalizes on their traditional strengths but also positions them as essential pillars in the evolving domain of citizen science.

Acknowledgements

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Change – The transformative power of citizen science

Closing knowledge gaps on the building stock with citizen science: introducing the Colouring Dresden platform

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Abstract

The building sector worldwide is responsible for massive CO_2 emissions. These emissions stem from both existing and newly constructed buildings, particularly from the extraction and production of materials. Solutions include promoting circular construction, smart investments, and political measures. However, information on materials, quantities, and routes is often incomplete or inaccessible. The "Colouring Dresden" project aims to gather, explore, and communicate knowledge about buildings via the open platform "Colouring Dresden", part of the international Colouring Cities Research Programme (CCRP). It is Germany's first citizen science project focused on data collection and disclosure about the built environment, especially buildings. In collaboration with stakeholders, the project developed research questions, adapted the platform, prioritized data collection features, and established citizen science actions and communication channels for knowledge transfer. These actions and knowledge transfer were crucial to the project's success. Various evaluation methods assessed their suitability in citizen science, providing insights into participant motivation, interests, and benefits for science, society, and individuals. The evaluation revealed significant differences in response quantity and data quality during data collection. The results demonstrate that citizen science projects can be effective in the built environment context, offering insights into appropriate action formats and evaluation methods. This contributes to the advancement of citizen science in Germany, enabling targeted planning of future urban citizen science projects to enhance participant motivation and collect information to reduce CO_2 emissions in the building sector.

Keywords: architecture, building knowledge, Citizen Science, Colouring Dresden, CCRP, open data, platform.

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Introduction: Why bridging building knowledge

The building stock is considered the largest economic and cultural capital. We spend up to 86,9% of our time indoors (Klepeis et al. 2001). Tenants in Germany pay up to 30% of their net income on gross rent (Lebuhn et al. 2017). On the other hand, buildings and their construction consume resources and impact the environment. The UN states that the use and construction of buildings causes 40% of annual global CO_2 emissions (United Nations Environment Programme 2020). That's why the building stock hold significant potential for climate mitigation and adaptation, exemplified by strategies such as energy-efficient renovation, conservation, reuse, and adaptations to address extreme weather- and climate-related events (European Environment Agency 2022). To achieve this objective, it is essential to create a solid knowledge base on the building stock for science, politics and society. However, essential information about the building materials used, the age of the building and its condition is often incomplete or difficult to access. Citizen Science (CS) emerges as a viable solution in this context.

The project "Colouring Dresden" aims to collect, explore and communicate knowledge about the building stock of the City of Dresden, Germany, through an open platform "Colouring Dresden" coordinated by the Leibniz Institute of Ecological Urban and Regional Development.

The platform code originated in the UK, where the first "Colouring London" platform was set up (Hudson et al. 2018) and later the global network Colouring Cities Research Programme (CCRP) was established at the Alan Turing Institute (Hecht et al. 2023). The CCRP collaboration team currently consists of academic partners from twelve countries (Hudson 2024).

In close cooperation with local stakeholders from civil society and practice (like libraries, museums, associations and school labs), administration (city of Dresden) and research (University) the following steps were worked out and openly documented on Zenodo (https://zenodo.org/communities/ioer_dresden/records?q=%22Colouring%20Dresden%22&l=list&p=1&s=10&sort=bestmatch): The project's conceptualization involved developing research questions, adapting the platform with open-source code, prioritizing data collection features, and establishing CS actions and communication channels for knowledge dissemination. The last step included identifying key audiences, creating targeted communication strategies, and utilizing various media platforms and feedback from workshops to ensure broad outreach. The target group has been identified through surveys and training and includes people interested in architecture, maps and digitisation.

Enabling participation

The CS actions and knowledge transfer proved to be key factors for the CS project. It requires a balanced exchange between coordinators and participants as both contributors and recipients of knowledge. It ensures not only a higher level of participation, but also consistency and accuracy in the data collected, making the project more reliable and trustful (Haklay 2015).

The following five opportunities existed for knowledge contribution (Figure 1A): Collecting data, supporting events, contributing of data bases, developing the code and launching a new Colouring Cities initiative.

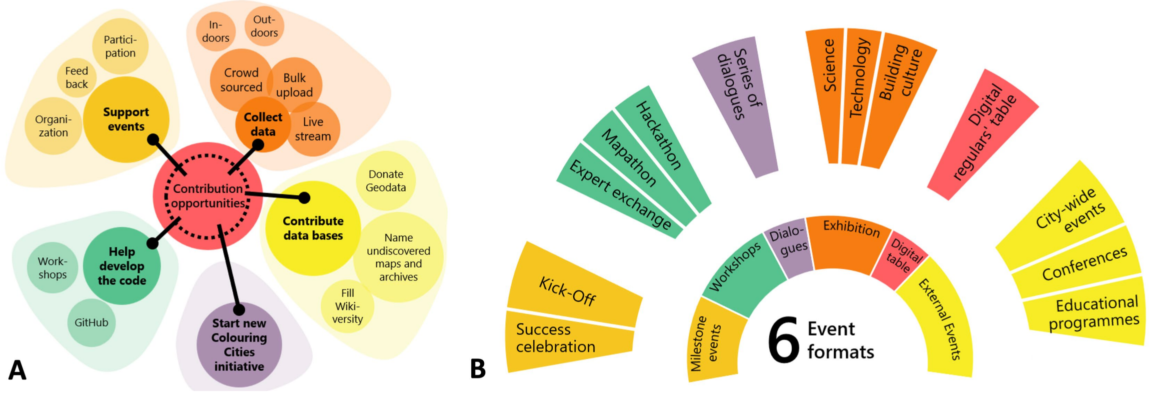

Figure 1. Facilitating Participation in Colouring Dresden. **A** contribution opportunities **B** developed and implemented event formats.

Data collection on the platform (https://colouring.dresden.ioer.de/) occurs in three ways: bulk upload (uploading a large amount of existing building data); live streaming and visualising of official data sets from public sources; and crowdsourcing. If data is available for a building, it appears in colour. Mapping from indoor and outdoor, individual and group training and gamification elements such as visualisation of fill levels and the dashboard were provided to facilitate data collection.

Supporting events promoted the engagement by fostering participation and offering valuable feedback. External partners were also invited to co-organize events, which resulted in six event formats (Fig. 1B): milestone events, workshops, dialogues, exhibitions, digital regulars table, and external events. Each format targeted distinct audience demographics by varying venues, schedules, levels of interaction, and other parameters.

CSists have also been able to engage with the open source code at events or at home. The code is available on GitHub (https://github.com/colouring-cities/colouring-dresden) and enables editing and providing feedback by the CSists.

Contributions to the databases can be made directly, through entries in Wikiversity (https://de.wikiversity.org/wiki/Projekt:Colouring_Dresden), the CCRP´s open manual at GitHub, or indirectly through suggestions of undiscovered projects, maps or archives.

Starting a new Colouring Cities initiative is the opportunity for institutions to start a complete new local CS initiative in their city. Some cities have already expressed their interest and exploratory work is underway to set up such platforms.

Evaluating participation

Evaluation can identify improvements for outreach and communication strategies. Various qualitative and quantitative methods, timed and lasting differently during the project, offer insights into participants' motivations, interests, and societal benefits.

Significant differences were found in the number of contributions according to complexity and geographical distribution. In the initial 29 weeks (from Launch on the 06.03.2023 till funding end 01.10.2023) following the platform's launch, 99 registered users collectively made 21.599 edits, averaging 720 edits per week and 103 edits per day. It is apparent that some features are more attractive or easier to map than others (Fig. 2A). More edits were recorded in the city centre of Dresden than in the suburbs (Fig. 2B), which is a typical phenomenon in crowdsourcing projects such as OpenStreetMap (Hecht et al. 2013). Observations indicated that the action formats led to increased mapping activity on the platform. The effectiveness of communication channels was higher in the first half of the project compared to the second. Further research into this is underway.

The evaluation's second finding focused on participants' motivations during events. A questionnaire at ten different events showed that the acquiring knowledge emerged as the predominant motivation (21%), followed by supporting the project (18%). Personal development, participation in scientific endeavours, networking opportunities, and meeting new individuals were equally cited motivations (12% each). Conversely, addressing local issues in Dresden represented the least prevalent motivation, accounting for 10%.

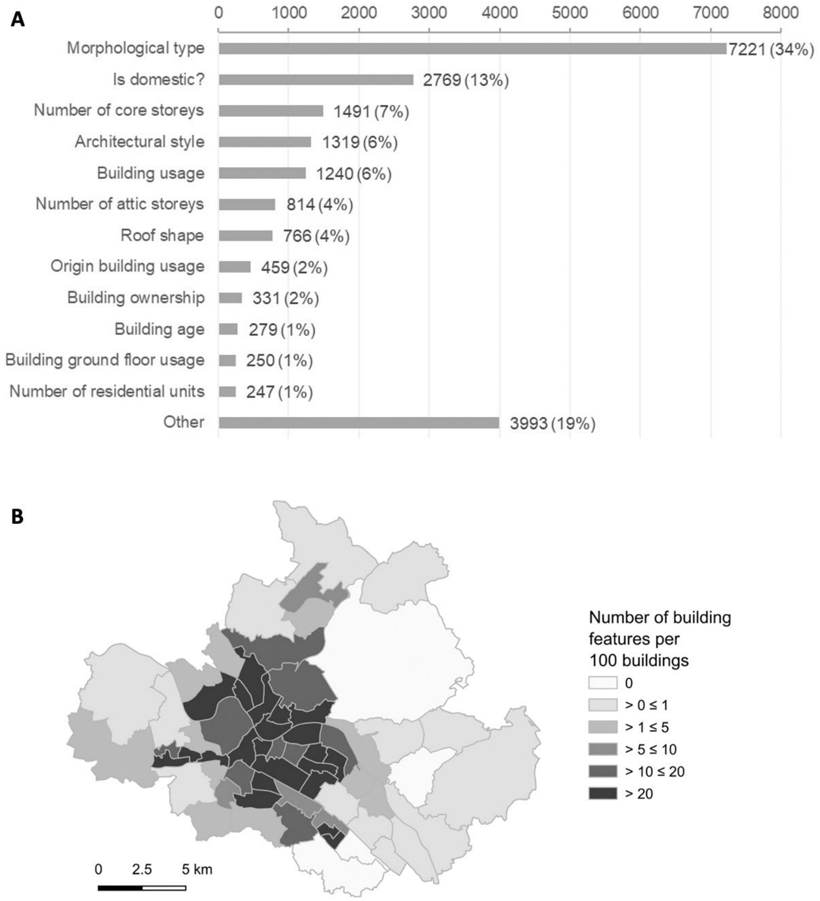

Figure 2. Mapping activities from 06.03.2023 to 01.10.2023 showing: **A** the total number of building features and **B** the spatial pattern of edits.

Discussion and Conclusion

Several key areas can be identified for future research. Firstly, there is potential for advances in the prediction of building characteristics and types through artificial intelligence (AI). Secondly, comparative analysis of data quality between citizen science, official sources and AI-generated data offers valuable insights. In addition, exploration of critical data studies and their applicability as governance tools is essential.

Current discussions show a potential government involvement in managing the Colouring Dresden project. Furthermore, there was interest in the demographic categorization of participants, the utilization of collected data, and distinguishing the Colouring Dresden features from OpenStreetMap (OSM). In addition, the discussion showed that there is a need to address how to deal with mixed uses within a building.

The project shows in general that CS can be successful in context of built environment research in terms of user activation and participation, data collection, but also the learning effects for the participants and respectful, sustainable cooperative collaboration. They also offer insights into suitable action formats and evaluation methods. This contributes to the further development of CS in Germany and enables the targeted planning of actions in future urban CS projects to increase the motivation of participants and to collect information on reducing CO_2 emissions in the building sector.

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Change – The transformative power of citizen science

Shifting perspectives: collecting stories of post-extractive f*utures in a mining town

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Abstract

The shrinking town of Eisenerz lies at the foot of the Erzberg mountain, Austria's largest and best-known site of iron-ore extraction. The post-industrial town is experiencing a rural exodus, affecting women in particular. Within this complex field, the citizen science project Stories of Post-extractive F*utures focuses on intersectional feminist perspectives on an area of mineral extraction. It collates stories of care in order to broaden the perceptions of mining areas and focus future perspectives on feminist narrations. We ask: Which practices contribute to the continuance of the community? The collected material shows, discusses and negotiates the spatial practices of repair amid extraction of multiple actors.

We work with local associations and different age groups to reach diverse groups and profit from a lively network of local associations. Thinking and knowing with the diverse actors and their—often surprising—practices, the citizen scientists shape the project on several levels: they collect and locate stories of practices; they research private archives; they report and sometimes even organize. Mutual learning takes place in meetings and shared activities, and through the process of transformation into drawings by East Styrian artist Roswitha Weingrill. The collected knowledge will contribute to creating imaginaries of future stories of a liveable community.

Keywords: artistic research, care, citizen science, extractivism, gender, urban development

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Figure 1. Erzberg Mountain with the town of Eisenerz. Photo: Karin Reisinger, 2021.

Introduction

The shrinking town of Eisenerz lies at the foot of the Erzberg mountain, Austria's largest and best-known site of iron-ore extraction. The post-industrial town is experiencing a rural exodus, affecting women in particular (Weber 2012). Mining is predominantly narrated in male, heroic narratives, while counter-narratives of repair, care, reproduction and maintenance are mostly overlooked. With this thesis, and starting from an intersectional feminist approach within this complex field, the citizen science project *Stories of Post-extractive F*utures* rests on the presumption that in a shrinking town with the highest average age of the nation (StatATLAS 2023) the requirement for care is extremely high. First, the ageing population inevitably leads to a high demand for nursing care; and, second, the numerous vacant buildings (with long histories from the formerly thriving mining town) also require care to avoid decaying and becoming uninhabitable. The aim of our project was to understand the post-industrial situation from a feminist perspective in order to learn how to deal with losses and to adapt to changing environments.

Background and methodology

The citizen science project takes a feminist approach to knowledge production in order to "unlock the potential of embedded, diverse, and culturally sensitive knowledge" (Heinisch et al. 2021, 19 97). We have furthermore learnt from participatory planning and artistic processes. The bottom-up feminist tradition of participation provides a rigid basis for the citizen science quality of expanding academic concepts of knowledge (Heinisch et al. 2021): feminist demands to rethink objectivity and inclusiveness and to understand knowledge as democratic, situated and shared (Haraway 1988; Longino 1990, 2002; Harding 2015; and many more) are strong guidelines for including the knowledge of citizen scientists. Responding to calls for, and insights into, epistemological pluralism (Ruphy 2016), inclusiveness and diversity, the project is strongly based on equity (see also Liboiron 2019). Locality and a multiplicity of perspectives are key for this project, in line with an ethical discourse in citizen science projects worldwide, which, for example, discuss a feminist ethics of care in citizen science (Fotopoulou 2019). Based on these intersectional feminist research perspectives, within a traditional area of mineral extraction, the decision was taken, together with the local citizens, to collect stories of care to broaden the perceptions of mining areas and to focus diverse narrations for future perspectives (see also Reisinger 2024). In order to get a fuller picture of the spatial practices (Rendell 2020) that are necessary in a post-industrial community with the nation's highest average age, and consequently a high number of vacant buildings, the central question was: *Which practices contribute to the continuance of the community?*

To obtain diverse contributions, we worked with various groups who were extremely supportive and sometimes even organized gatherings for us; the youth centre, the *Olle zoum* association, which runs a communitarian space for gatherings and second-hand shopping, *Jugend am Werk* (a local workshop for people with dis/abilities), *Volkshilfe* (the local retirement home), the *Vereinsgemeinschaft* (a local umbrella association) and the *Museum im alten Rathaus* (the local museum). Furthermore, the town's municipality supported the project with ongoing discussions about the methodology and with local organizations, especially Bianca Klapfer.

We located all stories with maps designed for the purpose; and the artist Roswitha Weingrill, who has roots in Styria, transformed the collated stories into drawings, which allowed for (at least) partial anonymity and emphasized the diversity of practices—and thus the agency of the citizens. All of the drawings were checked and agreed by the people who had contributed the stories, and they often had to be changed accordingly. Rethinking the relationship between the object and subject in research, we swapped the evaluators with those being evaluated, and the interpreters with those being interpreted, in order to reach a collective narration of a community that is often misunderstood or misinterpreted in newspapers and research.

Results

Based on around 115 drawings, a collage of a town was created by shifting the perspective, allowing for critical consideration of individual involvement in the care sector, as well as a broadened scope of infrastructure maintenance. Thus, we hoped to leave an imprint on the community and further post-industrial areas. Many of the collected stories are published on the *Mountains of Ore* website to display an altered understanding of town structures (https://www.mountains-of-ore.org/en/pef/map/). The map shows collected stories of care,

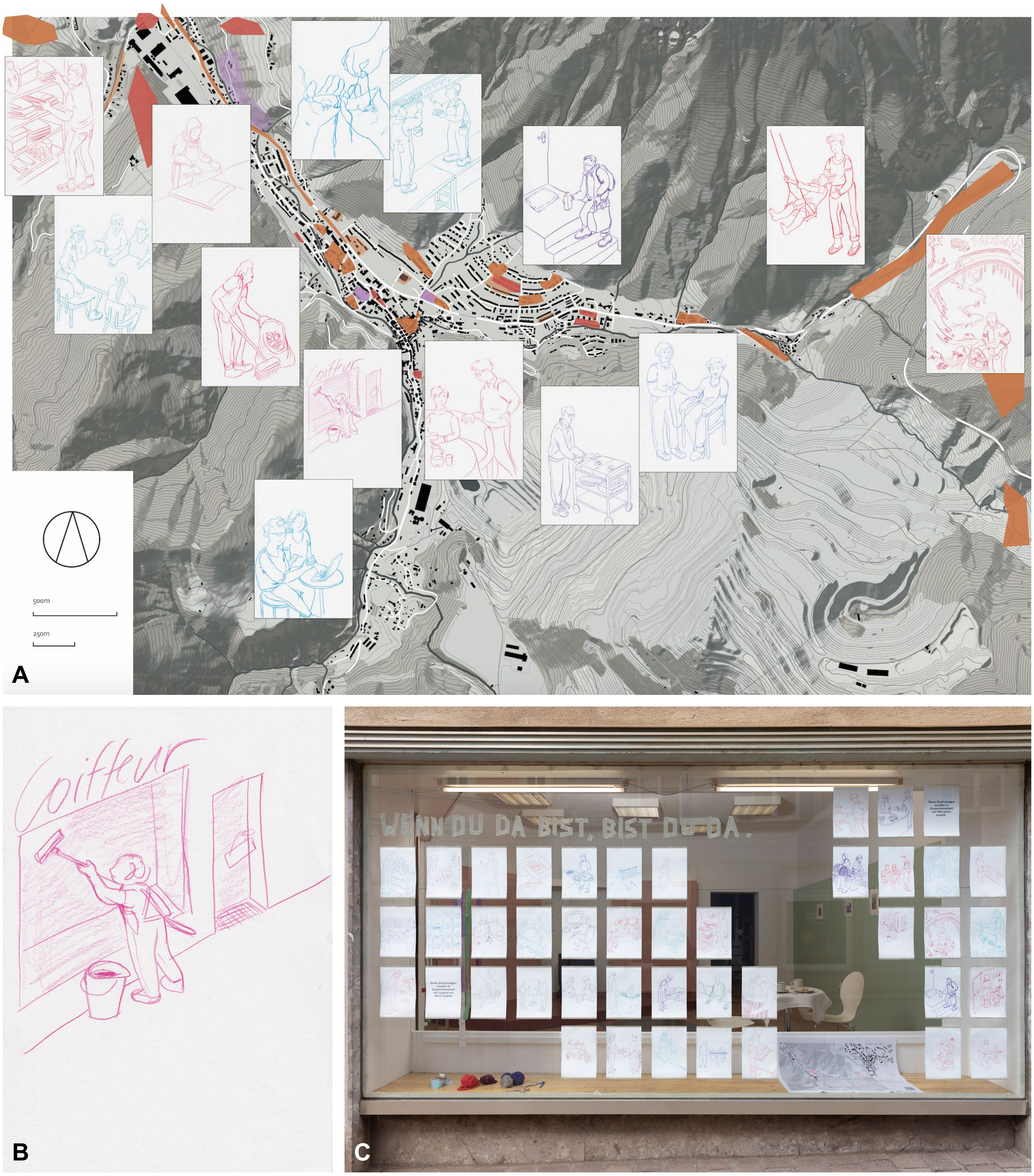

Figure 2. A Collage of a selection of the drawings and the interactive map, accessible at mountains-of-ore.org. The map displays both active (giving) and passive (receiving) care activities. Drawings: Roswitha Weingrill. Map: Mo Hartmann, Karin Reisinger and Larissa Zekl. With geo-information by GIS Styria, Digital Atlas. Interactive online version: https://www.mountains-of-ore.org/en/pef/map/. **B.** In one of the meetings with *Olle zoum,* we were told that a group of women cleans the shop windows of forlorn shops in the centre of town in their free time. The person who contributed this story also took care of passing on the drawing to the respective women after it was exhibited in Eisenerz. Drawing: © Roswitha Weingrill. **C.** Photo of the *City of Care* exhibition, taking place in Eisenerz, 22.3.2024–8.5.2024. Photo: © mani froh.

for example women who work together to clean the facades of forlorn houses, a family that runs a café with affordable food, a small group that runs the youth centre, and people who distribute cheap food to people in need — to offer a glimpse into the variety of often surprising contributions. The project also shows the care activities of people who are considered care-dependent.

A concluding exhibition called *City of Care* mirrors the results back into the community. The evaluation of the complex impacts is, as is mostly the case in artistic projects, beyond our scope. Despite the high number of drawings and collected stories, it should be noted that this project, despite its limited resources but nonetheless considerable diversity, has only scratched the surface of a complex network of voluntary work. It does not claim to be complete; instead, it offers a rich collection of partial and situated knowledges (Haraway 1988), hinting at a fuller picture of rural and post-industrial specificities of extractivism.

Discussion

The collected material, comprising approximately 115 drawings and 10 maps and summarized in an interactive map on the mountains-of-ore.org website (Mountains of Ore 2024), shows, discusses and negotiates the spatial practices of repair amid extraction of multiple actors, paying special attention to actors whose roles and life worlds are often omitted in traditional knowledge production. The work with local associations and different age groups has reached diverse groups and profited from the very lively local network of groups. Thinking and knowing with the diverse actors and their—often surprising—practices, the citizen scientists shaped the project on many levels: they criticized and modified our initial project approach; they collected and located stories of practices; they researched private archives; they sometimes even organized. They also evaluated the gathered knowledge on smaller and larger scales and contributed to forms of knowledge dissemination. Depending on the involvement, engagement and also critiques of citizens, it is hoped that the work done so far will lead to suggesting possible next steps.

Mutual learning has taken place in meetings and shared activities, and through the process of transformation into drawings by East Styrian artist Roswitha Weingrill. The collected knowledge will contribute to creating imaginaries of future stories of a liveable community. With the help of artistic methods, these stories are illustrated and made accessible in multiple formats. Following an exhibition in the town of Eisenerz, the citizens received the original project drawings for future reflection and their individual uses. This is a crucial, yet modest, step in the process of giving back to the community and those who co-shaped the knowledge.

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Change – The transformative power of citizen science

Showcasing citizen science to promote changes and engagement in your community

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Abstract

Result dissemination in Citizen Science is pivotal for raising awareness of pressing challenges. By witnessing their contributions' impact, citizens become empowered scientific agents, prompting shifts in habits and attitudes.

The Citizen Science Office of Barcelona promotes various dissemination actions, from talks, workshops, and exhibitions at community centres, libraries, or city events, to cultural proposals that combine citizen science and artistic languages. Since 2016, the Office's programs have engaged nearly 14,000 neighbours and schoolchildren who have collected over 10,000 measurements. These actions have motivated citizens to tackle environmental and social challenges. In the process, they develop critical thinking and can propose changes and take action.

Sharing results beyond the research community underscores that Citizen Science transcends mere evidence collection—it's integral to project success. Enhancing research-society interaction is crucial for magnifying research impact and societal change.

Keywords: citizen science, results dissemination, awareness, community engagement, showcasing experiences.

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Introduction

Addressing environmental, social, and economic challenges is urgent. Recognizing the crucial role of science, technology, and innovation in responding to these challenges is a priority. UNESCO's open science principles state that new scientific knowledge should be accessible, inclusive, equitable, and sustainable. They recommend innovative, participatory methods engaging diverse social agents beyond traditional science, particularly through citizen science and other participatory forms (UNESCO 2021).

Citizen science is a methodology with great potential for opening up research to societal participation, from idea generation and planning to conducting research and disseminating results (Hecker et al. 2018).

Fostering connections between research and society raises awareness and commitment to current challenges. Since 2012, Barcelona City Council has supported a Citizen Science Office to bridge research and society. It offers guidance to pilot projects, reaching new audiences, and disseminating information at city events. Partnering with civic, cultural, and educational entities, it cultivates a Community of Practice with 20 active projects spanning environmental, health, and social concerns (Escobar and Bröll 2023).

Table 1. Active Citizen Science projects that collaborate with the Office.

Name	Description	Website
CoAct for Mental Health	Social support networks in mental health.	https://web.ub.edu/en/web/ciencia-ciutadana/coactuem-per-la-salut-mental
Floodup	Awareness regarding floods and intense rainfall and their impacts, as well as increasing the information available to the scientific community.	http://www.floodup.ub.edu/
I-CHANGE	Showing that behavioural change of single citizens is possible through citizen science initiatives which are using sensors and that this has an impact of their environmental footprint.	https://ichange-project.eu/
Lichens of Barcelona	Mapping of Barcelona's lichens by working with experts to identify the species, recognise them and interpret them	https://www.barcelona.cat/barcelonaciencia/en/science-city/science-and-citizenship/citizen-science/lichens-barcelona
Sound Map of Barcelona	Characterization of different public spaces in order to be able to understand analytically and scientifically those sounds that build the acoustic realities of the streets, squares and parks where we live.	https://www.bitlab.cat/projectes/mapa-sonor-de-barcelona/
Mosquito Alert	Investigate and control disease-carrying mosquitoes through an app.	https://www.mosquitoalert.com/en/
Observadores del Mar	Website by which people in contact with the sea can share their observations and experience regarding changing phenomena in this environment, which is useful for various marine research projects.	https://www.observadoresdelmar.es/

Name	Description	Website
Urban Butterfly Monitor Scheme (uBMS)	Collaborative network of volunteers who join forces to obtain data on butterfly populations in the cities of Barcelona and Madrid.	https://ubms.creaf.cat/en/
Observatori Metropolità de Papallones (mBMS)	Monitor the butterflies metropolitan areas and, at the same time, to be a laboratory for testing strategies to improve the abundance and diversity of this group of insects.	https://mbms.creaf.cat/
OdourCollect	Report odours to communities affected by odour nuisance with the aim of creating joint solutions with all stakeholders to improve the quality of life of the community.	https://odourcollect.eu/map
Plant*tes	Citizens report the presence of allergenic plants and their phenological status	https://www.planttes.com/
RitmeNatura	Citizens collaborate with observations to help the scientific team study the impacts of climate change on plants, animals and living beings in general.	https://www.ritmenatura.cat/
RiuNet	Interactive educational tool that helps any person to assess the hydrological and ecological conditions of a river.	https://www.ub.edu/fem/index.php/en/inici-riunet-en
TrackU	Validation of the community dimension of a tool for managing personnel at risk of SARS-COV-2 infection.	https://sites.google.com/view/estudi-tracku
WeCount	A project to count and measure mobility in cities.	https://www.wecountmovilidad.eu/
Network of Meteorological Observers	Network created to obtain meteorological data for Catalonia, based on manual observation by measuring the different variables.	https://www.meteo.cat/observacions/xom_observacio
Beepath	A project that allows us to study human mobility, recording it through mobile devices.	http://beepath.org/
BioBlitz Barris	Experts and citizens work hand in hand to identify as many species as possible in a given area.	https://www.barcelona.cat/barcelonaciencia/en/science-city/science-and-citizenship/citizen-science/bioblitz-barris
BioBlitzBcn	Biodiversity inventory of the city of Barcelona.	https://www.barcelona.cat/barcelonaciencia/en/science-city/science-and-citizenship/citizen-science/bioblitzbcn
Cities-Health	Citizens design and conduct experiments to explore how pollution in their environment is affecting their health.	https://www.citieshealthbcn.eu/

Disseminating Citizen Science in Barcelona

Figure 1. Citizen Science space at Barcelona Science Festival

From its inception, the Office has focused on disseminating citizen science. Actions include publishing a projects catalogue in 2015 "Citizen Science, 20 projects to make a city" (Oficina de Ciència Ciutadana de Barcelona 2015), organizing the Citizen Science Day, integrating projects into major city events like the "Riu Besós Day", hosting a dedicated space for citizen science at the annual Science Festival (see Figure 1), and incorporating participatory sessions and projects in the three editions of the City and Science Biennial.

As a public administration platform, the Office connects citizens with the research ecosystem, enhancing participation and visibility. It tackles significant challenges, contributes to the creation of common goods and shared resources, and facilitates knowledge transfer between science and society (DITOs consortium 2017). This is exemplified by two transversal programs:

- **Citizen Science in the Neighbourhoods**: developed in cultural centres and public libraries. 10 projects across 12 city areas have engaged approximately 12,000 participants.
- **Citizen Science in Schools:** in partnership with the Local Education Authority, seven editions of this program have been organized. 100 schools and 3,500 students who have participated in nine distinct research projects.

Showcasing experiences

Participation in citizen science projects can involve people from the formulation of the hypothesis and data collection, to the analysis and interpretation of results, as well as having a critical voice in the debate and the proposal of actions. This entails the collective generation of knowledge, promoting both education and capacity-building, as well as inclusion and empowerment, which are fundamental principles of open science (DITOs consortium 2017).

At their final stage, projects aim to share and evaluate their results and impacts. The outputs can include datasets, reports, academic papers, maps, software, or policy recommendations, each with different impacts. The communication of results will vary depending on the project type and target audience, tailored to the specific needs of each case (ACTION programme 2022). Following the conviction that it is necessary to go beyond the dissemination of results (Hecker et al. 2018), some of the projects participating in the "Citizen Science in Schools" program organize dissemination activities that emphasize the active role of project participants. Some examples, are:

- **Sharing results with other schools:** RitmeNatura (see Table 1 for this and further mentioned projects) and Mosquito Alert have organized events involving participating schools to disseminate their findings to a wider educational community.
- **Presenting results to a committee of experts:** in the Plant*tes project, a school hosted a final session with experts to review project results and discuss technical and citizen science elements. Held at the local public library, students and families from the community were also invited.
- **Organizing a video contest:** OdourCollect proposed a video contest where students could share their results on odour sampling related to air pollution. Additionally, they could explore the social aspects of olfactory memory through the creation of "Noses Stories." The contest was also held in a public library.
- **Photo-Voice exhibition:** utilizing photography as a participatory methodology, TrackU (see Figure 2) held exhibitions with the materials generated in the research process. These exhibitions were showcased in various locations, and are designed to be itinerant, allowing schools to share them within their facilities and other cultural centres in their neighbourhoods.

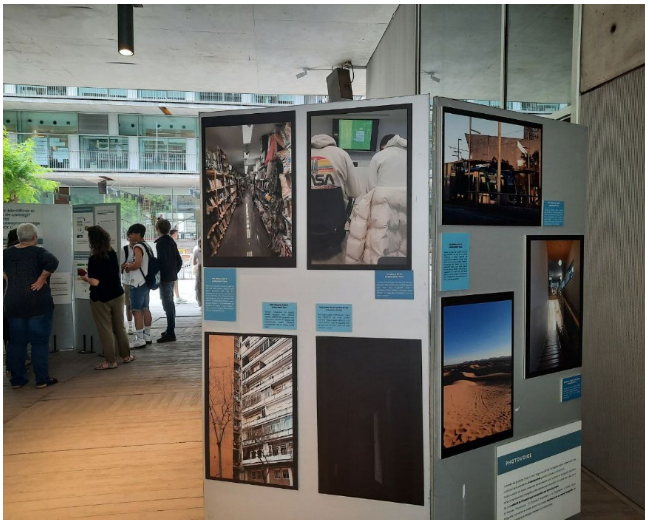
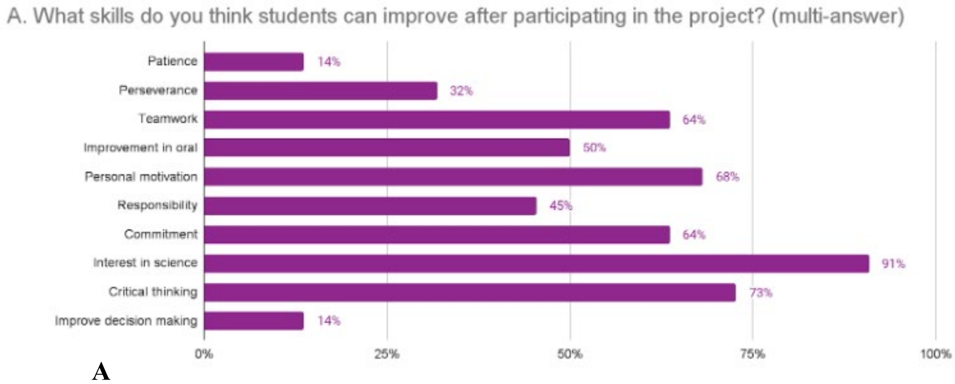


Figure 2. Photo-Voice exhibition from the TrackU project.



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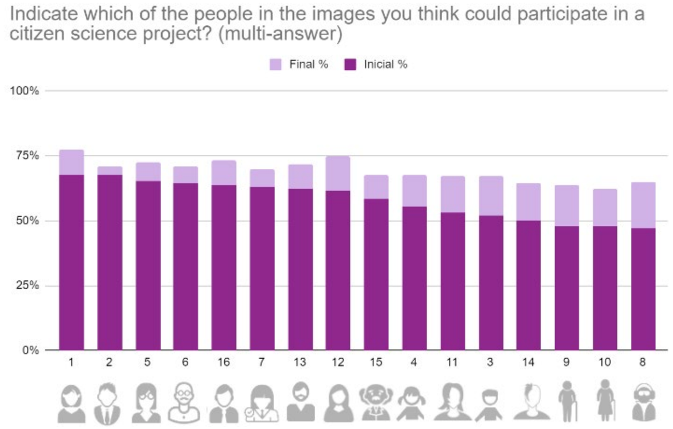

B

Figure 3. **A** Citizen Science in School 2022-23 Teacher's post-survey (23 responses). **B** Citizen Science in School 2022-23 Student's post-survey (260 responses). Survey's questions are included as additional material.

The Office conducts pre- and post-surveys with teachers and students, yielding 2,305 student responses and 131 teacher responses from 2019 to 2023. Feedback indicates improvements in teamwork, interest in science, critical thinking, and responsibility among students (Figure 3A). Additionally, involvement in research projects challenges preconceived notions about who can engage in scientific inquiry, inspiring scientific vocations among students (Figure 3B). According to a school director, that has participated in the program since the beginning, "We have noticed that now there are many more girls interested in science. These projects have a big impact".

A creative example of disseminating results among neighbourhood participants can be seen in the Barcelona Sound Map project. This project was originated from a citizen demand, and it has evolved to include the characterization of the soundscape in open public spaces. In each neighbourhood, Sound Map records the soundscapes reflecting the sonic heritage of the streets, squares, and parks. Citizens actively participate in different stages of the research process: they record sounds using professional equipment, analyse sound sources, and document the sensations, emotions, and cultural and social uses associated with these spaces.

As a way of sharing results, individuals contribute to the creation of sonic pieces that combine soundscapes with music. The connection with art plays a pivotal role in appealing to personal emotions and expressions, regardless of whether participants are actively involved in the creation process or are merely spectators.

Conclusion

Embracing creative approaches significantly enhance research result dissemination, especially in informal settings like festivals, broadening audience reach beyond engaged participants (Sánchez Vidal et al. 2023).

By participating in outreach activities, students learn that explaining the results is an important part of the research process, thus amplifying the effectiveness of Citizen Science as an educational tool.

Disseminating results in neighborhoods not only showcases research but also acknowledges citizens' active role, empowering them as community contributors. This recognition fosters active citizenship, improves critical thinking, promotes changes in attitudes and collaboration among various stakeholders.

It's essential to emphasize that sharing project results beyond participants or community strengthens the concept of citizen science as more than just a means of collecting evidence. It should be regarded as an essential component of any project. Finding innovative ways to encourage interaction between research and society is paramount to maximize the impact of its outcomes and drive meaningful societal changes.

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Change – The transformative power of citizen science

Exploring the marriage of citizen science & living labs – in support of green, social and digital transitions

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Abstract

The European Commission has identified the role of Living Labs and Citizen Science as needed tools for the process of citizen-centric knowledge valorisation. Backed by the Memorandum of Understanding (MoU) between the European Citizen Science Association (ECSA) and the European Network of Living Labs (ENoLL) signed in 2023, this workshop seeked to bridge these two worlds for mutual benefit and increased societal impact. During the workshop, we (1) introduced the features of Living Labs; (2) co-created practical examples on how Citizen Science and Living Labs can provide joint contributions in support of green, social and digital transitions; and (3) started to identify action items where the ECSA and ENoLL communities join forces to empower citizens to become true change makers. Although providing important first insights, the workshop revealed a need to develop a better understanding of the relationships and possible mutual benefits between Citizen Science and Living Labs. Next steps include a follow up mirror workshop at Open Living Lab Days conference 2024.

Keywords: citizen science, living labs, ECSA, ENoLL, mutual learning.

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Introduction

The accelerating changes in our daily lives request a holistic approach to public governance that accounts for green, social and digital transitions. It is imperative that citizens are not left out of the equation, and Citizen Science (CS) approaches can greatly contribute. However, there are also other ways of engaging citizens, academia, the public sector and industry in collaborative research and innovation, such as Living Labs (LL), Fab Labs and Maker Spaces—just to name a few.

It remains challenging to understand how existing methods and tools could be used in combination to address the grand challenges of our turbulent times (a goal shared by all initiatives). While LL struggle to engage citizens in their innovation process but succeed to involve key stakeholders to address local societal issues, CS can provide the missing piece while generating new knowledge aligned with societal needs to foster social innovation.

In this context, the European Commission (EC) has identified the role of LL and CS as needed tools for the process of citizen-centric knowledge valorisation (EC 2024). A big number of projects have been funded to investigate the impact of CS in society (Mačiulienė et al. 2021), as well as its role in the new European Higher Education Space (Vilariño 2024). Backed by the Memorandum of Understanding (MoU) between the European Citizen Science Association (ECSA) and the European Network of Living Labs (ENoLL) signed in 2023 (ECSA and ENoLL 2023), this workshop seeked to bridge these two worlds for mutual benefit and increased societal impact.

Methodology applied during ECSA 2024

During the workshop, we (1) introduced the features of LL; (2) co-created practical examples on how CS and LL can provide joint contributions in support of green, social and digital transitions; and (3) started to identify action items where the ECSA and ENoLL communities join forces to empower citizens to become true change makers.

Participants were expected to bring their experiences, questions, and individual perspectives. They left the event with a deeper understanding of LL and their role in societal transformation; insights into practical applications of CS in LL; opportunities for knowledge exchange; and a chance to contribute to a roadmap for future collaboration.

A four-phased co-creation method was used in groups, each addressing one of four pre-selected real case studies, related to contemporary challenges in health, energy transition, climate adaptation and Artificial Intelligence (AI), as follows:

- **Phase1: Introduction to Case Study**. Participants read general information (aloud or silently) given on the LL case study to prepare for the discussion and to be able to make proposals.
- **Phase2: Integration of CS in the LL**. Participants were invited to a role-play with the question: "As a CS expert, you join the LL. What would you add to the LL case?", to use their CS experience to

add more value proposition to the LL in four categories identified with a different colored hexagons, containing the following information (5W1H):

- WHO – How to increase Citizen engagement?
- WHAT – Which CS methodologies could you bring?
- HOW – What other services could you imagine?
- WHY/WHERE/WHEN – How can we address challenges closer to society?

- **Phase3: Win - Win - Win**. Participants were invited to answer the question: "What are the benefits & positive impacts of the marriage of CS & LL?". Three different colors were used per stakeholder.
- **Phase4: Creating bridges**. Participants addressed the "Definition of actions to unify both communities", through answering the question: "What concrete actions could start to bridge the communities?, constructing an action plan based on the previous exercises maps and defining a "must-go" action to be done for creating a strong and efficient bridge between CS & LL. Participants again used hexagons of different colors.

Results

In addition to the facilitators, the workshop was attended by 50 people, 60% women and 40% men, from 20 to 70 years old. Co-creation took place in 6 groups of around 8 persons each. The figures below give some impressions.

Figure 1. Impressions for the use of hexagons during the co-creation session in Ph2: table on climate adaptation (left) and table on health (right).

Figure 2. Impression of the reporting back from the groups.

Whereas many case study specific results were collected, the main overarching findings were:

- Overall, in discussions about **who** should participate more in LL, the participants underlined that inclusiveness should be guaranteed—particularly of underrepresented groups, including children, youth, or low income population. It is challenging to engage them, but those voices should be heard, and ethical considerations taken into account.
- When discussing **what** CS methodologies could bring to the LL, participants highlighted a wide diversity, from generic and comprehensive to specific applications. In summary the participants suggested participatory action research, adapting methods or discussing results of research, co-creating new questions, or researching questions posed by communities (by students, in curriculum, following the science shop methodology).
- Considering the approaches **how** to engage people in LLs, newly proposed services include: i) standard Apps, standard data and GDPR guidance; ii) CS training, and re-use of engagement practices; iii) life-long learning possibilities, skills gained as pathways to work for youth and enhance live chances; iv) creating a knowledge hub, or co-chair a joint ECSA/ENoLL working group.
- From the deliberations on addressing challenges closer to society (**why/where/when**) participants suggested the installation of public poll stations (jars with pencils & pens, digital QRs) in public spaces (parks…), focusing on specific topics in the neighborhood (childcare, loneliness, social inclusion) to address community issues. Moreover, it is necessary to find a common language and dedicate time to listening. Having CS expertise represented within the LL community and in particular LLs would be generally advisable.

The participants concluded that **benefits** can come at different scales, and longside the following dimensions:

- LL could benefit from the lessons learnt by CS on ethics, inclusiveness and equity, co-evaluation, strategies and methods. They might benefit also from a more citizen-driven, instead of technology-driven innovation, and an increase in knowledge generation - meaning that scientific knowledge meets everyday knowledge.
- For the CS community, LL offer the opportunity to increase the research impact, moving from research results to change and influencing politics and lead to policy changes based on evidence databases taken from real life-settings, making outcomes more relevant.
- Mutual benefits for CS and LL could come from working on inclusive structures, learning in workshops, or writing & submitting EU proposals, establishing links with other experts, to exchange and co-create knowledge. Sharings could be brought by joint conferences, shared stakeholders mapping, shared training and AI or shared principles.

Finally, suggested follow-up actions included:

1. Taking the high-level items of the MoU and substantiating those with more detailed points (such as the ones listed below).
2. Providing a more detailed introduction into LL to the CS community to allow for a wider debate.
3. Bringing existing ENoLL and ECSA working groups (for example on health) together to get to know each other and identify areas for collaboration.
4. Organizing joined workshops that focus on specific topics of common interest, e.g. how to increase resilience to climate change in neighborhoods.
5. Pairing up specific LL and CS projects that work on the same topic at the local level to learn from each other's experiences, methods and tools.

Conclusions and next steps

The workshop revealed a need to develop a better understanding of the relationships and possible mutual benefits between CS and LL—in the sense of the communities, approaches and individual projects, focusing on common/shared goals tackled through multidisciplinary teams focussing on methodologies instead of getting lost in terminology. Inclusiveness was highlighted as a way to widen impact, regarding the needs and focus of every project, and hearing all voices as a way to gain more impact.

Most of the participants had a CS background, so the results obtained focus on using common CS methods in LL, to have a science based approach. Accordingly, recommendations or comments are made from CS to the LL community. This setup made it more difficult to integrate methods from LL into CS projects, and a need to connect the scientific approach and data to day-to-day projects.

Next steps include a follow up mirror workshop at Open Living Lab Days conference 2024. For this follow-up workshop we are expecting to complete the joint value proposition in the opposite direction, i.e: how CS can bring value to the LL community to structured citizen-centric knowledge generation.

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Change – The transformative power of citizen science

Co-creating the future: exploring practices of co-created citizen science research across Europe

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Abstract
During the ECSA 2024 conference, we led discussions to build and share learning on co-creation practices across Europe. These discussions were centred around thought-provoking prompts based on best practices with underrepresented groups, barriers in a local setting, and ensuring legacy. The key takeaways from this discussion are related to building trust, community engagement, and time.

Keywords: challenges, co-creation, citizen science, community, inclusivity.

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Introduction

Co-creation is "*Citizen science that has been respectfully and equitably designed with and for the community*" (Dr. Claire Murray, participant of workshop).

At Stockholm Environmental Institute (SEI) York, our Citizen Science research group has been running and consulting on citizen science projects since 2008. Our aim is to create broader social change through citizen science theory and practice research that is inclusive, ethical, sensitive to existing power dynamics, and that equally centres both research and citizens (we define citizens as citizens of science,

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and citizens of the world). Recent co-created citizen science projects of ours include studying air quality in schools (SAMHE), working with young people with lived experience of mental health (Youth LIVES), and exploring how to achieve inclusive water and sanitation services.

Co-creation involves participants at all stages of the scientific process, from setting research objectives to dissemination of findings. Co-created citizen science projects, by nature, originate in direct response to the needs of the community. These projects are typically driven by a firm commitment to deliver tangible benefits to the residents within these communities, though are not without challenges.

Benefits and challenges of co-created Citizen Science

The benefits of co-creation are far reaching as shown in Figure 1. Active engagement of citizens at every stage of the scientific process ensures that the outcomes are deeply entrenched within the community's reality and context (Gunnel et al. 2021), can promote a more democratic production of scientific knowledge (Skarlatidou et al. 2019), and foster knowledge exchange among actors from different spheres who may not typically interact, amongst other benefits.

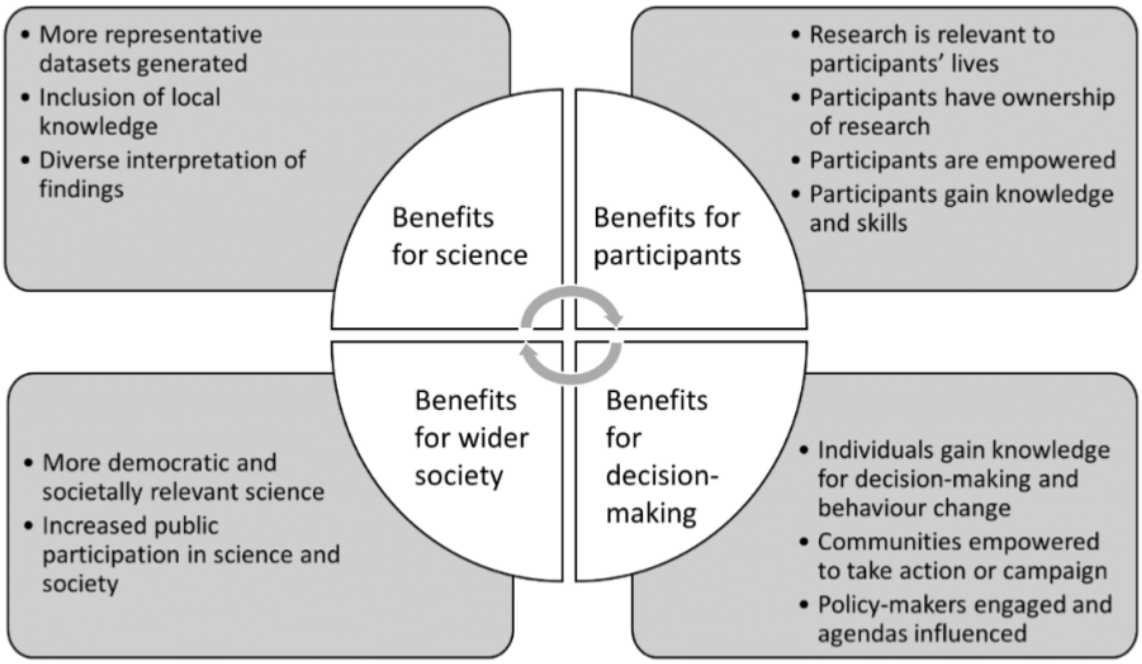

Figure 1. Benefits of co-created Citizen Science (Pateman and Wilkman, unpublished)

Co-creation also presents a range of challenges, unique to other citizen science methods given the depth of involvement from participants. Although broad challenges are well documented, as shown in Figure 2 (Gunnel et.al 2021), more insight into specific aspects of co-created Citizen Science is needed, specifically guidance on how to engage with underrepresented communities, overcome local barriers, and build legacy to ensure a non-extractive experience for participants.

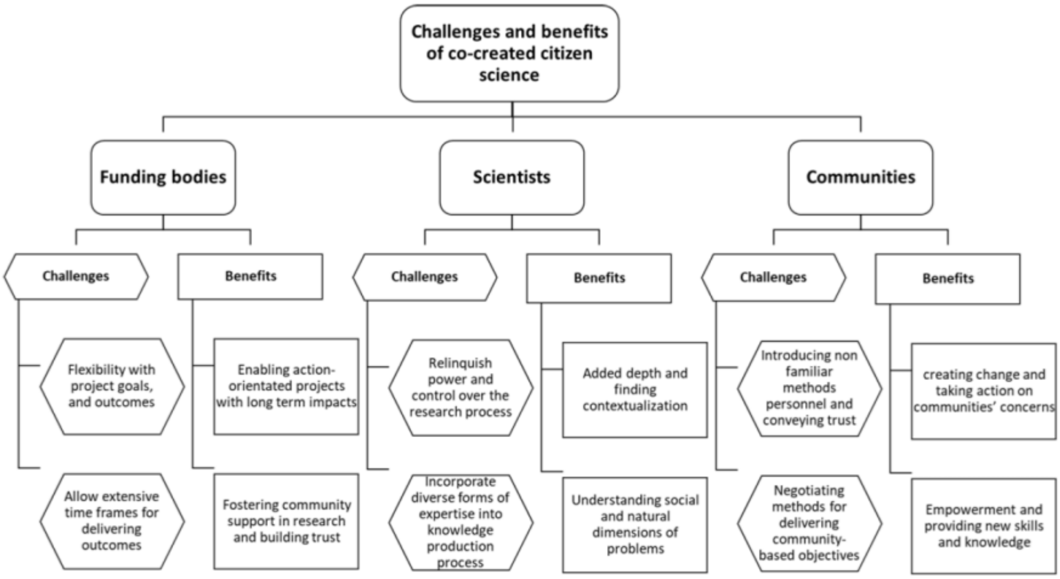

Figure 2. Challenges of co-created Citizen Science (Gunnell et al. 2021)

Discussion

To collect insights into these challenges to co-created Citizen Science, we led a discussion session for those interested in or already using co-creation in their work. Sixteen people from across Europe attended, bringing knowledge on co-created Citizen Science approaches from different countries. The discussion prompts were:

- What are the best practices when doing co-created citizen science with underrepresented groups?
- What are the barriers to doing co-created citizen science work in your country / setting? How have you overcome these?
- How have you ensured a lasting legacy with co-created projects? Or how could you in the future?

Engaging with underrepresented groups

Though co-created Citizen Science is founded in equitability, there are still communities within society which are underrepresented across Citizen Science projects (Pateman et. al. 2023). We asked, "What are the best practices when doing co-created citizen science with underrepresented groups?" and summarised the discussion below, defining "underrepresented groups" as those underrepresented within the participants' country.

- Local Leaders: Working closely with local leaders or facilitators who are already embedded in the community is an important way of reaching those you want to engage. Wherever possible, bringing community representatives onto the research team will help reach more diverse audiences.
- Finding people where they are: Even if you can't involve community representatives on your research team, you can still work with local organisations to actively go to the places where your participants spend their time, both in the real world and any digital spaces. "Gatekeepers" who work in your target community can help make connections. As always with citizen science, value those who show up—make sure they know their contribution is important and appreciated.
- Taking time: Building trust in the gatekeeper organisations and target communities takes time, as does understanding their different contexts and situations, considering culture, goals, interests, history, and fears. Additionally, respect should be given to things that participants do not want to share, for example, locations of particular species, or family recipes.
- Clarity and flexibility: Co-creation which centres the participant and their experiences requires you to regularly reflect on the project and be prepared to stop or change the research to accommodate participants' needs and ensure that they are safe / comfortable taking part. But whilst flexibility is required, you also need to give clear information about the project and what participation entails.
- Common communication: Clear communication is important, and you need to speak the language of your participants, both in terms of the actual words you use and the channels for communication.

Local barriers

Co-creation can be considered a non-traditional research method, therefore there can be considerable barriers to overcome, including barriers to participation, institutional challenges, and obstacles relating to researcher experience and perception as summarised below:

- Finding the right people: Lack of awareness of the opportunity is a key barrier for recruiting participants, as is participants' knowing what sort of contribution is valuable, and who the project is aiming to reach. There can also be challenges getting people to run co-created citizen science projects. Some researchers may lack knowledge about citizen science or the skills needed for engaging with participants.
- Power dynamics: There are always power dynamics involved in all projects—this should be acknowledged rather than ignored! Those leading projects will be responsible for any formal ethical approvals required, risk assessments, evaluation, project reporting, and thinking about publication authorship, which can reinforce hierarchies.
- Structural barriers: Co-created projects are sometimes challenging for funding panels to review, as elements such as research objectives and risk assessments will not be clear at the application stage, unless the proposal has been co-created with participants.
- Time and scale: As co-created projects require time to build, this can limit them to being relatively small in scale. Those running projects need to think carefully about what scale they want to work on, bearing in mind that the smaller the scale, the more relevant it is likely to be to local participants.

Legacy

Co-creation should be non-extractive and non-exploitative, and as part of this, it is important to create a lasting legacy to support continued engagement in the topic area, participants' interests, and to affect change in society. Insights are summarised below.

- Budgeting: Build time and finance into your projects to allow dissemination of findings well beyond scientific papers, through whatever mechanisms your participants wish.
- Exit plan: Plan the end of the project early, thinking about what other groups or opportunities you can signpost participants to. Make sure you build in time and budget for archiving information about the project and the data collected. Make sure you discuss with participants to see how they would like the data to be used.
- Collaborating on the legacy: Project legacy cannot depend on one person, so this responsibility should be shared, but it should be recognised some people might want to just be involved for the project lifetime. Work with special interest groups and other non-governmental organisations to understand what they could offer your participants once your project ends. Ensure that any additional funding bids arising from the project involve participants, so that the co-creation cycle continues!

Concluding comments

Discussions hinged around three key areas: trust, community, and time. To further these discussions, Dr. Rhys Archer will be leading a network on co-created Citizen Science. If you would like to be involved in ongoing discussions, please get in touch.

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Change – The transformative power of citizen science

Leveraging data science for change: navigating perspectives in a world of rapid transformation.

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Abstract

In today's interconnected world, data surged in volume. This exponential increase in data availability has sparked the rise of data science and artificial intelligence (AI), changing how we handle information (Aldoseri et al. 2023). In a world undergoing rapid change across various dimensions, it is important to involve data-driven methods to be able to assess and to follow, and assist citizens in their sustainable actions and projects. These methods help analyze, support, and motivate citizens in actions and projects, addressing complex issues like biodiversity loss, urban liveability, and local activism. With a focus on inclusivity and adaptability, the session aimed to discuss transformative potential approaches that integrate citizen science, data science, and human-computer interaction (HCI). Of particular importance was the focus on the ethical considerations of data science and AI, emphasizing fairness and equity in decision-making, and showcase real-world impacts. Additionally, we explored the conditions for cross-disciplinary collaborations among data scientists, citizen scientists, researchers, practitioners, within various citizen science projects. The current paper presents the session report, highlighting the main discussion points and conclusions.

Keywords: citizen science, data science, ethics, human-computer interaction

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Introduction

In today's interconnected world, data surged in volume. This exponential increase in data availability has sparked the rise of data science and artificial intelligence (AI), changing how we handle information (Aldoseri et al. 2023). In a world undergoing rapid change across various dimensions, it is important to involve data-driven methods to be able to assess and to follow, and assist citizens in their sustainable actions and projects. These methods help analyze, support, and motivate citizens in actions and projects, addressing complex issues like biodiversity loss, urban liveability, and local activism. With a focus on inclusivity and adaptability, the session aimed to discuss transformative potential approaches that integrate citizen science, data science, and human-computer interaction (HCI).

The session focused on four key topics. (1) Data-centric approaches in understanding open science, emphasizing the importance of participatory processes and complex network analysis in uncovering hidden dynamics and fostering relational well-being among participants. (2) The shift in data perspective in scientific research, the importance of tailored data collection and analysis methods to capture nuanced human behaviors in citizen science initiatives. (3) Ethical complexities of participatory technologies while emphasizing the collective responsibility to uphold individual rights and contributions. And (4) The role of data literacy in addressing Sustainable Development Goals(SDG).

Methodology – open discussions

The session was held during the ECSA conference in Vienna and facilitated by two of the co-authors of this paper. It brought together a diverse community of researchers, scientists, students, and public engagement practitioners. The session, organized for one and a half hours, followed an open-format structure, comprising four short presentations including interactive fishbowl discussions.

Summary of the presentation

The presentation session featured four speakers, each offering insights into the intersection of citizen science, data science, and ethical considerations.

The application of data science in engaging people and fostering new perspectives within citizen science initiatives is crucial. Marc Santolini emphasized the importance of leveraging data-centric approaches to analyze citizen science data, building a quantitative "science of citizen science". This endeavor focuses as much on measuring the quality of participation processes than the quantitative outcomes such as productivity and citations. Traditional data-driven methods in the science of science are indeed often not equipped in terms of data sources or measurable proxies to take into account the unique characteristics of citizen science projects, such as non-professional participation and perspectival diversity (Masselot et al. 2023). Using digital traces of participatory projects, such as interactions on social platforms, and constructs to measure the impact of participation, such as increases in Relational Well-Being, one can build integrative data-driven approaches to help mobilize people and offer new perspectives within citizen science initiatives, fostering inclusivity and facilitating meaningful contributions from diverse participants. A recent example is the analysis of the OpenCovid19 community, where digital traces were used to understand collaboration networks and the evolution of roles and structural elements within the community. Finally, the talk raised an important question about ethical considerations, such as addressing privacy concerns of using individual traces to measure the participation process.

Josep Perelló highlighted the necessity for a shift in perspective when approaching data in scientific research, particularly in the context of citizen science. The standard data-driven methods may not provide the necessary insights into certain situations or phenomena that are of concern to citizen groups and communities involved in citizen science projects. For instance, the data methods may not be the most appropriate for a better understanding of social interactions in a mental health care community or for better capturing air quality levels (Perelló et al. 2021) in a neighborhood just to name a couple of examples. Hence, it is important to practice mixed-methods approaches from participatory action research, and ethnographic studies and find ways to better combine qualitative and quantitative data analysis (Perelló et al. 2023). Overall, citizen science initiatives should focus on gathering data that is meaningful and relevant to the people involved.

Karen Soacha addressed the ethical challenges surrounding data sharing in citizen science projects. Platforms and technologies play a significant role in shaping ethical practices in citizen science. Platforms like iNaturalist and MINKA should take into account addressing the ethical challenges in data governance in citizen science projects, particularly the challenges of sharing data while protecting the privacy and ensuring fair acknowledgment of participants (Resnik et al. 2015). Therefore, addressing ethical challenges within citizen science by integrating considerations such as data privacy, benefit distribution, and participant decision-making is essential. There is a need to rethink terms of use, informed consent, and data licenses to better suit citizen science projects, alongside developing data management plans and data integrity plans.

Overall, the aim is to create a governance model that empowers participants and promotes ethical practices within the platform.

Finally, Francois Grey provided insights into the dimension of data literacy and highlighted the hidden information behind icons, representing the gaps between those who own data and those who need it for utilization. Addressing complex issues requires a multifaceted approach, including leveraging various skill sets such as data science. Within Geneva, where UN agencies hold significant influence, involvement with a specific SDG may not be enough. That's where citizen science and data science can play a role in addressing the data gaps and helping for better decision-making. For example, events like the SDG Olympiad empower youth around the world to tackle environmental and health challenges related to the UN Sustainable Development Goals. Moreover, partnerships and collaborations across continents empower young individuals to contribute meaningfully to global change.

The presentation highlighted the critical role of data science in citizen science, adapting new approaches to diverse participants. Ethical considerations, including privacy and acknowledgment of participants in digital platforms while diverse data collection and analysis methods were promoted to capture complexity.

Moreover, empowering youth and global partnerships emerged as a key strategy for promoting inclusivity and meaningful contributions to global challenges

Insights – Fishbowl Discussion

This format provided participants to share insights, experiences, and best practices related to key themes. This included several topics such as **"Inequalities in data,",** focused on participation inequalities and biases, **"Data privacy,"** focused on privacy concerns and safeguarding participant confidentiality within data-driven initiatives. Finally, participants discussed "**Algorithms and tools transparency**," the importance of transparency in algorithms and tools utilized in citizen science applications.

The session highlighted modeling inequality in data, emphasizing the need to address biases and integrate data science into citizen science projects by valuing interdisciplinary collaboration, transparency in algorithms, balancing data privacy with access and local interventions. Participants recognized data science's potential for positive social impact.

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Change – The transformative power of citizen science

Let's talk about data – impulses for good co-interpretation of data analysis in citizen (social) science

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Abstract

This conference proceedings addresses the topic of collaborative and multi-perspective co-interpretation of data in Citizen (Social) Sciences. Co-interpretation of data is a participatory research step that is often treated with less attention in practices of citizen science and science and technology studies. However, the question emerges as to what potential entails the co-interpretation of data in Citizen Data Science. At the European Citizen Science Association (ECSA) conference in 2024, four different topics were selected for an approach to discuss best practices of co-interpreting data in Citizen Data Science. These topics cover co-interpretation of data from the perspective of different actors, necessary knowledge, data types and applicable methods and resources for collaborative data analysis in Citizen Science. The results of the four thematic groups are summarized and classified in this report.

Keywords: citizen science, citizen data science, co-interpretation, data literacy, diverse knowledge.

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Introduction

The co-interpretation of research data has the potential to not only transfer expertise and meta-knowledge between researchers and citizen scientists. We assume that knowledge is essentially situated (Haraway 1988) and that every instance of situated knowledge is shaped by socialization, social class, milieu, lifestyle, and conditioned by their respective hegemony. The incorporation of diverse knowledge as „ecology of ideas"

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(Vickers 1968) into the interpretation of research data is contingent upon the adoption of more democratic citizen science approaches (Jaeger et al. 2023) and thus post-normal science (Funtowicz and Ravetz 1993). Furthermore, the co-interpretation of data offers a previously unexploited opportunity to transfer discipline-specific methodological knowledge and rule-based data reading skills. Consequently, data literacy is also crucial in the context of citizen science (Balázs et al. 2021; Schüller et al. 2021). In the ideal case, co-interpretation leads to greater trust in science (Kloetzer et al. 2021; Bromme 2020; Bonney 2016) due to the (self-)empowerment of citizen scientists concerning their knowledge of data handling and its scientific data interpretation. In particular, the field of social science offers a promising avenue for harnessing the potential of citizen scientists to contribute their diverse social perspectives to the interpretation of data, thereby enhancing its methodological triangulation (Flick 2011; Denzin 1970). Nevertheless, even if citizen science approaches are frequently evaluated based on their degree of participation (Eitzel et al. 2017; Haklay 2013; Shirk et al. 2012), there are still relatively few projects that also facilitate collaborative data interpretation (Heinisch 2017; Hinojosa 2021).

In the citizen social science project GINGER *(Exploring Society Together)* the "Public Data Sprint" format (Venturini et al. 2018; Segler and Gantenberg 2023) was piloted to co-interprete data on social cohesion. The objective of these intensive workshops is to interpret data in a given time, similar to hackathons in programming environments where participants collaborate to solve a problem. The objective was to disseminate this positive experience more widely in a workshop at ECSA 2024 and to discuss open questions on how to enhance the co-interpretation of data in citizen (social) sciences. In this proceeding, we will summarize the primary insights derived from the workshop discussions.

Compiling expertise for the co-interpretation of data

The workshop addressed four key topics: (1) the needs and interests of various actors involved in the co-interpretation of data (e.g., expert scientists, citizen scientists, NGOs, and other potential participants), (2) the disciplinary skills and resources required for co-interpretation of data, (3) data types that can be collaboratively analyzed, and (4) relevant methods and technologies for the co-interpretation of data.

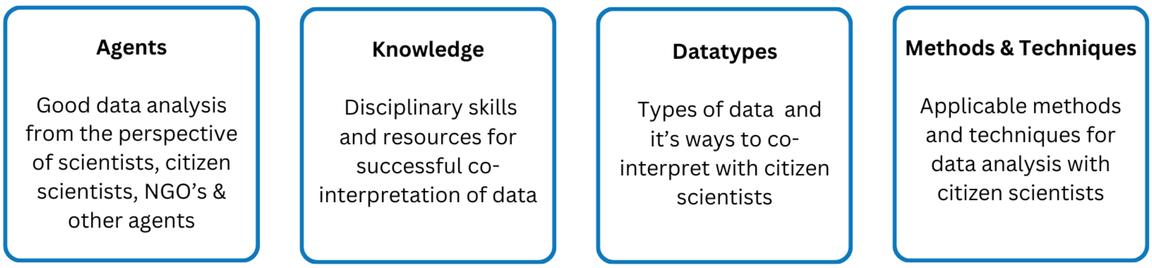

Figure 1. Workshopclusters - Agents, Knowledge, Datatypes and Methods & Techniques

Workshop-Cluster: Agents, Knowledge, Datatypes and Methods and Techniques

Upon assuming and discussing the **interests and needs of different stakeholders**, it became evident that *scientists* would benefit from the co-interpretation of data, which would lead to valuable analysis results, when applying to the FAIR principles. The Fair principles stipulate that data must be **F**indable, **A**ccessible, **I**nterpretable, and **R**eusable. Moreover, the data must also comply with ethical standards. In addition to appropriate training in data reading skills, *citizen scientists* also require an appreciative working environment in which they can work in a results-oriented manner and receive benefits and recognition for their contributions. It is assumed that *representatives of civil society organizations* will have a particular interest in analytical results that are transparent, reliable, and easy and accurate to communicate.

With regard to the **knowledge, skills, and resources required** for participatory data analysis, it was emphasized that all participants must have access to the respective knowledge to read data. The specific skills required for a given project and academic discipline will depend on the focus of the project and the discipline in question. The potential for data literacy to promote critical thinking among citizen scientists is particularly evident in the data processing and analysis phase. Consequently, it is imperative that non-experts receive training. It is of particular importance to provide accompanying materials such as guidelines, protocols, or digital training material in order to facilitate the learning process. It is therefore evident that social and pedagogical skills are of paramount importance for the effective co-interpretation with citizen scientists. Finally, tangible case studies could ensure further reflection on the optimal combination of skills and resources required for co-interpretating data.

The discussion focused on the usability of **accessible data types**, paid attention to the application of quantitative and qualitative data. In order to conduct the analysis of the previously mentioned data types, the participants of this expert group propose that co-interpretation of data can be effective when clustering the data. In particular, participation in quantitative data analysis requires technical learning environments that are easily accessible, even without programming skills, and allow for quick access. Further, it is considered important to provide stimulating moderation, professional support, and introduction to statistical programs. Moreover, the pre-selection, summarization or excerpts of data sets may be useful in order to reduce complexity. It is therefore crucial to be transparent about this procedure and to engage in critical reflection with citizen scientists.

With regard to the **methods and techniques** for effective co-interpretation of data with citizen scientists, it was proposed that the data analysis process be divided into discrete steps, a 'code of conduct' be established, and these steps be discussed in order to ensure a common understanding of the respective data analysis project. This could serve to define the most crucial conditions for scientific data analysis. Furthermore, it is decisive to consider the suitability of formats for data analysis training for non-experts, as this plays an important role in the methodological preparation for successful co-interpretation. Software recommendations for data analysis that is accessible include the open-source program JAMOVI or the social science and digital learning and analysis platform EPINetz, Orange for data mining, as well as programming environments that require in-depth specialist knowledge (at least in a supporting context) such as R, Shiny and Python. However, it is essential that appropriate (online) tutorials are made available in order for citizen scientists to be able to deploy them at a low threshold.

In addition to numerous valuable contributions, there has been a paucity of attention paid to the potential for scientists to learn from citizen scientists when co-interpreting data in the context of peer learning. It is also important to note that no citizen scientists participated in this workshop to share their perspectives, interests, and needs on the topic of co-interpretation of data. Nevertheless, more extreme approaches of data co-interpretation can be a valuable addition to citizen science research.

Conclusion

This endeavor to engage in a more in-depth discourse on the co-interpretation of data with citizen scientists is designed to foster further resonance, to be tested and to advance knowledge based on this summary. For supplementary practical development of co-interpretation of data with citizen scientists, it is recommended that the discussion be expanded with the various specific stakeholders themselves (e. g. scientists from different disciplines, citizen scientists) in focus sessions on good data interpretation. With regard to further theoretical discussion on data co-interpretation with citizen scientists, it is evident that there is a need for analysis and discussion on more precise definitions of doing data analysis with citizens, as well as research into the processes and benefits of co-interpreting data for both citizens and vocational researchers. Finally, we intend to establish an open exchange platform, entitled “Forum Citizen Data Science”, dedicated to the discussion of topics pertaining to citizen data science in the future.

Acknowledgments

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Change – The transformative power of citizen science

Does crowdsourced transcription data increase accessibility for blind and low vision users?

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Abstract

Many crowdsourcing and citizen science projects are conducted collaboratively by galleries, libraries, archives and museums (GLAMs) and research teams, and result in transcription data that could be helpful to blind and low vision users. Through usability and accessibility testing with blind and low vision scholarly users, we identify changes to GLAM systems and data sharing that can increase crowdsourcing, citizen science, and GLAM data discovery and utility for many blind and low vision users.

Keywords: assistive technology, cultural heritage, digital humanities, print-disability, usability.

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Introduction and landscape review

Volunteer crowdsourced transcription is a common method of data generation in citizen science and often engages a coalition of academics, cultural heritage practitioners from Galleries, Libraries, Archives, and Museums (GLAMs), and the public. Hundreds of GLAMs around the world collaborate in or run their own crowdsourced transcription projects to produce new datasets for research, and searchable text to create accessible pathways to digital images of source materials. For example, "Project PHaEDRA: Preserving Harvard's Early Data and Research in Astronomy" at Harvard's Wolbach

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Library, utilizes both Zooniverse and the Smithsonian Transcription Center (STC) to engage volunteers in transcription.

In a review of data practices by citizen science, community science, and crowdsourcing practitioners and researchers, Bowser et al (2020) found that while "many projects demonstrated willingness to make their data available" inappropriate data licensing, and insufficient provision of accessible formats for human and machine users create significant barriers to data access and reuse. Machine-readability is vital for assistive technologies, such as screen readers, Braille keyboards and other Braille devices. When crowdsourced data is not accessible to machines, it is not accessible to people who are blind or low vision (BLV) and use assistive technologies to access data, web content, and research results.

GLAMs have a core mission to make their collections publicly available, discoverable, and usable, and therefore could be central to addressing the problems Bowser et al (2020) identified. The STC, and the By the People (BTP) transcription project at the Library of Congress (USA), explicitly state that crowdsourced transcription makes collections accessible for BLV people (Ferriter et al. 2019; Haynes et al. 2019), and the BTP team report that volunteers are passionate about this mission (Shelton, 2021). Yet, while GLAM practitioners actively solicit transcriptions to improve accessibility for BLV users, research by Xie et al. (2018; 2020) suggests that the complexity of digital library systems poses significant challenges to data discovery for BLV users, which, we hypothesized, may persist even when crowdsourced transcriptions are integrated.

We present a subset of findings from Crowdsourced Data: Accuracy, Accessibility, Authority (CDAAA), a 3-year grant project to investigate whether GLAMs experience sociotechnical barriers to integrating crowdsourced transcriptions with discovery systems and whether transcription content is accessible to BLV users. We limit our discussion to RQ3 (Accessibility): "When transcription data is successfully integrated with a GLAM discovery system is it accessible to BLV people who use assistive technologies?"

This analysis focuses on crowdsourced transcriptions from Shakespeare's World, a collaboration between Zooniverse, the Folger Shakespeare Library, and the *Oxford English Dictionary* (2015–2019) that generated crowdsourced transcriptions of 12,578 single and double-page spreads of handwritten manuscripts from the1600s–1700s. The transcriptions were intended to enhance the discovery and accessibility of Folger collections and produce textual datasets for digital humanities, history of science, and Handwritten Text Recognition (HTR) research, and surface new words, usages and variants for the *OED* (Van Hyning 2019; Van Hyning and Jones 2021).

Methods

Between February and June 2024, we conducted 12 blended accessibility and usability interviews over Zoom with BLV academics who use GLAM systems for their work (duration ~120-minutes). The think-aloud protocol draws on user-experience and human-computer interaction research (Aizpurua et al. 2016; SUS protocol 2013; Lam et al. 2021; Schaadhardt et al. 2021); cultural heritage and disability studies (Lazar et al. 2017). 10 discovery systems for 9 GLAM organizations were tested; each was tested by 4 people.

We tested two Folger systems due to a data migration (March 2024). Participants performed three tasks for each of 3 GLAM systems:

1. locate the GLAM website;
2. locate transcriptions of any kind;
3. locate a specific transcription (Fig. 1).

Systems were tested in a counterbalanced order. 1 blind participant tested the Folger system Luna. 2 blind participants and 1 low vision participant tested its successor, Islandora (Table 1; N=4).

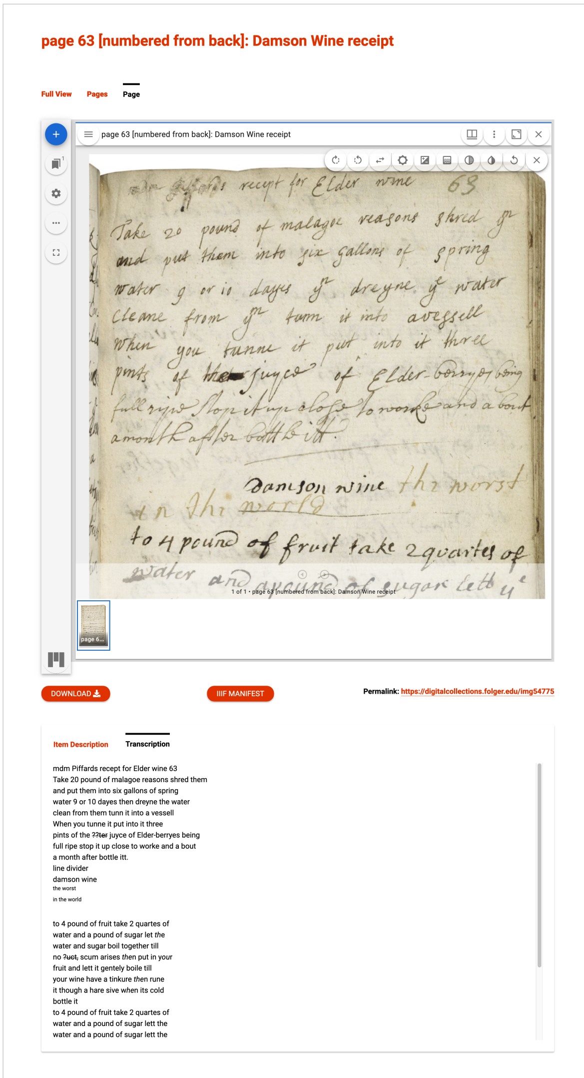

Figure 1. Folger Shakespeare Library manuscript and unedited transcription of wine receipts, https://digitalcollections.folger.edu/img54775. Islandora. Search prompt "worst in the world."

Results and Discussion

Table 1. Data from the 3 participants who tested the Folger Shakespeare Library systems.

ACC Tester ID	Blind or low vision	T1: Can you navigate to the Folger Shakespeare Library's website?	T2: Search for digitized materials i.e. images of manuscripts with transcriptions	T3: Search for "The worst in the world"	Rate statement: "This discovery system website is easy to use" (strongly agree, agree, neither agree nor disagree, somewhat disagree, strongly disagree)	Rate statement: "This website meets my needs as a user." (strongly agree, agree, neither agree nor disagree, somewhat disagree, strongly disagree)	LAM CMS test position
ACC-3	B	Complete Success	Failure	Success with minor issues	Agree	Agree	1
ACC-7	LV	Complete Success	Failure	Success with minor issues	Agree	Agree	2
ACC-9	B	Complete Success	Success with major issues	Success with minor issues	Neither agree nor disagree	Disagree	3
ACC-12	B	Complete Success	Failure	Success with major issues	Neither agree nor disagree	Agree	1

Participants were unaware of the availability of crowdsourced transcriptions in general, and were unfamiliar with searching for transcriptions through GLAMs. All participants found the Folger website (T1) easily but struggled with T2. Each user navigated Folger CMSs with some frustration, but ACC-3 and ACC-7 agreed with the statement "This system is easy to use" and thought it would meet their needs if they used it regularly. All emphasized the need for consistent page, filter, and search layouts. ACC-3 observed that for "screen reader users [...] it's like looking through a straw. Right? You don't see the whole thing. You just see exactly where you are right now."

ACC-3 and ACC-9 switched from screen readers to Braille keyboards to investigate the transcription after encountering insertions and deletions like "worst in the world", which they likened to "track-changes." The said transcription convention information would be helpful. ACC-7 could see deletions, but not the fainter "worst in the world". Transcription conventions including the question marks used by Zooniverse volunteers to indicate uncertainty were confusing. When asked to interpret duplicate lines (Fig. 1, final lines) ACC-7 speculated the original author was "probably not thinking and just writing quickly [...or] they were intoxicated themselves." The duplicates originate in aggregation difficulties on Zooniverse, but this information is missing.

Conclusion

Crowdsourced data holds great promise for accessibility of the scientific and cultural heritage record, but only if the content is discoverable, well structured, and well described. Standard fields and consistent system layout are vital for BLV users to navigate GLAM systems, confirming previous analysis of library systems by Xie et al (2018; 2020). Transcription data should include information about the conventions used, i.e.

insertions, deletions, original spelling, markup, and degree of editing, so users can understand how transcriptions relate to original texts. Finally, GLAMs and crowdsourcing teams could increase the impact of their projects by reaching out to BLV users about the existence and availability of the resulting data.

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Change – The transformative power of citizen science

Promoting change from field to plates: the case of nine European fair living-labs working collectively

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Abstract

Gathering citizens, research organizations, companies, policymakers and practitioners is often considered sufficient for creating a Living-lab aimed at change towards food system sustainability.

However, sustainability remains a social construct calling for a deliberation about the values that must be prioritised. These values need to be debated at each level of the food chain, from the choice of crops (neglected vs. main crops) and seeds (commons vs. intellectual property) through production (organic vs. weak agroecology) and processing (small-scale vs. industrial) to food supply and retail (local vs. global).

The DIVINFOOD project's Living-labs create favorable conditions for the emergence of such debates, in a food democracy perspective. Further to farmers, processors and researchers, they all aim to engage, around neglected and underutilized agrobiodiversity, groups of stakeholders that are still too rarely represented in participatory research approaches, such as teachers and students of agricultural schools, chefs, marginalized people, gardeners and citizen-led organisations.

All actors are regularly invited into:

- farmer's fields to observe, evaluate and comment on cultivated biodiversity, and Genotype-Environment (GxE) interactions,
- chefs' kitchens to taste, co-create recipes,
- laboratories to analyze, raise research questions, discuss results,
- micro-enterprises to co-conduct diagnosis,
- neighborhood associations to increase awareness about sustainable food systems,
- meetings with policy-makers to co-develop short food chains and territorial networks.

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Each of the 9 Living-labs acts in its own territory. Bringing them together allows to shape a meta-Living-lab in which changes are studied, debated, observed, documented, initiated, and reflected.

The connection of Living-labs makes it possible to think these changes locally and act globally for their realisation. By making collective decisions to give voice to very small structures in each region, this meta-living lab contributes to profound changes for the sustainability and diversity of the global food system.

Keywords: participatory, collaborative, neglected and underutilised crops, minor crops, GxE interactions, food democracy.

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Introduction

What does “Change” mean? Simple lick of paint? Adaptation? Modification? Revision? Transition? Revolution? Metamorphosis? Conversion? Or a major Switch? What do we want for agriculture and food in the future?

Does a Living-lab may promote Change from field to food? To what extent? and how ?

Living-labs are protean structures. Their definition is broad enough to allow each group of people to be named “Living-lab”. The grouping of a multinational seed company, a large agricultural cooperative, a company listed on the stock exchange, 2 farmers, 3 citizens and 1 researcher can claim the name of “Living-lab”.

But are the ethical values shared? Do everyone’s votes have the same weight? Are the power relations balanced? Is the degree of involvement expected from each stakeholder discussed?

The objective of this contribution is to propose new avenues for elaborating FAIR Living-labs addressing these issues to promote change in food systems.

How to build a FAIR Living-lab?

To date, the 9 Living-labs located in 7 countries (Denmark, France, Hungary, Italy, Portugal, Sweden, Switzerland) and built in the frame of the EU-DIVINFOOD project are highly diverse in terms of types of actors and history. Those in France, Switzerland and Italy emerge from participatory plant breeding programs implemented at least twenty years ago. At that time, researchers collaborated with organic farmers to select crop varieties adapted to their local environment (Chiffoleau and Desclaux 2006).

The program then evolved when farmers decided to process their harvest and sell the products (bread, pasta, etc.) on their own farm. New questions arose, requiring the involvement of a greater diversity of researchers from several disciplines and of partners, with whom they never worked before, such as food processors, chefs, teachers and students, citizens, gardeners, policy-makers, marginalized people, associations, etc.

Yet, gathering these different actors is not assumed to be sufficient to create a FAIR Living-lab aiming at promoting change. Each Living-lab must commit to create favorable conditions for the emergence of debates concerning values and commons, with the support of ethic charters and through processes and tools favoring democracy and learning for a critical participation (McTaggart et al. 2017).

In a food democracy perspective (Lang 1998), participatory researches are conducted in each Living-lab to determine i) the values to be prioritized when discussing crop varieties, production techniques (on-farm diversification), processing and marketing practices, ii) organizational dynamics that support sustainable food system valuing diversity, inclusion and justice (Ruben et al. 2021), (iii) the way to go further in mutual learning, co-construction of knowledge and capitalization of know-how at LLab and meta-LLab levels. Meetings of Living-labs coordinators are regularly scheduled to discuss objectives, statutes, governance, etc. Citizen consultations and prospective studies have also begun to take place in each Living-lab (Chiffoleau et al. 2024). The purpose is to discuss how to shift from fairly small local collectives involved in participatory research to the creation of FAIR Living-labs interconnected at European scale.

How to promote change from field to food?

DIVINFOOD is the acronym for "Co-constructing interactive short and mid-tier food chains to value agrobioDIVersity IN healthy plant-based FOOD". The first term "Co-constructing" is of key importance because "Change" is fundamentally a social construction (Camargo et al. 2013). The change is affecting the organizational structure as a whole, and consequently, there is a need to embrace a more inclusive approach by taking into account the expressed needs and wishes of people, thereby co-creating value (Payne 2008) and discussing also values with them. In the Living-lab, all actors have been invited to debate each level of the food chain, starting from the choice of the crops (do we investigate only main crops or rather neglected and underutilised crops?), the choice of the seeds (do we consider seed as a common or as an intellectual property?), the cropping system (do we target only organic producers or all producers?), the storage (is it interesting to consider the cold room or also the alternatives such as natural underground silo?), the processing (do we consider artisanal processes? industrial processes ? or both?), the packaging (do we target eco-friendly packaging or not only?), the transports logistics (do we focus only on local chains or do we also consider global chains needing long transport?), to food supply and marketing (is it relevant to consider both short and long chains?). It also includes the consideration of inputs and outputs needed or generated at each of these steps (e.g., sustainability at which costs? With which affordability of products for low-budget consumers?).

The nine Living-labs study minor cereals and legumes in European regions that face various climatic hazards and diverse socio-economic challenges (Laino 2023), with the aim of developing agrobiodiversity-rich value chains. One of the main topics of discussion concerns the notion of "environment". Typically,

Figure 1. Culinary art around neglected crops studied in Divinfood project
© Bouillon-Brume

the term “environment” is simply considered to cover only climate, soil, cropping system including weed and pests (Kang 1997). We propose here to expand this notion to components related to processing, marketing, economy, social, cultural and regulation.

Therefore the interactions between genotypes and environments (GxE) are no more studied in terms of yield or food quality but are extended to biodiversity, ecosystem services, benefits and costs.

The “adaptation” of a genotype, or variety, to an environment is now strongly linked to the “contribution” of this variety to the different dimensions of the environment (Desclaux 2020), assessed with stakeholders throughout the project. The question is no longer to think “how to react” but “how to act”. Similarly, the food system must no longer think globally to act locally (Gianinazzi 2018), but conversely, think locally to act globally.

Through consultations and debates, neglected species, alternative cropping systems, peasant and artisan processes and fair value sharing conditions have been confirmed as priority avenues to promote healthier, more sustainable diets and food systems, with the vigilance point that these processes must not be elitist.

Significance of the work for policy and practice

According to Enoll (https://enoll.org/about-us/what-are-living-labs/) “*Living Labs are open innovation ecosystems in real-life environments using iterative feedback processes throughout a lifecycle approach of an innovation to create sustainable impact. They focus on co-creation, rapid prototyping & testing and scaling-up innovations & businesses, providing (different types of) joint-value to the involved stakeholders.*”

Because this definition tends to be market-oriented, Living-labs may privilege certain types of "stakeholders". But, a shared and fair "Change" supposes to involve a large diversity of actors, geared to a FAIR Living-lab, with the support of processes and tools favoring democracy and critical participation.

"*Scaling-up innovations & businesses*" first requires that these innovations and businesses are not in the hands of one or two stakeholders but are considered as common goods.

The expectations of policymakers regarding the transformative potential of Living-labs or their ability to foster transitions must be tempered due to the wide variety of outcomes depending on how the dynamics of democratic decision-making, trust and concept of "commons" are dominant modes of interaction.

Living-labs can be instruments that provide a "favorable" context. This, in itself, does not guarantee democratic processes, trust and the commons. Therefore, how do we define values and principles to guide FAIR Living-lab action? The DIVINFOOD project is currently tackling these aspects.

A major CHANGE even during the ECSA poster session: The Participatory Poster!

CHANGE also concerned the poster presented during ECSA congress (Desclaux 2024) which was intended to be participatory. This poster aimed to present the DIVINFOOD project and the different Living-labs and to invite people to get involved in one of the Living-labs. But the particularity was that this poster was completely blank! Everyone was invited to contribute to the construction of the poster using different pre-cut elements (type of actors, questions addressed, location of the Living-labs, etc.), which they could position on the poster as they wished. The exercise of co-constructing a blank poster was a great success and many researchers left with the idea of spreading this type of concept! Learning by contributing...

Figure 2. The participatory poster presented at ECSA Congress 2024
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Change – The transformative power of citizen science

Old dialect words through the ages – the ABCs of dialect project

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Abstract

Language is subject to constant change. The use of words can change across generations, just as the meaning of words can change over the years. The FWF Top Citizen Science project "The ABCs of Dialect" aims to transcribe and reflect old dialect words contained on the more than 100-year-old paper slips of the Dictionary of Bavarian Dialects in Austria (WBÖ). On the one hand, historical data is digitally processed, analysed and made accessible via the Zooniverse platform; on the other hand, interested citizens should be inspired to rediscover their linguistic and regional heritage. A crowdsourcing approach enables more extensive processing and transcription of the materials, while in a special reflection section citizens simultaneously reflect on and discuss the use and meaning of the classified words.

Keywords: citizen science, dialects, language, cultural heritage.

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Over time, languages are subject to constant change. This affects various linguistic levels. Changes in the overall use and meaning of words, i.e. the lexicon, are typically those that are most prominently perceived by people. While the use of words can change over the course of generations, the meaning of words can also evolve over time. The German lexeme *Ampel*, for example, was borrowed from the Latin word *ampulla* and originally referred to a small container for oil, before it then took on the meaning "lamp" and finally "traffic light".

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Dialects are considered to carry a particularly high level of cultural content of a language. Changes in the lexis of this typically spoken register of languages are particularly interesting to capture and have been the subject of a wide range of diachronic and synchronic studies across various languages.

As regards the German language, historic projects from the 19th and early 20th century, e.g., the Wenker project (Fleischer 2017) or the Dictionary of Bavarian Dialects in Austria (WBÖ) (Stöckle 2021) have aimed at capturing the regional variation of local dialects by making an attempt at documenting the local speech of the population. Nowadays better known as citizen science, i.e., the participation of lay persons at different stages of the research process (Pettibone and Ziegler 2016), these historic projects have already then seen the participation of local populations as a key aspect to understand language usage and practiced early approaches to what is now known as citizen science. The Top Citizen Science (https://www.fwf.ac.at/en/funding/portfolio/communication/top-citizen-science) project "The ABCs of Dialect" (FWF TCS134) follows up on this and brings a historic non-standard language resource into the 21st century together with citizen science methodologies and digital technologies.

The project aims to transcribe, reflect and analyze the old manuscripts and dialect words found on the over 100-year-old paper slips of the WBÖ. At the basis of the project lies a large and rich collection, mostly collected in the first half of the 20th century. Founded in 1913, the aim of the dictionary project was to comprehensively document the richly structured Bavarian dialects of (historical) Austria. To this end, language material was collected over the following decades on the basis of 109 questionnaires with the help of volunteer collectors, which was to serve as an empirical basis for the dictionary. The questionnaire-based collections were supplemented by direct surveys carried out by trained dialectologists in the form of field trips and questionnaire surveys. In addition to the empirically collected data, excerpts were taken from dialectological literature and other written sources. In this way, it was not only possible to fill gaps in the lexicographic material, but older stages of Bavarian dialects were also included in the data collection. Fig. 1 shows an example of a paper slip from the data collection, depicting the lemma *abfetznen* ("to brawl") (Wahlmüller 2020).

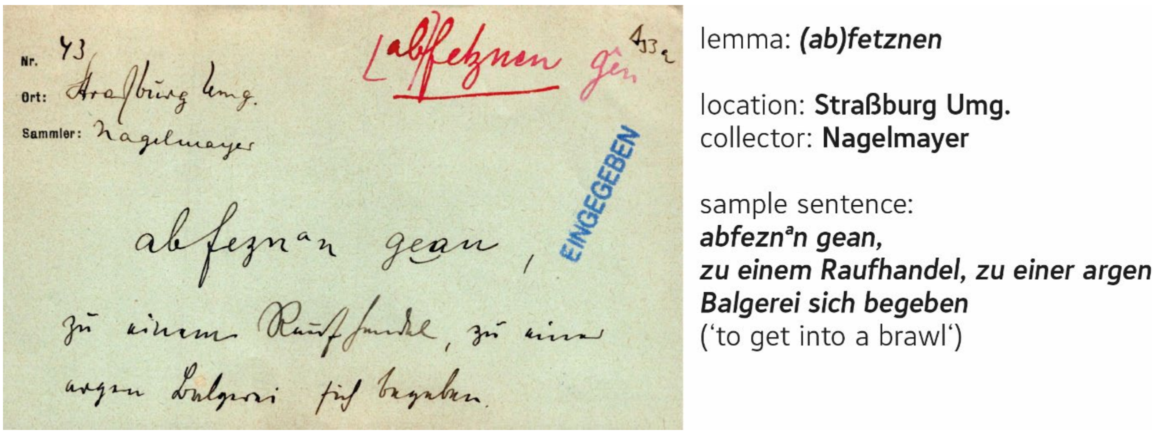

Figure 1. Example of a WBÖ paper slip on the lemma *abfetznen* "to brawl"

In addition to the lemma and information on the origin, this paper slip also contains a sample sentence illustrating the use of the lexeme. However, due to the empirical method which involved non-professional collectors, the type of information on the paper slips may vary considerably. While information on the origin and the lemma is available for most of the data, only a smaller proportion contains sample sentences. In addition, there is often information on the meaning, pronunciation or grammar.

In order to facilitate the work with the data and at the same time speed up the lexicographical work on the dictionary articles, a digital database was set up in the 1990s. As the first three volumes of the dictionary, covering the initial letters A, B/P and C, had already been published at this time, digitization (i.e., manual transcription) was started from the letter D onwards (Bowers and Stöckle 2018). Since December 2018, this database has been publicly accessible via the Lexical Information System Austria (LIÖ) (https://lioe.dioe.at/).

The project's main focus is to make a part of this rich and diverse non-standard language resource openly available to society and to fill people with enthusiasm for their own linguistic and regional heritage. In particular, the project aims to transcribe and reflect the paper slips ranging from letters A, B/P to C (hence the name of the project). This part of the collection comprises of over 400.000 paper slips which have to-date not been digitised. The historical language data is digitally processed, analyzed and made accessible via the Zooniverse platform, which is a popular crowdsourcing platform for a diverse range of citizen science projects (Van Hyning and Jones 2021), including projects on cultural heritage (Ridge 2020). A crowdsourcing approach enables more extensive editing and transcription of the materials, while in a special reflection section, citizens simultaneously reflect on and discuss the current use and meaning of the classified words. This combined approach of digital citizen science methods and reflections on individual language use makes it possible to demonstrate and analyze language change using old dialect words. To-date, the project counts over 1900 transcriptions and over 120 reflections of which over 60% show that the participants encountered the words in question for the first time.

One of the main challenges of the project lies in the range of diverse old handwriting systems used to note the German dialect words on the paper slips, including Kurrent script (*Kurrentschrift*) and Sütterlin, that are not in use any longer and that people nowadays also find increasingly difficult to read. Therefore, our project offers a range of supporting materials and aims to enhance data quality by having each paper slip transcribed by three participants. It also aspires to foster cross-generational participation, where younger persons who are typically more versed in handling digital tools like the transcription platform, and older persons who are typically more familiar with old handwriting systems, come together in analyzing and reflecting on their linguistic heritage. Additionally, pupils have also enjoyed learning new skills and old vocabulary in the context of the annual *Citizen Science Award*, organised by Austria's Agency for Education and Internationalisation (OeAD) (https://youngscience.at/de/awards-und-guetesiegel/citizen-science-award) where school classes, families and individual persons can participate in a diverse range of citizen science projects. While the pupils' (ages 15 and up) transcriptions tend to be less accurate – as they are not used to reading a lot of different handwritings anymore – they usually contribute more data to the project than other people by motivating and/or challenging each other.

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Change – The transformative power of citizen science

"A song all about AI": a musical exhibition booth to foster artificial intelligence literacy

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Abstract

In a participatory project to improve general artificial intelligence (AI) literacy, we worked with citizen scientists, artists and AI experts to collect pressing questions about AI and to answer them creatively. The result, created in collaboration with the singer-songwriter "Blonder Engel", was "A song all about AI", written in Upper Austrian dialect in order to reach a target group that differs completely from that of English-language specialist publications on AI. To add interactive elements and to address a wider audience, we used the song and its music video as a starting point for developing a participatory exhibition booth that debuted at the ECSA 2024 Citizen Science Day. Results gathered at its first outing show that it is a successful means both of interactive, art-based science communication and of collecting data on a diverse audience's AI awareness.

Keywords: art and science, citizen science, human-AI interaction, music, open innovation in science, participatory science, science communication.

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Introduction

Whether we like it or not, artificial intelligence (AI) is here to stay and affects us all, making it essential that as many people as possible gain a basic understanding of it – "AI literacy" (Long and Magerko 2020; Ng et. al. 2021) –, which in turn raises the question of how to achieve this.

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The LIT Robopsychology Lab researched this in a participatory process: Within the project “How to explain AI”, we worked with 20 citizen scientists, AI experts and artists as co-researchers. Together we explored questions on the subject of AI in everyday life and how to answer them creatively (Meyer et al. 2023). The results: a collection of questions about AI, a wealth of answers, and a particular form of knowledge communication: “A Song all about AI” (original title: “A Liadl, ans üwa KI”), created in cooperation with the singer-songwriter “Blonder Engel.”

The song was written in Upper Austrian dialect and therefore speaks to a completely different target group than English-language specialist publications. However, for those who do not understand this dialect, to whom this particular style of music does not appeal or who cannot hear music, the ability of this song to foster AI literacy is limited. We thus used the song as a basis for further work on encouraging broad and diverse exchange on AI.

Approach: A participatory exhibition booth

The song resulting from the participatory project conveys the questions and topics collected with the group of citizen scientists. A single song can neither reach everyone nor address all the questions and explanations around a complex topic such as AI. It can, however, encourage people to think about the topic, to exchange ideas and to engage with it further. The song is therefore ideally suited to (i) interactive, art-based science communication and (ii) triggering collection of further, more diverse qualitative data on citizens‘ opinions, observations, knowledge and ideas about AI.

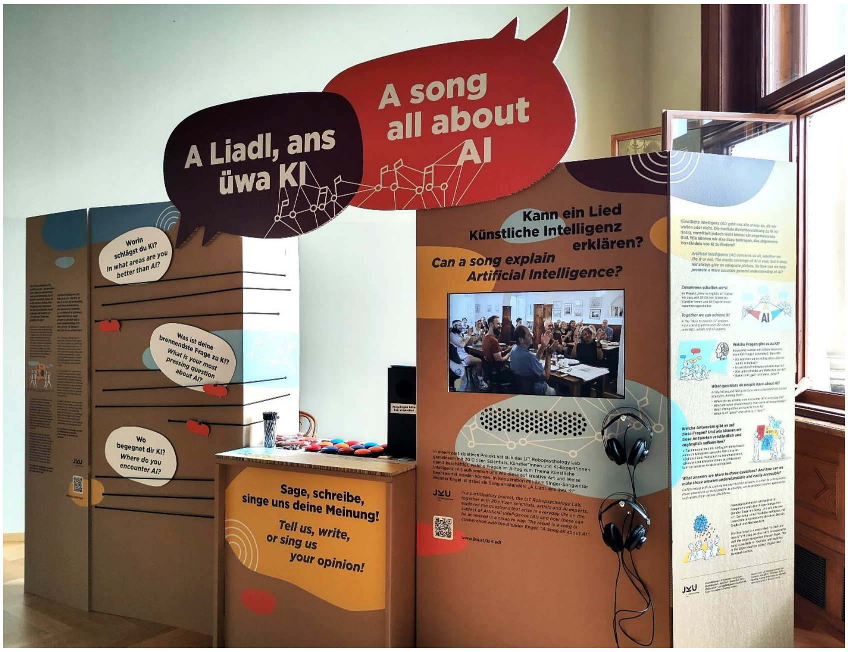

Figure 1. The participatory exhibition booth

The exhibition booth (Figs 1, 2) offers various possibilities to delve personally into the topic of AI in daily life:

- listen to the song via loudspeaker or headphones and watch the music video with subtitles in Upper-Austrian dialect, German or English
- leave a voice note by pressing a voice button
- listen to voice notes left by others
- answer the impulse questions in writing on a card and attach it to the interaction wall (Fig. 2)
- read other people's contributions
- take away a copy of the lyrics in Upper-Austrian dialect, German or English
- fill in gaps in the lyrics to formulate one's own thoughts
- take a sticker showing a quote from the song and a URL linking to more information
- discuss own questions or opinions with a member of the team
- read background information on AI literacy and the participatory project behind the song

These forms of interaction were designed to be simple and low-tech in order to avoid additional barriers to engagement with the complex and technical topic of AI: Pen and paper are very common, and the voice buttons are easy to use.

The questions in the big white bubbles on the left side of the booth (Fig. 1) are exchangeable and chosen from a pool of seven impulse questions in both German and English. Each relates to a specific part of the song, e.g.:

- In what areas are you better than AI?
- What is your most pressing question about AI?
- Where do you encounter AI?
- What price do we pay for AI?
- What should everyone know about AI?

Results of the booth's debut

The ECSA 2024 Citizen Science Day in the Natural History Museum Vienna (April 6, 2024) brought a wide audience to our exhibition booth: persons of all ages, some coming alone, some in groups, some particularly for the event, some just for the museum. Below we present an overview of their participatory contributions (Fig. 2).

Figure 2. Participation at the Citizen Science Day

Written contributions

In total, 27 cards were pinned to the interaction wall. Answers were written in both German and English. For this paper, we translated all contributions into English. All questions and answers are published on the project website.

Answers to the impulse question: In what areas are you better than AI?

- Making friends
- Diversity
- Humor
- Organization
- Cycling
- Laughter
- Critical questioning
- Personal hygiene

- Love
- Discursive thinking
- Sport
- Cooking
- Emotion
- Transferring “old” knowledge to a new context
- Creative areas such as: writing/photography

Voice contributions

In total, seven voice contributions were recorded by visitors. Some contained single words, others longer statements of the visitor’s personal perspective on AI, one a verse of the presented song in another language and one a performance of a visitor’s own made-up song about AI.

Personal discourse

At all times, members of our team were available for questions and discussions. As expected, this proved to be a very important part of the exchange on the topic. Some visitors became involved in conversation and then captured their thoughts as notes on the interaction wall or as voice recordings. Some listened to the song first and then engaged in discussions with us.

Classification of the results

The number of contributions from this first outing does not yet suffice for a sound evaluation of the covered topics. However, a favorite question to which people related the most emerged, both in written and spoken contributions as well as conversations: “In what areas are you better than AI?”. This question addresses the differences between humans and AI and was of particular concern to many in the prior participatory process as well. In respect to AI literacy, it is important for people to realize they have abilities that AI does not have.

Conclusion & Outlook

In the process of the underlying project the citizen scientists defined the requirement to develop an interactive intervention. The song has its advantages: It is available online and can be consumed and used as often as desired, regardless of time and place. However, it is not interactive. The debut of the participatory exhibition booth showed it to be an effective addition to the song, fostering interaction and personal, on-site engagement. The interaction and discourse with the visitors demonstrated that – as intended – the booth works well both for art-supported science communication and for collecting qualitative data on a diverse audience’s level of knowledge about AI.

The results affirm our intention to continue using the exhibition booth at further locations with various audiences. The data will be published on the project website and analyzed in terms of the most frequently represented topics. Over time, the contributions of those who engaged with the booth enrich the song for a diverse exchange on AI.

Acknowledgements

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Change – The transformative power of citizen science

The MLE CS responsible and inclusive scalability toolkit

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Abstract

This paper presents the Scalability Toolkit developed in 2021–2023 within the "Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice" to provide a theoretical and methodological framework to support the scaling of CS projects and initiatives responsibly and inclusively.

The Toolkit is made of three components: i) a multidimensional qualitative definition of scalability, ii) an operational scalability matrix composed of four models (scaling up, out, deep and down) and two approaches (top-down and bottom-up), and iii) eight action areas for policy making.

Building on this work, further research as well as a cultural mind shift is needed to further develop value-driven scalability models in CS according to more qualitative and ethical dimensions, the specific logic of CS projects as well as their domain and context dependency.

Keywords: citizen science, policy, practice, upscaling, scalability, sustainability, open science.

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Introduction

This paper presents the Scalability Toolkit developed in 2021–2023 within the "Mutual Learning Exercise on Citizen Science Initiatives – Policy and Practice" (hereafter indicated as MLE CSI-PP). The MLE CSI-PP project was initiated by the DG Research and Innovation as part of the Policy Support Facility to focus on five specific and operational R&I topics related to citizen science (CS) with eleven EU countries participating in the MLE CSI-PP.

The Scalability Toolkit stems from Topic 5 of the MLE CSI-PP which focused on scaling up CS and aimed at filling a gap of knowledge about success factors and challenges for scaling up CS projects as well as generating insights on CS infrastructures and funding developed across Europe in support of upscaling CS.

A literature review conducted in 2022 showed that only a few CS studies addressed the topic of scalability/up-scaling CS projects (i.e., Maccani et al. 2020, Maturano 2020), and that there was a lack of consensus on the meaning of scalability as either underexplored or used inconsistently as a synonym of spreading or replicating (Maccani et al. 2020). It furthermore showed limited knowledge about success factors and challenges for scaling up CS projects, apart from the 9-Drivers framework developed in a study supported by the Joint Research Center of the European Commission (Maccani et al. 2020).

Despite the «Scaling Ambition» of successful CS projects and initiatives developed across Europe in the past years (Maturano 2020), questions about what scalability means in CS, how to measure it, and how to scale CS projects and initiatives were still under-investigated in the field of CS.

Methods

Considering the limited literature on the topic, a mixed-methods approach was applied to address the open questions mentioned above. It consisted of i) literature review, ii) interviews with seven experts in the field of CS and related disciplines, iii) a survey distributed among the participants in the MLE CSI-PP project and iv) three focus groups run during a 2-day workshop held in 2022 in Berlin with the project team and external stakeholders (Fig. 1).

Further details about the mixed-methods approach can be found in the Discussion Paper which was prepared as a baseline study for the participants in the Berlin workshop (Radicchi et al. 2022). The knowledge generated through the three focus groups held during the Berlin workshop was analysed through qualitative content analysis and leveraged to produce the Thematic Report, which includes the Scalability Toolkit (Radicchi et al. 2023).

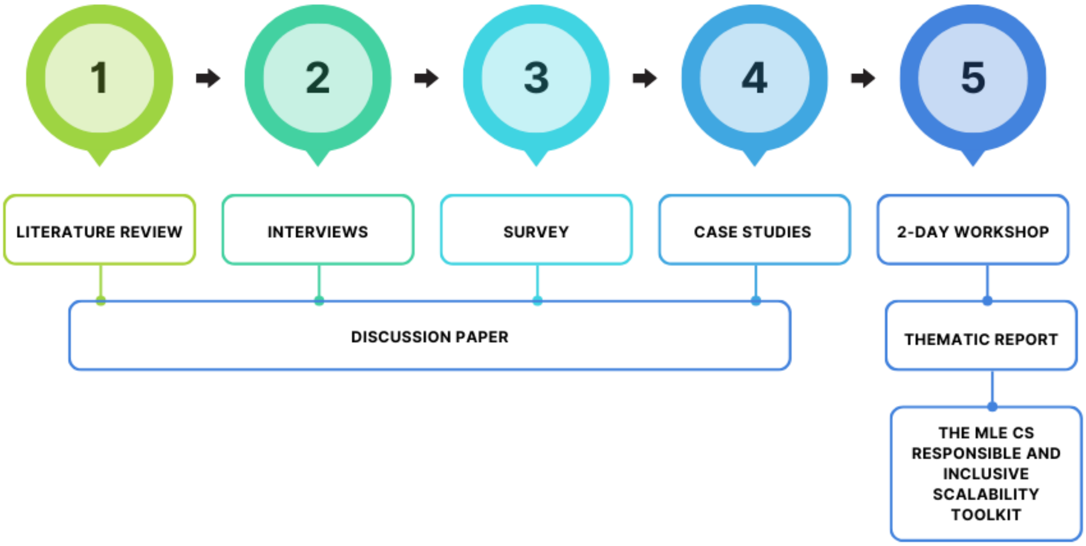

Figure 1 illustrates the mixed-methods methodology and outputs underpinning the development of the MLE CS Responsible and Inclusive Scalability Toolkit (image © Antonella Radicchi 2024, presented during ECSA24 conference)

Results and Discussion: The MLE CS Responsible and Inclusive Scalability Toolkit

The MLE CS Scalability Toolkit offers a theoretical and methodological framework to support the scaling of CS projects and initiatives in a responsible and inclusive way.

This Toolkit is made of three components: i) a multidimensional qualitative definition of scalability, ii) an operational scalability framework and iii) eight action areas for policy making. These three components are summarised below and further described in (Radicchi et al. 2023).

It became evident in the MLE CSI-PP project that it is important to move beyond quantitative definitions of scalability, which refer to rapid growth in the size of the number of participants or the geographical area covered (Maccani et al. 2020). Conversely, we argue that (up)scaling should be (re)defined according to more qualitative, inclusive and responsible dimensions, the specific logics of CS projects and initiatives as well as their domain and context dependency.

Following the logic of a qualitative, inclusive and context/domain-specific definition of scalability, four models and two approaches to scalability were identified (Fig. 2) building on systemic social innovation scholarship (e.g., Virani 2015) and the collective knowledge generated through the three focus groups (Radicchi et al. 2022; Radicchi et al. 2023).

These four scalability models (scaling up, out, deep and down) and the two approaches (top-down and bottom-up) are to be intended as not mutually exclusive. They are briefly explained in the following and in greater detail in (Radicchi et al. 2023).

The “scaling up model” refers to institutional changes achieved through the upscaled CS projects/initiatives, which can become an integral part of a policy or an approach within a given institution or lead to policy and/or legal changes. The “scaling out model” is mainly quantitative and refers to the replication and dissemination of CS projects/initiatives according to specific dimensions such as the geographic and the temporal spread, the research scope, the communities engaged, the amount of data collected, and the technology/methodology deployed. The “scaling deep model” is primarily qualitative and refers to CS projects that have an impact on cultural changes and beliefs such as trust in science by the citizens and trust in CS by the scientists. The “scaling down” model refers to quantitative change at the level of de-growth which can occur in relation to the geographic/temporal spread, the communities engaged, the amount of data collected, and the technology/methodology deployed, with the ultimate goal to remain aligned to the projects’ logic and aims.

Top-down approaches imply a deliberate (political, scientific or science engagement) strategy to upscale a certain project (see, e.g., the Plastic Pirates project), whereas in the case of bottom-up approaches the scaling is more organic and fostered by grassroots movements with support from local stakeholders (see, e.g., the OpenStreetMap project).

The MLE CSI-PP project was meant to generate knowledge to inform CS policy and practice. During the Berlin workshop, one of the focus groups was dedicated to the discussion of scalability in CS for policy-makers willing to support the responsible and inclusive scalability of CS projects. From the analysis of the data generated by the participants in the focus group, eight action areas were identified. They revolve around the need to i) rethink the meaning of innovation and scalability and ii) foster and support responsible and inclusive scalability approaches through ad-hoc funding programmes and evaluation criteria. These action areas are further described in (Radicchi et al. 2023).

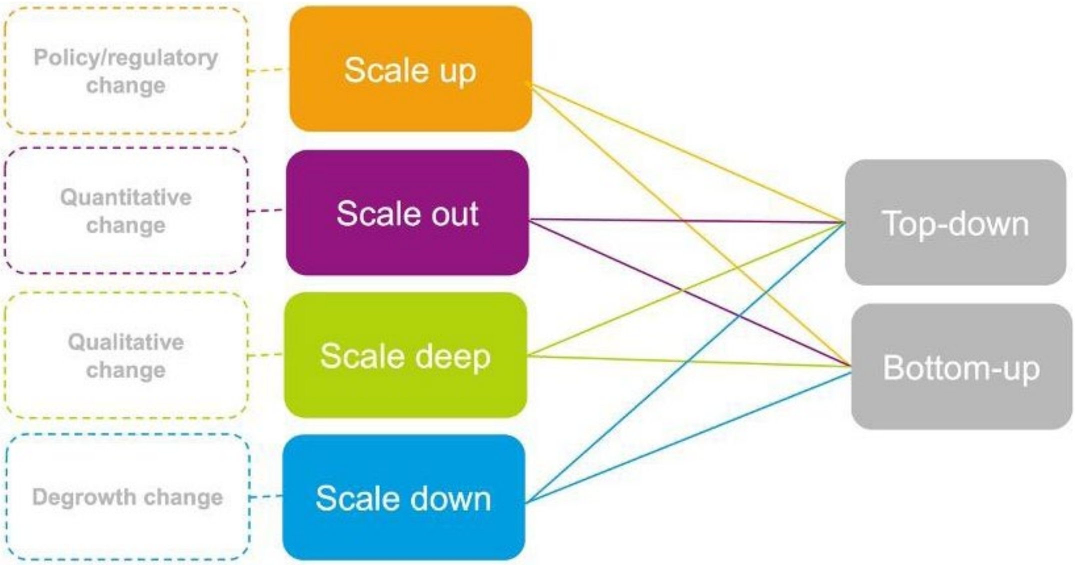

Figure 2 illustrates the four models and the two approaches to scalability in CS which compose the MLE CS Responsible and Inclusive Scalability Framework (image © Antonella Radicchi 2024 presented during ECSA24 conference)

Conclusions

The MLE CS Scalability Toolkit supports inclusive and responsible scalability in CS.

Building on this work, further research as well as a cultural mind shift is needed to further develop value-driven scalability models in CS beyond the profit-driven logic underpinning entrepreneurial innovation. Along these lines, it's encouraging to see novel EU projects currently underway (such as IMPETUS, OTTERS, ScienceUS and Crops) that aim to further explore the topic of scalability in CS in support of social, cultural and environmental innovation and responsible changes.

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Change – The transformative power of citizen science

Science for change tools: the new methodological toolbox to create zero-waste collaborative workshops

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Abstract

Collaborative practices are more common every day in contexts where citizens of different backgrounds need to be involved in science and decision-making processes. These practices often translate into co-creation workshops, in which we find two main issues to address. First, the lack of an expert to guide the sessions and second, the quantity of consumable material that is used in these activities. In order to address these two issues, we have carried out an experimental study in 22 citizen science projects that has brought us to develop a sustainable toolbox for collaboration. This paper summarizes the experience of presenting and testing the toolbox with citizen science experts at the ECSA Conference 2024.

Keywords: co-design, collaboration, methodology, participation, sustainability, toolkit, citizen science.

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Introduction

In the interdisciplinary world we live in, collaboration is on the rise. Design thinking, co-creation and co-design practices represent an opportunity for constant improvement and innovation. They promote joint decision-making, the balance of power among participants, and the use of multidisciplinary knowledge to achieve a specific goal (Knight et al. 2020). Characteristics that are very needed in citizen science projects.

These projects are very common in academic contexts (Guasch et al. 2020). Co-creation is used to carry out group projects, add diverse knowledge, detect common challenges, find synergies, experiment

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together, analyze, summarize, and many other processes that serve both to transmit, understand and assimilate knowledge.

We can also find collaborative practices for citizen science both in the private and in the public sectors, where these types of activities are used to reach and listen to citizens (Ansell and Torfing 2021; Guasch et al. 2019). Both companies and institutions often need to know the needs and opinions of the general public. This is why co-production sessions are usually organized to find strategies to identify and face social, environmental and health challenges.

Finally, on many occasions it is necessary to involve all the aforementioned audiences and others, such as the media, to reach consensus on issues that affect them all (Magalhães et al. 2022; Matozinhos et al. 2022).

In the context of all these activities, we have observed two main problems. On the one hand, the lack of training in session facilitation and moderation by the people responsible for the workshops. On the other hand, a lot of consumable material is used for each session. In order to address these two issues, we have developed and are now testing a new methodological toolbox: Science For Change Tools (SFC Tools). This is the first time that the logic and the development process behind the toolbox is presented.

Methods

The workshop carried out during the ECSA Conference 2024 consisted of four main parts: (1) an icebreaker, (2) a presentation about the toolbox, (3) a hands-on exercise, and (4) a questionnaire.

For the first part, the icebreaker, the room facilitator asked four questions to the participants, which they were asked to answer using the materials they had on the table (Figure 1). They were asked to choose the color that best suited their answer: green for totally agree, yellow for partially agree, orange for partially disagree and red for totally disagree. The questions were related to their experience with collaborative workshops.

These questions brought us to the second part of the session: the presentation of the toolbox. In this part, we introduced the four ideas on which the toolbox is based: the idea of a puzzle, the idea of something

Figure 1. SFC Tools hexagonal shapes and participants at the table.

that can grow in all directions, the hexagonal shape, and the sticky note. We also talked about the philosophy of thinking with our hands so that everything that is spoken in a workshop remains written down. After this, we introduced the five prototypes that we have developed so far and the different arrangements that can be done using the hexagonal shapes.

Then, we moved on to the hands-on exercise. This consisted of presenting a case study and working on the five phases of the design thinking process: (1) empathize, (2) define, (3) ideate, (4) prototype, and (5) test. In the phase of empathizing, participants were asked to select a topic and a public within the case study, and build a bridge of needs between these two. In the phase of defining, they were asked to group the needs by similarity and put a title to each group of needs. In the ideation phase, they were asked to propose solutions around the groups of needs. In the prototyping phase they were asked to choose one of the solutions they proposed and answer the questions: What? Why? Who? Where? When? How? Finally, the testing phase would be done after the end of the workshop.

To finish the session, we did an online questionnaire using the Slido platform. We asked participants the following questions: (1) Can you share your first impressions of the toolkit with us? (2) How likely is it that you would use the kit in your professional and/or academic environment? (3) On what occasions and for what purposes would you use it? (4) What material would you produce the pieces from? (5) How much would you pay for the whole pack? (6) How would you describe SFC Tools in a word?

Results

In the icebreaker, we discovered that participants were not very familiar with designing collaborative workshops, but they were quite familiar with facilitating them. They were very familiar with participating in them and it was very likely that they would only think of post-its when envisioning these types of activities. About half of them had thought about what happens to the materials after the sessions, and the other half had never thought about that.

Figure 2. Resulting map of the hands-on exercise of one group.

In the hands-on exercise (Figure 2) participants came up with many needs and solutions for the topics and publics within the case study. Since the goal of this workshop was having participants experiment with the toolkit, we are not deepening the content of their proposals.

The actual results of the session for us were the answers given in the questionnaire, which are displayed below:

(1) Can you share your first impressions of the toolkit with us?

- Love the inclusive design.
- I like it a lot. Once you know the rationale behind it, even more.
- Love the inclusivity of the colors/patterns. More sustainable/biobased materials would be better.
- Cool - need to work a bit more to understand better.
- Fun.
- Love the shapes, colors, symbols!
- Fascinating.
- I love it!
- Playful
- Awesome!

(2) How likely is it that you would use the kit in your professional and/or academic environment?

- 75% very likely.
- 13% quite likely.
- 13% neutral.

(3) On what occasions and for what purposes would you use it?

- During the next community of practice, climate assembly deliberation.
- Collaborative workshops with my team, consortium partners, in Citizen Science projects, conferences, etc.
- Workshops, but also simple meetings with my colleagues.
- Co-design a survey with participants.
- Internal planning/brainstorming, workshops with researchers or stakeholders (adults).
- Planning research group strategy.
- I don’t know yet.
- For co-creation sessions, with colleagues, with kids in citizen science projects.
- Teaching at the University.

(4) What material would you produce the pieces from?

- Wood - 0%.
- Plastic - 14%.
- Other - 86%. They proposed cork and corn.

(5) How much would you pay for the whole pack?

- 43% would pay 25-50€.
- 43% would pay 50-75€.
- 14% would pay +100€.

(6) How would you describe SFC Tools in a word?

- Insightful, intuitive, inclusive, multifunctional, exciting, magic, easy, hexagons, innovative.

Conclusions

This workshop revealed new insights for the development of the physical reusable materials included in the SFC Tools methodological toolbox. On the one hand, we verified that the toolkit is well received by an audience that is very familiar with collaborative tools and activities in the field of citizen science. On the other hand, we discovered that the material of the hexagons was criticized and new options were given to develop the final ones.

Next steps include the testing of new materials for the hexagons, and the development of the digital part of the toolkit to complement them.

Acknowledgments

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Change – The transformative power of citizen science

Game on: exploring game-based tools for citizen engagement in climate research and policy

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Abstract

The climate crisis requires far-reaching changes which need to be supported by citizens and policymakers alike. New methods of public engagement are necessary to transform the public's needs into actionable knowledge. Games offer potential for engagement through their central role in contemporary culture, allowing citizens to experience the policy process and voice their concerns. The EU-funded project GREAT involves citizens and policy stakeholders as players and co-researchers to explore new formats of political participation regarding climate change. In a series of workshops, local actors have been engaged in distinct phases of the research process: the exploration of current climate issues and the definition of research questions, transferring these issues into a collaborative serious game, and the analysis and interpretation of the data collected during the execution of the game. An initial review of the methodical approaches implemented with policymakers and citizens reveal potential, but also several limitations and challenges encountered in the engagement process. Our initial analysis confirms the potential of game-based approaches for citizen participation and engagement with climate change and their transferability to other social issues. These experiences demonstrate how the ever-growing cultural role of games could be leveraged for supporting the changes necessary to address societal challenges.

Keywords: engagement, citizens, games, participation, climate change, policy.

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Introduction

Successfully addressing societal challenges like the climate crisis requires a facilitated dialogue across all stakeholders and a stronger involvement of citizens in climate policy (Kythreotis et al. 2019). Identifying the main concerns of citizens and their communities should form the basis of this dialogue, in addition to jointly developing new understandings and solutions.

Such a process of co-producing new knowledge is a core part of the methodology of Citizen Science (Kythreotis et al. 2019). Contributory approaches to citizen science often intend an observational role for citizens consisting of data collection (Kythreotis et al. 2019, Albert et al. 2021). In contrast, participatory approaches and citizen social science emphasise the inclusion of non-researchers in all research phases as well as the consideration of social concerns (Albert et al. 2021, Kieslinger et al. 2022). As the climate crisis is one of the most pressing social concerns, public engagement in the research and policy process can play a crucial role for effective action.

In practice, several barriers stand in the way of citizen engagement in climate research and policy (Ianniello et al. 2019). Public engagement processes often reach only the small portion of already engaged citizens. As these participants do not necessarily represent the wider public or underrepresented groups, engagement processes and their influence on policies may be characterised by power imbalances. Furthermore, public engagement processes are often not evaluated, resulting in an incomplete evidence base to assess their benefits and limitations.

These issues call for further research and new methods for citizen engagement, particularly on complex and multi-layered issues such as climate change (Kythreotis et al. 2019). Game-based approaches offer new avenues by using role-play, points, and narratives for promoting engagement with climate change and policy dialogue (Fernández Galeote et al. 2021).

In the EU-funded research project GREAT (https://www.greatproject.gg/), we leverage the central role of games in contemporary culture to promote citizens' reflection and expression regarding climate change. The project involves citizens and policy stakeholders throughout a game-based research process, including co-creation of research topics, co-design of game approaches, and co-analysis of data. We report on participatory activities implemented to collaboratively develop a dilemma-based game (see https://dibl.eu/ for a description of the platform used). In this contribution, we focus on the implemented activities and reflect on the first experiences from this participatory process. The project tests a dilemma-based game approach for qualitative and a quiz-based approach for reaching large audiences.

Methods

We have integrated participatory formats along an 8-step cycle for game-based research established as part of the GREAT project. The research cycle represents a logical sequence of steps guiding the implementation of a game-based research tool (see Fig. 1). We implemented 14 participatory workshops with a total of 84 participants along four steps of this research cycle.

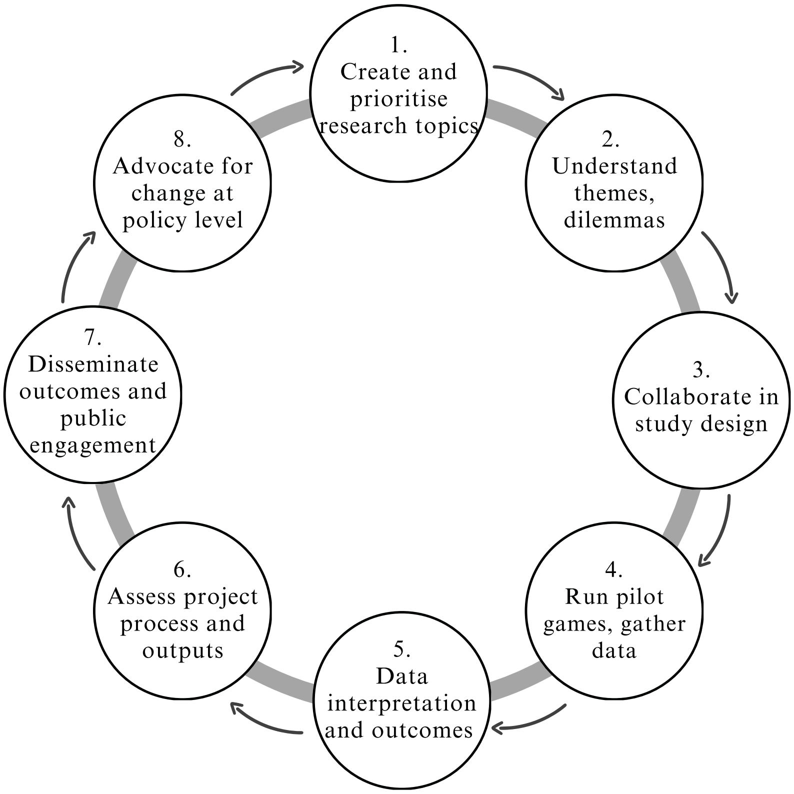

Figure 1. 8-step research cycle

Three types of participants were involved: firstly, external stakeholders engaged in local climate policies, secondly, participants from within GREAT organisations but not directly involved in the project, and thirdly, researchers involved in the project. Step 4 is not included here as we did not collect participatory data at this stage.

The workshop activities are summarised in Table 1. They were documented through audio recordings or written notes and in standardised templates. The documentation and extensive reflections among workshop facilitators form the basis for results and conclusions.

Table 1. Overview of workshops.

Research cycle step (Fig. 1)	**Step 1**	**Step 2**	**Step 3**	**Step 5**
Participants	5 workshops involving policymakers, (university) students, NGOs	4 workshops involving policymakers, (university) students, NGOs, project partners	3 workshops involving project partners, NGOs	2 workshops with researchers and university students
Activities	Preparatory individual interviews, voting, structured group work, and open group discussion	Group discussion, group work, skills training	Interactive training session for using the game platform and game design	Interactive workshop and group discussion with social science data and climate data

Results

Step 1 explored local climate issues with stakeholders. We experienced a trade-off between time-intensive open group discussions and short structured formats, e.g. timed discussions and decision-making. While the first allowed in-depth explorations of the topics, the shorter formats were more efficient but lacked depth. Moreover, participants with their own agenda (i.e., the environmental NGO) achieved more focussed outcomes and could be retained for subsequent steps.

Step 2 aimed to translate the most relevant climate issue into themes for a game, define expected results, and identify relevant target groups. Retaining participant engagement was challenging, as policymakers showed limited commitment due to a lack of immediate relevance. Workshops with students who similarly saw no immediate relevance benefited from a more structured and directed approach compared to the open discussion and ideation formats used with policymakers. In turn, participants with their own agenda showed stronger involvement in influencing game themes according to their interests.

Step 3 focussed on the co-design of the game itself. This step was mostly conducted with project team members as only one participant group from the earlier steps was interested in being further involved. Participants contributed to the study design by defining target groups, game scenarios, and evaluation methods, resulting in a clear game and study design strategy.

In step 5, we piloted collaborative data analysis with two participant groups: university students and social scientists. The workshop with university students used graphs depicting climate change data (available at https://climatedata.imf.org/pages/climatechange-data), which prompted a discussion on climate issues and policies. The workshop with social scientists introduced an external survey dataset on climate policies. Collaborative data analysis with a statistics software revealed limitations of the survey methodology and the data. This suggests that participants' skills can strongly influence the focus of data analysis and interpretation.

Discussion

Our pilot activities showcase the potential of participatory engagement in developing game-based tools to address climate change. The game-based research process offered multiple opportunities to involve various stakeholders in discussions about climate change and in the design of the study. However, we also encountered several challenges. Engaging stakeholders beyond the first step proved challenging without a clear need. The participatory formats showed an engagement gap, whereby researchers and policymakers are compensated but citizens volunteer their time. Expectations and time management are thus crucial. Transforming participants' concerns into the logic of our game-based approach was also challenging, especially with limited participant commitment. This may increase the researchers' dominance throughout the participatory process. Relatedly, we could not engage stakeholders further in step 4 of the research cycle which prevented participatory activities or data collection with the game-based tool in this stage. Finally, data sprints may pose difficulties for those unfamiliar with data. To be effective with diverse participant groups, data sprints require thorough preparation, knowledge of the data and participants' needs, and effective visualisations by facilitators.

Conclusion

Our approach seems promising but requires more experimentation and reflection, especially with participants engaged throughout the whole research cycle. During the GREAT project, we plan to conduct at least 12 case studies across different topics related to climate change and respective policies, offering ample opportunities for citizen and policy engagement. In these future case studies, we plan on conducting further participatory activities for all steps in the research cycle, e.g., data collection. Finally, we see a potential for the transferability to other societal challenges, e.g. related to SDGs.

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Change – The transformative power of citizen science

Rethinking impact assessment in citizen science

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Abstract

Why are people still struggling with effectively demonstrating the wide and diverse impact of their citizen science activities? After many years of developing impact assessment frameworks, models, and guidelines it seems that capturing the manifold effects of citizen science on individuals, communities and our society at large is still a challenge. Considering the richness and diversity of participatory research in citizen science that often spans across disciplines and offers engagement at various levels it is obvious that there is no one-model-fits-all approach for impact assessment. However, it is important to provide evidence for the achievements, also in the longer term, from the project actors perspectives and from the funders view. The focus session during the ECSA2024 conference aimed to have a close look at the current challenges citizen science actors are facing when planning and conducting their impact assessment. To dive deep into the problem and discuss user-oriented solutions we applied a design thinking method. The full day session revealed several challenges that were clustered around 5 topics, namely: timing, methodology, stakeholders, planning, and ethics. The 5 personas created around those challenges gave deeper insights into the issues and creative solutions, including platforms, prizes and spaces for more exchange on impact assessment were prototyped. Many participants expressed their interest in joining an ECSA working group on impact assessment in citizen science to keep working on the topic.

Keywords: impact assessment, evaluation, design thinking.

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Introduction

Over the years, considerable effort has been dedicated to illustrating the multifaceted nature of citizen science and its potential impact on individuals, communities, and society. Various endeavours have been made to conceptualize the process through frameworks and to furnish guidelines and tools, exemplified by those employed in European-funded projects like MICS (https://mics.tools), ACTION (https://actionproject.eu), IMPETUS (https://impetus4cs.eu), or ECS (https://eu-citizen.science/ecs_project/). The implementation of these impact assessment methods has yielded some success in showcasing the influence of citizen science across domains and thematic areas. Consequently, citizen engagement has garnered recognition as a valuable approach in Research and Innovation (R&I) policies, spanning from the UNESCO Recommendations on Open Science (UNESCO 2021) to the OECD's guidelines on transdisciplinary research (OECD 2020) and the mission-oriented approach adopted in Horizon Europe (European Commission 2023).

Practically, the community has developed both qualitative and quantitative metrics to furnish evidence of impact across different levels and stakeholder groups. However, numerous initiatives still encounter difficulties in impact assessment due to a disconnect between the intended measurements of our models and the practical implementation within project contexts. Challenges include the temporal aspect of impacts often extending beyond project lifetimes, as well as the complexity of collecting evaluation data from diverse stakeholder groups, constrained by time, resources, and engagement.

These challenges resonate across all stakeholders, encompassing project owners and implementers, academic researchers, citizen scientists, funding agencies, and administrators alike. Our collaborative working session at the ECSA2024 conference aimed to critically assess the current methodologies and their challenges for bringing evidence for the societal impact of citizen science and to explore avenues for transcending the mere collection of key performance indicators (KPIs), storytelling, and the crafting of policy briefs that often go unread.

Methods

The focus session format was suggested by the conference organisers as an experimental 4.5-hour format (divided by 2 breaks after 1.5 hours each) dedicated to a specific topic proposed by the focus session conveners. This specific focus session was designed for participants to work in a highly collaborative manner, applying design thinking methodologies. According to some guidelines, in design thinking almost 80% of the whole process is spent on analysing the problem (Pferzinger et al. 2020).

Thus, the focus session began by exploring the problem of impact assessment in citizen science in detail and developed a set of Point of Views (PoVs), which would go deeper into understanding the issues. Personas were co-designed for a detailed problem analysis and to exemplify the PoVs. In a final step the participants were brainstorming and prototyping new ideas and solutions.

To ensure a truly multi-stakeholder perspective, statements from conference participants were also collected during breaks and networking opportunities. The structure of the focus session was guided along three parts (Fig.1).

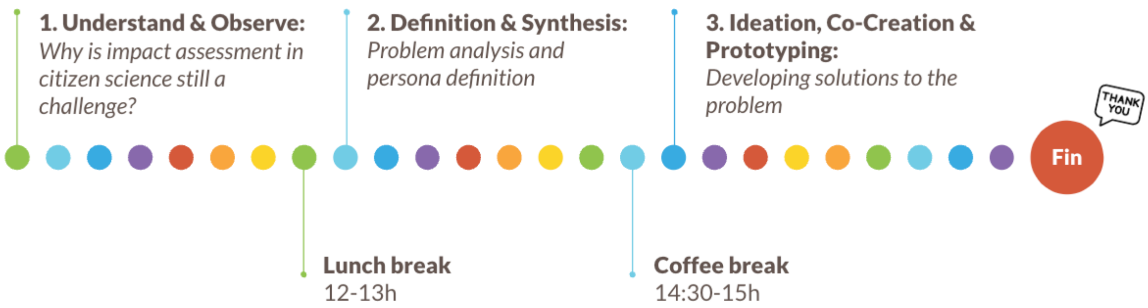

Figure 1. Focus session approach

Results

Part 1: Understanding and Observing Challenges in Impact Assessment

The inaugural segment of our focus session delved into the diverse array of problems and obstacles surrounding impact assessment. Participants contributed insights from various perspectives, culminating in the identification of five major challenge clusters:

1. Methodological Challenge: How can we develop a flexible and modular "cookbook" for evaluation and impact assessment in citizen science?
2. Ethical Challenge: What strategies can ensure inclusivity, non-invasiveness, and non-extractiveness in impact assessment practices?
3. Time Challenge: How do we address temporal constraints in impact assessment, such as capturing impacts that may occur post the conclusion of a citizen science initiative?
4. Stakeholder Challenge: Whose impacts are we assessing, and who should participate in the assessment process?
5. Planning Challenge: How can we effectively plan impact assessment within dynamic participatory processes where goals and activities may evolve over time?

Part 2: Defining Personas and Synthesizing Challenges

Building upon the challenge clusters identified in the first session, participants in the second session delved deeper into problem analysis by crafting Personas representing distinct challenges. Personas can be understood as fictional characters embodying various perspectives, which aid in understanding our community's needs, experiences, and behaviors. In the description of the Personas we elaborated each challenge into a comprehensive PoV.

Figure 2. Workshop outputs (2a: personas; 2b: prototypes)

Meet Mathilde, Charlie, Ximi, Fabio, and Hydra, who stand for the five challenges identified previously (Fig. 2a): Mathilde is a researcher struggling for her recognition and in search of creative ways of showing impact, which she wants to co-define with her research participants. Fabio the funder understands her needs but is himself bound to internal KPIs of his funding agency and needs to deliver standard quantitative success indicators from the project he is responsible for. Ximi and Charlie are citizen scientists. While Charlie is frustrated by the timeframe of the citizen science project they are very actively engaged in and wants to see change right away, Ximi has an activist attitude and feels that he his left out from the impact assessment in the environmental project he is contributing to. Finally, Hydra is an early career researcher, who co-designed an evaluation method that is not well accepted by mainstream evaluation academics but finds it important to include her stakeholders in the design of the whole evaluation process.

Part 3: Ideation, Co-creation, and Prototyping Solutions

In the final session, participants were tasked with a creatively stimulating endeavor. Working in groups, they brainstormed potential solutions to assist the Personas in addressing their challenges. To foster creativity, solutions were presented through Play-Doh prototypes (Fig. 2b), sparking imaginative thinking and collaboration among participants. The prototypes were revealing a variety of ideas: e.g. an AI-bases decision support system to select the most appropriate evaluation strategy and method; spaces for exchange and sharing of experiences in impact assessment; a citizen science impact prize and a recognition system for local champions.

Discussion

As the strong interest and good participation has shown, there are clearly many challenges related to impact assessment in citizen science. The variety of issues raised in the first part led to the five clusters that were elaborated in more detail in the following sessions. However, the collection of issues was even wider and a few more clusters could have been formed, such as capacity building or specific contextual constraints and how to deal with them.

Reflecting on the method itself, we noted that overall, the process was perceived as engaging and informal feedback from participants was very positive. However, we encountered some challenges along the way. For example, organizing a full day session in the context of a conference is demanding for the organizers and participants, as participants may not be able to dedicate a whole day to one specific topic.

Conclusion

In the end, participants collaboratively worked on current challenges and strategies for impact assessment of citizen science. The intense discussions and the interest expressed by most participants clearly revealed that there is appetite for a more intense and dedicated exchange about the topic. An ECSA working group will thus be initiated.

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