INTEGRATING OPEN AND CITIZEN SCIENCE INTO
ACTIVE LEARNING APPROACHES IN HIGHER EDUCATION

Academia permeating society through Citizen Science
Use cases of engagement in Higher Education

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Abstract:	**The document corresponds to activities 1 of Output 1 (Field analysis: Positioning HEIs in open and citizen science for open knowledge and innovation). This study helps to identify how HEIs currently perform in citizen science activities, which is the untapped potential therein, and the ways in which the HEIs can cater to the needs for citizen participation in science for society. It also addresses open innovation and new forms of participatory science.**
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List of Abbreviations

Abbreviations	Description
CS	Citizen science
HEI	Higher education institution
OS	Open science
PPSR	Public Participation in Scientific Research
RRI	Responsible Research and Innovation
SDGs	Sustainable Development Goals adopted by United Nations Member States in 2015

Executive Summary

Although the relationship of science and society goes back to the origins of human civilization, there has recently been a widespread reconsideration of this relationship, situated within a context of increasing claims for fairer and more sustainable societies (cf. climate change, social inclusion). The role of scientific knowledge in tackling pressing world issues has come to the fore, as well as the role of citizens in engaging in action for more tangible measures to be adopted by policy makers. In fact, while there has been a continuous call for science to better respond to societal needs, it is now the case that citizens engage in this process, together with traditional scientific production hubs, to collectively make this change happen. This trend creates new forms of knowledge production and circulation, affecting the way citizens, higher education institutions (HEIs), research centres, public and private sector institutions, local and national governments, and pan-European and international organisations co-work to the benefit of society as a whole (Miller, 2017; Mahr et al., 2018).

It is believed that open science, especially through one of its components, citizen science, can address grand challenges, respond to diminishing societal trust in science, contribute to the creation of common goods and shared resources, and facilitate knowledge transfer between science and society to stimulate innovation (DITOs consortium, 2017).

Within this context, the current publication attempts to outline the role HEIs play in open and citizen science, and to leverage their engagement in it. Thus, this study allows us to identify how HEIs currently perform in citizen science activities, which is the untapped potential therein, and the ways in which the HEIs can cater to the needs for citizen participation in science for society. It also addresses open innovation, through the socio-digital advancements of crowdsourcing (Howe, 2006), produsage (Bruns, 2008), and new forms of participatory governance (digital activism, open data policies, open government).

To address this objective, the study is structured in the following manner. In chapter 1, based on the literature, we offer a theoretical outline regarding open- and citizen science definitions and the role HEIs are called to play. Chapter 2 describes the methodology adopted in this study. In chapter 3, we offer an analysis of 20 selected citizen science projects that are reviewed in regard to a set of parameters contributing to the understanding of the various dimensions of HE involvement (or the lack of). In chapter 4 we synthesise the results of chapter 3 and open up the discussion into engagement pathways HEIs can adopt to strengthen their position as bridges between science and society. The publication contains a list of abbreviations, an annex, indicative further readings, and acknowledgements.

Chapter 1: Open and citizen science

"Citizen science is both an aim and enabler of open science."

Open Science Training Handbook, 2018

1.1 At the origins: open science

Citizen science, participatory research, public engagement with science and technology, community-based research, do-it-yourself (DIY) research: several concepts can apply to the engagement of the public in the production of scientific knowledge. Although each of the aforementioned terms differs at some points from the others, they all reflect an increasing interest in doing science in a more open fashion. Their common denominator is open science and its various forms are outlined below.

Open science is a global phenomenon affecting many dimensions of everyday life. Open access to publications and open data are, however, considered to be its cornerstones. More generally, open science "concerns all aspects of the research cycle, from scientific discovery and scientific review to research assessment, publishing and outreach" (European Commission, 2019). One of the most commonly used definitions of open science refers to:

> "the practice of science in such a way that others can collaborate and contribute, where research data, lab notes and other research processes are freely available, under terms that enable reuse, redistribution and reproduction of the research and its underlying data and methods." (FOSTER, nd).

Open science is being acknowledged as a top priority in European Union-wide strategies (among others, the "Digital Market" priority and the priority of "Democratic Change" under the European Commission priorities 2014-2019, as well as in the Vision of the new European Commission College 2019-2024). The European Commission structures its open science policy around eight 'ambitions' or priorities. The first proposition of the eight priorities appears in a 2018 paper by an external advisors group (Open Science Policy Platform, 2018), leading to a December 2019 publication by the European Commission (European Commission, 2019).

The eight ambitions of open science are[1]:

- Open Data: FAIR (Findable, Accessible, Interoperable and Re-usable data) and open data sharing should become the default option for the results of EU-funded scientific research.
- European Open Science Cloud (EOSC): A "federated ecosystem of research data infrastructures" will allow the scientific community to share and process publicly funded research results and data across borders and scientific domains.
- New Generation Metrics: New indicators must be developed to complement the conventional indicators for research quality and impact, so as to do justice to open science practices.
- Future of scholarly communication: Peer-reviewed scientific publications should be freely accessible, and the early sharing of different kinds of research outputs should be encouraged.

[1] All ambitions are stated verbatim.

- Rewards: Research career evaluation systems should fully acknowledge open science activities.
- Research integrity: All publicly funded research in the EU should adhere to commonly agreed standards of research integrity.
- Education and skills: All scientists in Europe should have the necessary skills and support to apply open science research routines and practices.
- Citizen science: The general public should be able to make significant contributions and be recognised as valid European science knowledge producers.

Citizen science, which is the focal point of this study, is the catalyst in open science, as it has the potential to "increase the input of knowledge producers into a more Open science environment" (European Commission, 2016: 45).

1.2 European Union initiatives enabling open science

Several ground-breaking initiatives support the implementation of the open science objective. Among them, OpenAIRE is the pre-eminent pan-European initiative that has supported the European Commission to implement its open access and open science requirements for over ten years. More precisely, OpenAIRE's mission is to provide unlimited, barrier free, open access to research outputs financed by public funding in Europe. Figure 1 shows how OpenAIRE actively contributes to the European Open Science Cloud (EOSC), the "research open science cloud", that is implemented to promote access and reuse of research data in Europe.

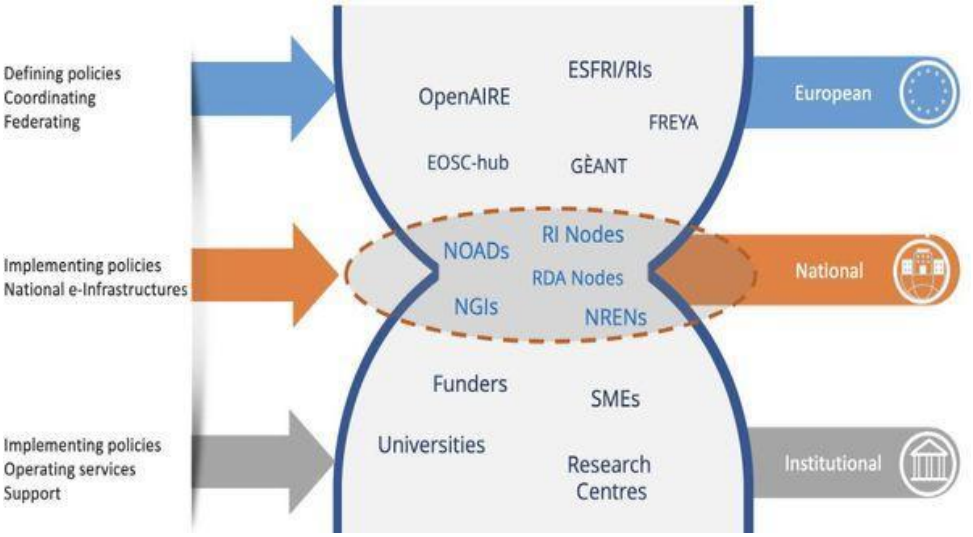

Figure 1: The open science panorama of stakeholders (source: OpenAIRE https://www.openaire.eu/openaire-and-eosc)

1.3 Role of HEIs in open science

Naturally, universities play a fundamental role in the various forms of open science. In the figure above, universities work as catalysts on the institutional level and contribute to "implementing policies, operating

services and [offering] support" (Figure 1). It is worth repeating that open access policies are paramount in the adoption of open science at universities. The European University Association, representing more than 800 universities and national rectors' conferences in 48 European countries, has issued the publication "Towards Full Open Access in 2020: Aims and recommendations for university leaders and National Rectors' Conferences" (EUA, 2017). On the country level, the policies adopted by European universities can be found at the EU member state pages collected in the "Open science overview in Europe" provided by OpenAIRE. These pages also highlight examples of European universities having created research data policies and services to support management of research data.

There is wealth of resources on the role of HEIs in open science, as well as ways of unleashing the potential of researchers in committing to open science. For instance, the growing interest in Responsible Research and Innovation (RRI), with leading initiatives such as FIT4RRI (https://fit4rri.eu/), RRItools (https://www.rri-tools.eu/), NewHoRRIzon (https://newhorrizon.eu/) among others. In addition, OpenAIRE initiatives for training researchers on skills related to open science have been implemented around Europe.

In terms of skills, the importance of HEIs (including academic libraries) in supporting and promoting open science is highlighted in several EU policies. Among them, the 2017 Report of the Working Group on Education and Skills under Open Science (European Commission, 2017b) emphasises the need to shape HE students/next generation researchers as "open science citizens". More precisely:

> "The European Research Area (ERA) should work in closer collaboration with the European Higher Education Area (EHEA) (...), enabling the next generations of researchers to evolve as Open science citizens. (...) New generations of scientists and researchers, as the driving force for innovation and economic growth, are of vital importance to Europe's future competitiveness and leadership." (p. 16)

Moreover, the Erasmus+ 2019 programme guide highlights the importance of "knowledge-creating teams of students and academics, possibly together with researchers, businesses, regional actors and civil society actors [that] (...) address together societal and other challenges of their choice in a multi-disciplinary approach through innovative learning and training that equip students and researchers with high-level, entrepreneurial, Open science and transferable skills" (Erasmus+, 2019).

Finally, data stewardship, (Teperek et al., 2018) is a new function adopted by universities to support scientific staff with data management and also to ease the open science pathway. Since 2017, Delft University of Technology (TU Delft) has embarked on an ambitious Data Stewardship project, one which has been adopted and refined by other pioneering institutions. As these topics go beyond the scope of the current study, we will now move to its core topic, namely civic engagement in open science for universities.

1.4 Potential of HEIs in citizen-enhanced open science

Beyond the institutional horizon of each university, open science strengthens the connection to the world outside academia. Citizen-enhanced open science can potentially be a term that broadens open science through the inclusion of citizens in its fabric.

Under the priority "Educate for the future and invest in people who will make the change", the 2017 publication LAB – FAB – APP by an expert group on maximising the impact of EU Research & Innovation Programmes (European Commission, 2017a), claims that:

> "Europe's universities need urgent renewal, to stimulate entrepreneurship and tear down

> disciplinary borders. Strong non-disciplinary collaborations between universities and industry should become the rule and not the exception. (...) Projects should include training activities for the next generation of researchers and innovators, particularly skills needed for data-driven open science. Whenever possible, citizen science should be encouraged, where citizens become providers and users of data. This will reinforce and give new meaning to the policy of open access to publications and data; this openness should enable citizens and citizen groups to participate in evidence-based policy and decision-making." (p. 13)

Based on the claim above, the LAB – FAB – APP study urges towards action that provides the opportunity to "stimulate co-design and co-creation through citizen involvement." (ibid, p. 19)

The interest in the citation above resides in the relationship that is drawn between change in universities through innovation partially built on citizen engagement. It also emphasises the role of citizens as providers but also as users of scientific data generated, in a more dialogic relation than mere data delivery on the user side. Moreover, it emphasises the role of skills, a crucial component of the university evolution that will be discussed hereafter. This leads us to the definition of citizen science and its connections to closely related concepts.

1.5 Citizen science

Citizen science is not a radically new concept or practice, and this section outlines its origins, offers a definition and connects it to related terms that will be used throughout this study.

It is common to situate citizen science under the umbrella term "public participation in scientific research" (PPSR). PPSR can be broadly understood as a way to generate scientific knowledge, motivate public engagement with scientific research and advocacy, and provide education about a scientific subject matter (Loss et al., 2015). PPSR precedes and contains citizen science, as Rick Bonney, one of pioneers of this concept, and colleagues claim (Bonney et al., 2009): PPSR is designed to:

> actively involve the public directly in the multifaceted and iterative processes of scientific investigation. Such efforts include citizen science, volunteer monitoring, and participatory action research. Projects that fall into these categories allow participants to learn both science content and process while experiencing the fun and excitement of research. (p. 10).

Regarding the definition of citizen science, there is wealth of understandings, which reflects the growing interest in this field of studies. Eitzel et al. (2017) offer a panorama of available definitions by reviewing the theoretical, historical, geopolitical, and disciplinary context of citizen science terminology. Shanley et al. (2019b) provide an inventory of citizen science definitions. Other attempts to critically address citizen science are made by, among others, Vélot (2016) and Strasser et al. (2019). Related terms exist, such as participatory research (English, Richardson & Garzón-Galvis, 2018; Göbel, 2019), citizen engagement in science and policy (Figueiredo Nascimento, Cuccillato, Schade & Guimaraes Pereira, 2016), public engagement with science and technology, community-based research, do-it-yourself (DIY) research. Herodotou, Sharples, and Scanlon (2018) put forward the concept of "citizen inquiry", that raises the need for citizen science projects that will provide opportunities to the public to initiate and conduct their own personally meaningful research and will explicitly target informal science learning. The plethora of terms can be considered as a healthy sign of a field in full evolution.

Regarding the meaning of citizen science that will be adopted in this study, we opt for a definition that situates the term within the realm of open science and its results that is relevant and meaningful to the

advancement of (open) science. Based on this understanding of the term, it is not only the dimension of public engagement in the process of scientific research that is fundamental (as it is the case of most definitions of PPSR), but also the fact that citizen science "requires at least a basic degree of openness" (DITOs consortium, 2017).

The emphasis of citizen science on releasing publicly available data is manifested in the ten principles of citizen science, produced by the European Citizen Science Association (ECSA, 2015). Principle #7 states that "citizen science project data and meta-data are made publicly available and, where possible, results are published in an open access format". Seen from this perspective, efforts should made so that "many citizen science projects make the data they generate accessible to some degree or contribute to the development of freely (re)usable research tools and methods" (ibid).

Figure 2 illustrates core concepts and areas of synergy between open science and citizen science according to Vohland and Göbel (2017), where the accessibility of research results and processes is an example of where the two concepts coincide.

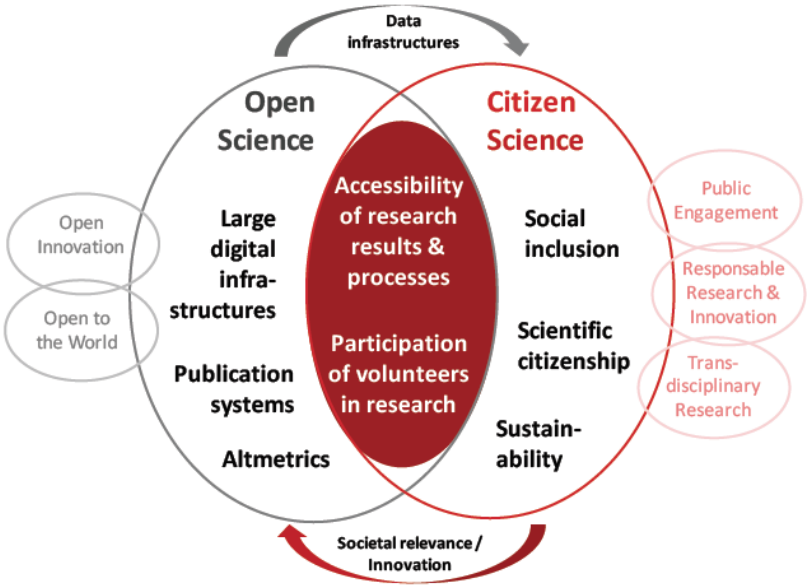

Figure 2: Open science and citizen science core concepts and areas of Synergy from Vohland and Göbel, 2017. Translated from German in DITOs consortium (2017).

Along the same lines, Dörler and Heigl (2019) claim that "all data and results of a given citizen science project [should] be published open access, provided there are no legal or ethical barriers to doing so. In our view, this is an important step toward increased transparency and trust in citizen science projects". Although this understanding of the term limits its reach and practices, we argue that this is a way for citizen science to situate itself as a dynamic component of the open science endeavour that facilitates the cooperation between scientists and volunteers. To emphasise the pivotal role of open science, the term "citizen-enhanced open science" (Zourou, 2020) could potentially be an alternative to citizen science as it denotes its origin and also its contribution to the development of open science and through the

requirement for openness it contributes to the achievement of the eight open science ambitions of the European Union (cf. 1.1). It further enables a "knowledge commons", (OCSDnet, 2017), that can be understood as a collective endeavour towards more transparency on global level and more opportunities for civic empowerment.

This would potentially scale up citizen science by making the results more transparent and sharable, that is essentially needed to address global societal topics, such as the United Nations Sustainable Development Goals (SDGs). Citizen science has the potential to contribute to social and environmental challenges such as those depicted in the SDGs (Fritz et al., 2019) but some standardisation is needed (De Pourcq & Ceccaroni, 2018). In this respect, the FAIR data principles (Findable, Accessible, Interoperable, Reproductible, (Wilkinson et al., 2016)) can be a possible path towards this goal.

With respect to the term "citizen", Eitzel et al. (2017) offer a detailed analysis of concepts used to describe non-academic participants in science (amateur, layperson, volunteer, etc.) and the intricacies in defining their status and contribution, but also their rights in a scientific endeavour. What is important to mention in relation to the present study is that, as citizen science projects gain complexity, so do the roles adopted by citizens. This can also involve highly skilled volunteers with specific areas of expertise who cater for crucial stages of a project. For example, in Epidemium, one of the 20 projects analysed in this study (chapter 2), along with mainstream volunteer contributions, specific scientific expertise has been sought "where professionals with expertise deemed useful for the advancement of projects (...) They are there to answer questions and thus make the research process more fluid". (Tauvel-Mocquet, 2018, p. 67). Thus, the term "citizen" should not disguise the wealth of roles, competences and skills present within projects, the orchestration of which is a key feature of the design of a project. This point will be addressed in relation to roles that HE staff can play during several stages of a citizen science cycle.

Finally, the fact that citizen science gains traction in both the scientific as well as in the policy agenda should not hide the fact that it is a field in full evolution. First, we are far from reaching a consensus on the aim and processes to adopt with respect to citizen science on the international level. A scholarly debate that originated from the 2019 paper by Heigl et al. (2019a), commented on by Auerbach et al. (2019) and responded to by Heigl et al. (2019b) is indicative of the numerous open issues to tackle. Second, the lack of consensus in terminology is visible among the initiators of citizen science projects, by taking only two examples as reference, Foldit (case 24, Annex), and PatientLikeMe (case 44, Annex). Whereas on the Foldit website it states that (Foldit is) "a crowdsourcing computer game", on PatientLikeMe it claimed that it is "a personalized health network". However, both are categorised as citizen science projects in this and other studies, which for some may be considered as an overgeneralisation that disregards terminological nuances. We thus argue that no solid "community awareness" has yet been developed among practitioners of citizen science. Third, the growing interest in citizen science should not hide the fact that participation is far from being massive. A 2014 study on Foldit showed that in spite of the massive number of registered users, only a few contribute actively (Curtis, 2014). These elements set citizen science on a realistic basis and depict the current picture of this evolving field.

1.6 Related terms: open knowledge, open innovation and crowdsourcing

An overview of open science and citizen science concepts would be incomplete without referring to two closely related terms, open knowledge and open innovation. Open knowledge is understood as "any

knowledge (either embodied in artefacts, in social practices, or in research outputs) that is freely circulated – without any legal, technological or social restriction" (Open Knowledge Foundation, nd).

With regards to open innovation, the term was initially coined by Harry Chesbrough, who referred to "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough & Crowther, 2006). Thus, in its original form, the term is grounded in economics (Chesbrough himself is a business innovation scholar) and the party that benefits from the inflows and outflows of knowledge is the corporate sector. For Seltzer and Mahmoudi (2012), who analyse citizen participation, open innovation and crowdsourcing practices, open innovation "refers to the conscious effort by firms to incorporate ideas originating outside the firm in innovation processes within the firm, or to send internally created ideas outside of the firm for commercial application" (p. 1).

The term has been used recently in a broader context by, among others, the European Union publication *Open innovation, open science, open to the world - a vision for Europe* (European Commission, 2016) from which we borrow the definition which will be adopted in our study: "Open Innovation is to open up the innovation process to all active players so that knowledge can circulate more freely and be transformed into products and services…" (ibid, p. 11). What makes citizen involvement relevant to the open innovation process is that "Open innovation is about involving far more actors in the innovation process, from researchers, to entrepreneurs, to users, to governments and civil society" (ibid, p. 88).

Ideally, open innovation can be understood as the manifestation of open science through its transformation into products and services. However, this is to be validated in each specific context, as there are two major challenges in the convergence of open innovation with open and citizen science. The first is the output of the activity. Whereas "citizen science activities involve citizens in scientific endeavour" (principle #1 of the ten principles of CS, ECSA 2015) and "citizen science projects have a genuine science outcome" (principle #2 of the same publication), open innovation products and services may not have this scientific orientation, as it is the case for market products. The second is compliance to the open science principles. This is not always the case as in several contexts which benefit from citizen contributions in an open collaboration environment (cf. 1.8 below), the end result becomes proprietary by the institution initiating the open innovation project. This is a point to which we will return in the discussion of the actual open innovation component of the citizen science projects under scrutiny (4.2).

The open innovation concept discussed above brought to the fore the issue of utilisation of (non-remunerated) citizen contributions to a final result that may not always be publicly available. Within this context of open, distributed social participation, the term crowdsourcing was coined by Howe (2006) and refers to the engagement of individuals who voluntarily offer their knowledge to a knowledge seeker (such as a social group, an organisation, a company, etc.). Crowdsourcing implies favouring the commitment of motivated users in the production process. Depending on the context it can not only be seen as a movement towards massive user engagement in an unrestricted and collaborative manner, but also as a means by which companies exploit users' collective efforts of knowledge building, without corresponding remuneration, "[by] tap[ping] the latent talent of the crowd" (Howe, 2006).

Crowdsourcing has been analysed from an educational perspective (Paulin & Haythornthwaite, 2016; Zourou & Potolia, 2020) as well as for its potential in citizen science, namely for its affinities with user involvement in PPSR. The term "crowd science" has been used to some extent (Scheliga, Friesike, Puschmann, & Fecher, 2018). As both crowdsourcing and citizen science are fuelled by voluntary participation to an open call for participation, several authors claim that "[t]he defining characteristic of

both citizen science and crowdsourcing, however, is their location at the point where public participation and knowledge production – or societal context and epistemology – meet, even if that intersection can take many different forms" (Shanley, Parker, Schade, & Bonn, 2019a, p. 1).

In contrast, there are several features that differentiate crowdsourcing from citizen science. We have, however, only outlined a few, as a more detailed analysis is expected on this matter.

Firstly, in crowdsourcing the process and outcomes are only legitimised by the initiator and the crowd has no other role than providing input with no decision-making power. For Seltzer and Mahmoudi (2012) who offer a critical analysis of crowdsourcing, citizen participation and open innovation, crowdsourcing is not open but instead reliant on individual and independent work (p. 5). Furthermore, crowdsourcing does not rely on the decisions of any party other than the sponsors for conferring legitimacy on solutions. In contrast, citizen participation is expected to give voice to those most affected by a given political decision (cf. environmental justice citizen science projects) and to provide a means for those likely to be excluded (by the decision-making process), crowdsourcing has no such brief (p. 8).

Secondly, whereas in citizen science the result is an exclusively scientific outcome, in crowdsourcing it is not, as it can take a variety of other forms. Thirdly, in line with the open science origins of citizen science, access to the result of the activity belongs to the knowledge commons (or at least it is expected to), with reference to open access and re-use of the scientific result achieved through the citizen science activity, whereas in crowdsourcing the result belongs to the initiator of the activity, and in the majority of cases the collective, crowd-based result becomes proprietary.

These nuances are worth considering when analysing volunteer engagement in an open call for participation, which is the convergence point between citizen science and crowdsourcing.

1.7 Citizen science typologies

As different interpretations may arise in light of the dynamics of citizen science, any attempt at categorisation should be considered indicative. However, there is wealth of typologies to describe the forms citizen science projects might take, reflecting the growing importance of citizen science.

To capture the nuances of citizen science, a group of scholars belonging to the EU-Citizen.Science project and to the European Citizen Science Association (ECSA), launched a survey in late 2019 with the aim of understanding which activities, and under which conditions, should be considered to be citizen science (link). The team presented different forms of public participation in research and asked the audience to decide to what degree the case described to them could be labelled as a citizen science activity. While the results of the survey will be released in mid-2020, the exercise per se reflects the complexity of categorisation of citizen science activities.

One of the first typologies that served as source of inspiration for more recent activities is provided by Bonney et al. (2009). It has been adopted by Tweddle, Robinson, Pocock, & Roy (2012) in their analysis of biodiversity citizen science projects and will also be employed within the framework of our analysis (cf. 2.1). More precisely, Bonney et al. (2009) identify three major categories, namely contributory projects, collaborative projects and co-created projects. According to the authors, these are defined as:

- "Contributory projects, which are generally designed by scientists and for which members of the public primarily contribute data

- Collaborative projects, which are generally designed by scientists and for which members of the public contribute data but also may help to refine project design, analyse data, or disseminate findings
- Co-created projects, which are designed by scientists and members of the public working together and for which at least some of the public participants are actively involved in most or all steps of the scientific process". (Bonney et al. 2009, p. 11).

Another widespread typology is provided by Haklay (2015), who identifies six types of citizen science initiatives, from the most rudimentary to the most sophisticated ones:

> "From passive sensing, where participants use available sensors (e.g., in smartphones); volunteer computing, in which participants donate the unused processing power of their computers and devices; volunteer thinking, in which participants engage in cognitive tasks to assist scientists; to full-scale environmental and ecological observations, participatory sensing, and civic/community science, which include active engagement in building and deploying scientific tools and methods. Examples from various scientific domains – physics, biology, life sciences, ecology, and environmental sciences – ground the analysis in real life activities." (p. 5)

In their 2019 study on environmental citizen science projects of high policy relevance, Turbé et al., inspired by Haklay's 2015 paper, identify seven citizen science types: passive sensing, volunteer computing, crowdsourcing, occasional reporting, monitoring, civic science, and DIY engineering projects. Other suitable typologies are provided by Herodotou (2018), Scheliga et al. (2018), Bonney et al. (2013) and Schaefer and Kieslinger (2019).

For the needs of this study we will employ the "models of citizen engagement in science", provided by the Socientize group (Sanz, Holocher-Ertl, Kieslinger, García, and Silva, 2014), cf. Figure 3. We opted for this typology as its items are clear-cut, and, as Dörler and Heigl mention (2019), there is lack of hierarchisation of the contribution by citizens. It also contains two categories we consider important in citizen science: (I) serious games, where people collect data or find solutions for problems by playing computer games, and (II) grassroots activities, where the whole scientific project is sometimes carried out without any professional scientist involved.

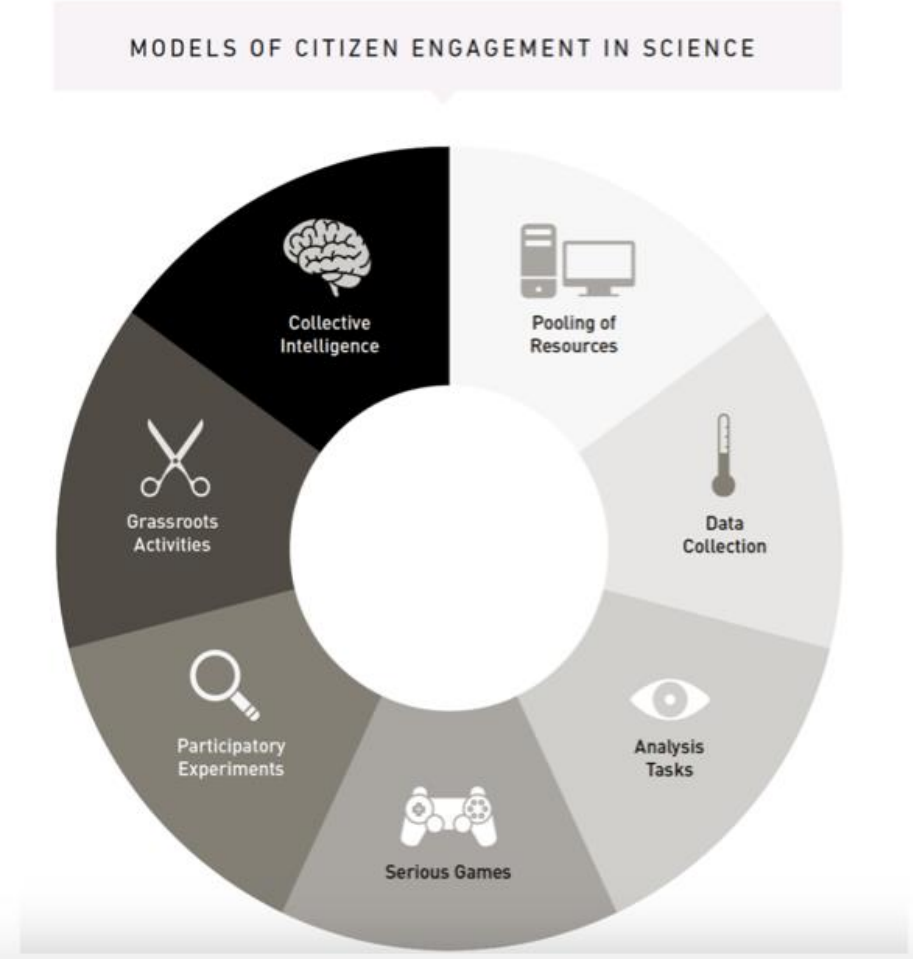

Figure 3: models of citizen engagement in science (Sanz et al., 2014)

Chapter 2: Methodology

This chapter describes the methodology adopted in the identification and selection of citizen science initiatives which will be examined from the perspective of the contribution (or lack of) of HEIs. The chapter is structured according to the analytical steps adopted, namely the identification of selection criteria (2.1), the collection of resources (2.2), the identification of 20 practices to be further analysed (2.3) and the typology against which the practices have been analysed (2.4). The limitations of the study are presented in 2.5.

The steps towards the accomplishment of the study are presented in Table 1. A synopsis of each step is provided in the following sections.

Steps	Content	Timeline
1	Designing the framework of the study; setting criteria for selection of practice	September 2019
2	Building a pool of citizen science projects; data collection by team members	October-November 2019
3	Identification of 20 indicative cases; additional input by case from team memb	December 2019
4	Analysis of each case with respect to the typology	January 2020
5	Peer review and validation of the 20 cases and of the overall study	January 2020

Table 1. Steps towards the accomplishment of the study

2.1 Step 1: selection criteria

Citizen science projects are numerous and diverse (especially when considering projects aggregated by platforms such as Zooniverse and Scistarter). To better scope out our topic (understanding the role of higher education in citizen science), we thus set the following selection criteria:

- Engage individuals outside universities in the process.

This criterion guarantees that the selected citizen science projects do not mostly or exclusively involve HE staff and students, and that they are geared towards communities and society in general.

- Involve to some extent a HEI.

This criterion connects the project with the targeted type of institutions of this study. However, we allowed ourselves to add cases where the link with academia was missing or vague, as an opportunity for further exploration.

- Incorporate an open dimension.

This criterion ensures that selected practices are rooted in the conceptual framework of openness (and open science). The form of openness has not been specified at this stage, as projects may have embraced open access, open data, open collaboration modalities with stakeholders, etc.

- Address open innovation (optional).

Cases that address the (so far largely underexplored) connection between citizen science and open innovation are sought. This criterion pertains to activities in which citizens have created and/or shared innovative solutions (said solutions often address a technical challenge or social problem drawn from

observation or from previous knowledge). We thus looked for practices that resulted in something (knowledge, ideation, artifact) innovative and which were not mere observations.

With regard to sites serving as pools for the identification of citizen science projects to select, there was no particular advice to team members. As the present study is short-scale, team members were invited to identify relevant projects either figuring on citizen science aggregators/platforms as the ones listed below, or not. Naturally it would have been impossible to analyse each project showcased in each of these platforms (indicative list):

- Scistarter https://scistarter.org/
- Zooinverse https://www.zooniverse.org/
- iNaturalist https://www.inaturalist.org/
- iSpot (https://www.ispotnature.org/)
- nQuire (https://nquire.org.uk/)
- CitSci.org projects list (https://www.citsci.org/)
- National aggregators or platforms, indicatively:
- Austria: https://www.citizen-science.at/ (in German)
- Australia: https://www.ala.org.au/ and Australian Citizen Science Association https://citizenscience.org.au/
- Germany: https://www.buergerschaffenwissen.de/
- Switzerland: https://www.schweiz-forscht.ch/de/
- Sweden: https://www.artportalen.se/
- Spain: https://natusfera.gbif.es/
- France: https://www.open-sciences-participatives.org/home/ and https://www.tela-botanica.org/

2.2 Step 2: building a pool of citizen science projects

Between October and November 2019 team members collected a wealth of practices (85 practices) by filling in a shared documentation chart corresponding to the criteria above. A review of all data collected has been operated against the selection criteria by the leading author.

Although the initial goal of the study was only to identify and analyse 20 cases in depth (cf. 2.3), due to the interest that the rest of cases presented, we decided to valorise and present them in a condensed form in an Annex [Annex 1]. This contains 65 use cases of which we acknowledge the value and potential in the academia-society relationship through citizen science.

2.3 Step 3: identification of 20 practices for further analysis

For the selection of the 20 cases to be further analysed among the total of 85, we applied some additional criteria:

- Geographical distribution spanning across the world and with emphasis to the European Union
- Impact and sustainability
- Originality

- Less represented citizen science areas such as: environmental justice, species preservation/ extinction, and cultural and linguistic variety

2.4 Step 4: Typology applied to the 20 use cases

This step consists of the analysis of the 20 cases – citizen science projects – against a list of the items allowing us to gain an in-depth understanding of each case and more specifically the role that HEIs currently play or still not play, as an opportunity or invitation for further deployment. Part of the items of the list are descriptive and others belong to typologies discussed in 1.7.

1. **Website**: URL of the use case

2. **Outline:** An up to 200-word description synthesizing core information

3. **Main organisers:** The organising institution(s), whether a university or not

4. **Types of activity:** This refers to the "models of citizen engagement in science" (cf. 1.7, fig. 3), provided by the Socientize project, (Sanz et al., 2014). The types are:

a) Pooling of resources

b) Data collection

c) Analysis tasks

d) Serious games

e) Participatory experiments

f) Grassroots activities

e) Collective intelligence

5. **Format:** Several pieces of information contribute to this feature:

a) The participation modality (activity at a physical location, completely online, blended)

b) Digital means used (Internet, social networks to support the event, a mobile app, etc.)

c) Duration (24h, 48h, one week, one semester, etc.)

6. **HE roles:** This feature relates to the role a university has played in the project as an institution. There is no predefined list of items. More than one role can appear.

7. **HE staff investment and their profile:** This feature relates to the individual level of university staff. For instance, we look for the degree of investment of academic staff, and the profile of it. Involvement of students can also be mentioned in this item. Some of the characteristics of academic staff that can be filled in are: skills and competencies; types of profiles, roles of individual members of HEIs.

8. **Type of HE investment:** In this feature we seek to code the investment of HEI as technical (academic expertise), material (such as sponsoring, hosting an event, offering grants, etc.) human resources (all types of human resources investment by university staff, not exclusively academic), and their combinations.

9. **Quality and impact of the achieved activity:** With regards to impact: publicly shared data demonstrating impact. With regards to quality: quality indicators and measures.

10. **Ethical and legal considerations, data management:** Ethical and legal considerations, data management; any mentions to FAIR (Findable/Accessible/Interoperable/Re-usable) data or policies.

11. **Sustainability considerations:** Data that relate to components such as funding, community uptake, business openings, sustainability measures after the end of the activity or project.

12. **Citizen science approach:** Contributory or collaborative or co-created, in reference to the Bonney et al. typology (2009), cf. 1.7.

2.5 Limitations of the study

Before moving to the analysis of the 20 use cases (chapter 3) and the subsequent synthesis of results (chapter 4), we would like to state some factors that can be considered to be limitations to this study, namely its size (20 projects) and its selection method (indicative sample). With respect to the sample size, the INOS study does not claim of being an exhaustive study of this fast-developing field. Regarding the selection method of the 20 cases belonging to the sample, it coincides with some criteria set upfront (cf. 2.1) which can be regarded as subjective. Furthermore, a meta-analysis of use cases could counter-balance the inconveniences of a sample study.

Chapter 3: 20 indicative citizen science projects

This chapter offers an analysis of 20 selected citizen science projects with the aim of clearly identifying the contribution of HEIs (or lack of) in them. The objective of this analysis is to document “grey zones” that impede successful implementation, as a means to raise awareness about some of the major obstacles and pitfalls in design, implementation, assessment and sustainability.

This analysis will offer the material for the synthesis of findings (chapter 4) and will open the floor to a set of recommendations to HEIs for enhancing their societal role by means of citizen science (separate publication of INOS partnership).

1. Epidemium

1. **Website:** http://epidemium.cc/

2. **Outline:** Epidemium is an open and collaborative scientific research project that aims to study the epidemiology of cancers through the exploitation of open data, based on the implication of a community of volunteers who develop projects in teams. Three types of Challenges have been set: 1. See cancers, 2. Foresee Cancers, and 3. Cancer Mortality prediction. Epidemium supports each team in its research until publication. A 5-step plan has been developed to help publications reach this stage. This plan includes the review of each step by experts and a mid-challenge presentation to the jury. At the end of the challenge, each selected team will present their results, including a scientific poster and a publication paper draft. As openness is one of the programme's core values, every contribution, database, content, and piece of code used or produced within your project will be released under open licences.

3. **Main organisers:** Pharmaceutical company Roche; community lab La Paillasse; think-tank Club Jade. Associated partners: cancer research federation Cancéropole CLARA in Lyon, STIM (a company), engineering school Mines ParisTech.

For information, the Epidemium team consists of:

- Two people to coordinate the programme (including 1 MD working in epidemiology and new technology methodology applied in healthcare)
- One person for the community management (master's degree in Communication)
- One tool maintainer (master's degree in science)
- One legal advisor (PhD in open source law)
- A few people (2/4) involved from partners (in Communication, programme follow-up and budget monitoring, etc.) more focused on support activities
- External providers for the community platform development, data preparation and graphic communication tools.

4. **Type of activity:** Collective intelligence.

5. **Format:**

a. **Participation modalities:** Face-to-face meetings (called “Bocal" and "Pool") for core team members (belonging to the teams that address the challenges); meetups for team members and general audience - a pool of volunteers.

b. **Location:** Different locations in France for face-to-face meetings and online for open data analyses.

c. **Duration:** The project ended in 2018. However, during its lifetime, the recommended milestones and time frame for the teams addressing one of the three challenges figures below:

- Definition of the research project [4 weeks]
- State of the art [4 weeks]
- Data selection and method [4 weeks]
- Research and analysis [10 weeks]

- Results and draft for a scientific paper [2 weeks].

6. **HE role(s):** MINES ParisTech has a secondary role in the project. It contributed (together with the company STIM) to the creation of the CK map, a tool that provided a better understanding of what is cancer and its treatment, which data and data analysis technics' are available today and how they are used.

7. **HE staff investment and their profile:** A member of the core team is a staff member at the Centre for Research in Epidemiology and Statistics, affiliate to Paris Descartes University. Other University staff members are involved on a volunteer basis as external advisors. In addition, higher education schools are involved, especially with students from Polytechnic schools (Centrale-Supelec and ESIEA). They are students participating in the challenges.

8. **Type of HE staff investment:** Human resources

9. **Quality and impact of the achieved activity:** From the programme, the most significative outcomes are:

- Four scientific articles (including the abstract book during the RECOM 2018 conference)
- Two white paper (One on Epidemium and one on free models in oncology)
- One book : Santé et intelligence artificielle – publisher : CNRS
- Mentioned in the French health data hub report in 2018 as one inspirational example
- Two international conferences organised (RECOMB satellite with DREAM Challenge team and data in healthcare with Curie Institute)
- 32 projects (including 17 finalists)
- 50+ events (conference, training session, research presentation, etc.)
- 350+ experts included
- 1 300+ community members
- 25+ press articles

10. **Ethical and legal considerations, data management:** The programme is framed by two committees: one scientific committee and one ethics committee. The ethics committee in charge of the ethic evaluation of the project wrote an ethic charter available on page 123 in the programme's white paper.

11. **Sustainability considerations** (funding, community uptake, business openings): The project is completed. No information about its possible re-opening or its finalisation is available.

12. **Citizen science approach:** Collaborative.

2. Aalborg University's Megaprojects

1. **Website:** https://www.megaprojekter.aau.dk/ and https://megaprojects.moodle.aau.dk/

2. **Outline:** Megaprojects is an initiative of Aalborg University (AAU), Denmark, which concerns solving the world's grand challenges: The United Nations Sustainable Development Goals (SDGs), through engagement of university staff and students. Megaprojects are regular semester projects where groups of students from across semesters and educational backgrounds meet and inspire each other to consider solutions to a big societal challenge. Across disciplines and degree programmes, AAU students prepare themselves to tackle the challenging, yet exciting, task of assisting local communities (i.e. the municipality and its business community) in creating sustainable development in a wide range of sectors. This is all part of the new initiative on megaprojects, developed by the university under the vision: Grand challenges must be addressed across disciplinary boundaries as well as across degree programmes and semesters. In October 2019 Aalborg Mayor Thomas Kastrup-Larsen and AAU Pro-rector Inger Aske signed a cooperation agreement on the university's first two megaprojects: 'Sustainable Living' and 'The Circular Region'.

3. **Main organisers:** Aalborg University, Denmark.

4. **Type of activity:** Collective intelligence.

5. **Format:**

a. **Participation modalities:** Open only to AAU students and faculty, Megaprojects take place during the mainstream practice of teaching at AAU (lectures, student group work, online interaction and collaboration modalities).

b. **Location:** Currently only at AAU in Aalborg campus, to be expanded to all AAU campuses from next semester.

c. **Duration:** One semester during the pilot phase; to be expanded to several semesters and up to 2-3 years.

6. **HE role(s)**: Aalborg University provides students and staff to solve the challenges.

7. **HE staff investment and their profile:** All levels of HE staff investment: academic, technical and administrative.

8. **Type of HE investment:** University staff create a framework for students to work within in cooperation with external stakeholders and taking into account the curriculum of the involved study programmes. They also monitor student projects.

9. **Quality and impact of the achieved activity:** Not yet, this initiative is in a pilot phase.

10. **Ethical and legal considerations, data management:** Since the final outcome is student projects, the usual practice is that reports are openly accessible unless they contain personal sensitive data or data that are not to be published (e.g. in case of cooperating with an external stakeholder and where some data are under copyright).

11. **Sustainability considerations** (funding, community uptake, business openings): Funding is provided by AAU.

12. **Citizen science approach:** Collaborative.

3. Collecting litter and data to combat plastic pollution in Denmark

1. **Website:** https://astra.dk/nyhed/collecting-litter-and-data-combat-plastic-pollution

2. **Outline:** The world's first national mapping of plastic pollution was carried out in Denmark in the framework of the 2019 Mass Experiment ("Masse-eksperiment"), which took place during the annual Danish Science Week (week 39). It was organised by two institutions. First, Astra, a national Danish centre for science learning, focusing on the teaching of science subjects for the benefit of the entire community, and, second, MarinePlastic, a Danish multidisciplinary centre for research into marine plastic pollution. The initiative succeeded in mobilising around 57,000 Danish children who participated in an effort to clean up the country's natural environment from plastic pollution and gather data for the European Environment Agency's (EEA's) Marine LitterWatch database.

3. **Main organisers**: Astra; MarinePlastic. Involved: European Environment Agency (with Marine LitterWatch mobile app). Linked to: the #EUBeachCleanUp campaign.

4. **Type of activity:** Data collection (main type of activity), participatory experiments.

5. **Format:** Research (data collection) and scientific studies (e.g. in connection with the polymer determination) carried out by primary and secondary education students and their teachers.

a. **Participation modalities:** a) Compulsory part: collection and registration of plastic categories. b) Voluntary part: determination of polymer types (from 5th - 6th grade up to and including secondary education).

b. **Location:** Nationwide (92 out of 98 municipalities), in the natural environment (not just in or near water).

c. **Duration:** The Mass Experiment was part of the Science Festival 2019, which takes place annually in week 39. However, it could be conducted within three weeks, i.e. weeks 38, 39 and 40.

6. **HE role(s):** No explicit mention of HE involvement regarding the Mass Experiment 2019. However, HE staff are involved in both organising institutions in the following ways:

a. **Astra:** i) Board members: University College Lillebælt - Astra's chairman is their former rector. ii) HE partners with which Astra engages in projects: Aalborg Universitet, Aarhus Universitet, Danmarks Tekniske Universitet, University of Copenhagen, the IT University of Copenhagen, University College South Denmark, Universitat Autònoma de Barcelona, VIA University College.

b. **MarinePlastic:** Several representatives in their research group: Aalborg University; Aarhus University; DTU - Technical University of Denmark; Roskilde University.

7. **HE staff investment and their profile:**

a. **Astra:** Erik Knudsen, consultant, former rector, University College Lillebælt as their chairman.

b. **MarinePlastic:** All scientists involved and their profiles can be found here.

- Types: Scholars and researchers.
- Roles: Aalborg University - Analysis Methods, Sources and Occurrence, Decomposition, Project Management and Joint Activities; Aarhus University - Regulation and Community Action, Analysis Methods, Sources and Occurrence, Decomposition; DTU Technical University of Denmark - Regulation and Community Action, Ecological Consequences; Roskilde University - Regulation and Community Action, Ecological Consequences, Project Management and Joint Activities.

8. **Type of HE investment:** Primarily technical and human resources.

9. **Quality and impact of the achieved activity:** A massive experiment, as the name ("Masse-eksperiment") suggests: 57,000 children participated, in 92/98 municipalities nationwide, and with 22 types of plastic categorised. The results will be used by researchers and will be included in the EEA's marine waste database, which forms the basis for new EU legislation. Better data on plastic pollution helps to inform policies and tackle this significant problem.

10. **Ethical and legal considerations, data management:** Not mentioned.

11. **Sustainability considerations** (funding, community uptake, business openings): Mass Experiments take place every year in the framework of the Danish Science Week (see above description) and their topics are linked with the theme of that year's Science Week. This specific initiative only took place once and will probably not be repeated. However, the collected data will become part of the EEA database on marine litter to support further action.

12. **Citizen science approach** (regarding the Mass Experiment 2019): Collaborative.

4. Tallinn University LIFE projects

1. **Website**: https://www.tlu.ee/en/elu and https://elu.tlu.ee/ for details in Estonian.

2. **Outline:** LIFE (ELU in Estonian) is a university-wide project-based course, compulsory for Bachelor's and Master's level students. The main objective of LIFE is to support the development of the competence of resolving interdisciplinary problems using general competences and teamwork skills. Students from different study areas are invited to collaborate with academics to carry out projects focusing on problems of their own interest. In so doing, the course encourages the development of thinking and argumentative skills, metacognitive skills and critical thinking as well as self-management, application of knowledge and lifelong learning skills. The initiator of a LIFE project idea can be either a lecturer, a student or a partner from outside the university (entrepreneurs, NGOs, organisations, etc.).

3. **Main organisers:** Tallinn University.

4. **Type of activity:** Pooling of resources (main type of activity), collective intelligence.

5. **Format:**

a. **Participation modalities:** Learning activities take place in teams consisting of 6-8 students. The project team must include students from at least three different study areas. Up to three teams, consisting

of 6-8 students, can join one project. Within the LIFE course, projects are carried out in cooperation with the supervisor(s) and students, and they include the following components: defining a common topic or problem, setting goals, creating an action plan and carrying out the plan as intended.

b. **Location:** Tallinn University (Estonia).

c. **Duration:** Academic year (autumn - spring).

6. **HE role(s)**: Tallinn University as the initiator and host of LIFE; all six academic units and Haapsalu College as LIFE supervisors; lecturers and students as LIFE project supervisors.

7. **HE staff investment and their profile:** Lecturers and researchers as LIFE project initiators and supervisors.

8. **Type of HE investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity:** The LIFE course is assessed on a non-differentiated assessment scale and has a course volume of 6ECTS. All supervisors are responsible for ensuring that all the students can participate in the course. Quality training is available for university teachers and students. For project quality two rounds of public evaluations led by external evaluators (university staff) are conducted, one at mid-project, and the other at the end of the project. The interdisciplinarity, scientific merits and project teamwork are evaluated formatively. For ensuring quality, reporting of the projects is structured for teams using the poster template, and for individual students who have to fill in the self-reflection templates. The impact is communicated with public poster sessions at the university, as well as all posters and projects being available in the LIFE website.

10. **Ethical and legal considerations, data management:** The LIFE team has developed a data management plan for intellectual project outcomes (ongoing).

11. **Sustainability considerations** (funding, community uptake, business openings): Ongoing initiative, sustained by Tallinn University.

12. **Citizen science approach**: Co-created.

5. Ocean i3

1. **Website:** https://euskampus.eus/en/programmes-en/euskampus-bordeaux/ocean-i3

2. **Outline:** Led by the University of the Basque Country (Spain) and the University of Bordeaux (France), in the framework of Bordeaux-Euskampus Campus partnership, *Ocean i3* is a teaching project with a mission to contribute to the reduction of plastic pollution on the Basque-Aquitaine transboundary coast. The project invites students from various disciplines such as business administration, law, teaching, nursing, engineering, criminology and sports management to collaborate with teachers to promote an interdisciplinary approach in order to understand and respond to this challenge and its complexity.

3. **Main organisers:** University of the Basque Country (UPV/EHU); University of Bordeaux; Foundation Euskampus Fundazioa.

4. **Type of activity:** Pooling of resources (main type of activity), collective intelligence, serious games, participatory experiment.

5. **Format:**

a. **Participation modalities:** During the 2018-19 edition, students and faculty participated in 5 workshops.

b. **Location:** (by workshop of the 2018-19 edition:) 1st - Water Sports Center, Hendaye; 2nd - Ekoetxea Txingudi Interpretation Centre; 3rd - The Surfrider Foundation Europe, Biarritz; 4th - Aquarium of Donostia - San Sebastian; 5th - UPV/EHU Centro Joxe Mari Korta in Donostia-San Sebastian.

c. **Duration:** Workshops January-June 2019.

6. **HE role(s)**: The two universities act as initiators and hosts; their scientific staff as teachers and collaborators.

7. **HE staff investment and their profile:** University staff from the various faculties and from both universities work together as an "international innovation team" to co-design the pedagogical proposal based on the development of competences related to research-based learning, interdisciplinarity and sustainability.

8. **Type of HE investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity:**

a. **Quality:** i) An educational innovation project based on Research-Based Learning (RBL) methodologies. *Ocean i3* adopts the "Mission-Oriented Research and Innovation" approach (Fischer et al., 2018[2]), and Civic University (Godard et al., 2012[3]) approach. ii) Ocean i3 is also a field of experimentation on multilingualism and interculturality for the deployment of the Bordeaux-Euskampus Campus. This is based on collaboration with the DREAM group (Donostia Research Group in Education and Multilingualism UPV / EHU) and the expertise of the Euskampus team in this field.

b. **Impact:** For the first year (2018-19), 17 students, 19 teachers and 18 stakeholders have participated. The projects associated with Ocean i3 have accredited a total of 127 ECTS. The main results have been: 17 RBL projects, 3 internships, 2 citizen awareness activities, 6 academic communications and 6 media communications.

10. **Ethical and legal considerations, data management:** In terms of ethics, Ocean i3 takes the Responsible Research and Innovation (RRI) framework as well as the United Nations' SDG agenda. Open science is one of the RRI's key dimensions but is still something we need to define for this project.

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[2] Fischer, R. & al. (2018). *Mission-oriented research & innovation in the European Union*. *Brussels: European Commission*. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/c24b005f-5334-11e8-be1d-01aa75ed71a1/language-en

[3] Goddard, J., Kempton, L., & Vallance, P. (2012). The civic university: Connecting the global and the local. In *Universities, Cities and Regions* (pp. 67-87). Routledge.

11. **Sustainability considerations** (funding, community uptake, business openings): The 2019-20 edition has already started with internal funding, with co-funding obtained from UE Interreg POCTEFA programme for the period January 2020-December 2021.

12. **Citizen science approach:** Collaborative; (in part) Co-created.

6. Project Discovery: Citizen science with Eve Online

1. **Website:** https://www.eveonline.com/discovery

2. **Outline:** Project Discovery leverages Massively Multiplayer online Role-Playing Games (MMRPGs) to engage citizens in cutting-edge scientific research. The first iteration of Project Discovery focused on the Human Protein Atlas, to characterise the structures of cells, using players' identification skills, and will help scientists identify proteins within human cells. In this way, playing Project Discovery helps scientists understand how human cells are built (source). The Human Atlas has now ended and Project Discovery has moved on to exoplanet hunting (https://www.eveonline.com/discovery). In this phase of Project Discovery, which is a collaboration between CCP Games, Massively Multiplayer Online Science (MMOS), Reykjavík University and University of Geneva, players analyse graphs for variations in a star's luminosity, possibly indicating the transit of an exoplanet (source). This happens within Eve Online, which is a space-based, persistent world MMRPG developed and published by CCP Games. Players of Eve Online can participate in a number of in-game professions and activities, including mining, piracy, manufacturing, trading, exploration, and combat. The game contains a total of 7,800 star systems that can be visited by players. Players are provided with the luminosity curves of stars. Identifying a change in a star's brightness nets them an in-game reward while also potentially indicating to scientists that an undiscovered planet has passed in front of the star. In late 2017, at the Astronomy Department of Geneva University, a first analysis of 44.4 million classifications provided by 77,709 players was undertaken (source). Around 4 million samples are analysed every month, or 135 thousand per day (source). To date, users have collected more than 200 million annotations on exoplanets, a massive feat and perhaps an all-time record in citizen science.

3. **Main organisers:** CCP Games, Massively Multiplayer Online Science (MMOS), Reykjavík University and University of Geneva.

4. **Type of activity:** Collective intelligence.

5. **Format:**

a. **Participation modalities**: Participants contribute to data annotation during the immersive game EVE Online.

b. **Location:** Exclusively online.

c. **Duration:** Unlimited.

6. **HE role(s):** Design, implementation and assessment of the project, in collaboration with private companies for software development. The project is led by Professor Michel Mayor, who, in 1995, together with Didier Queloz, discovered 51 Pegasi b – the first exoplanet orbiting a main sequence star. Both scholars have been co-awarded the 2019 Nobel Prize in Physics.

7. **HE staff investment and their profile:** Research staff at the University of Geneva and University of Reykjavik. Research field: astronomy (physics). The data collected by participants are monitored by a team of astronomers at Geneva University, led by Professor (and Nobel Prize winner) Michel Mayor. When a consensus has been reached, they will confirm whether or not the players have identified a new exoplanet.

8. **Type of HE investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity:**

a. **Quality:** research publications produced (for example: a paper published in Nature journal).

b. **Impact:** 425,000 players have participated in Project Discovery, resulting in more than 65.7 million submissions (source). In the first iteration of Project Discovery (Proteneinomics), participation by 322,006 gamers over the course of 1 year provided nearly 33 million classifications of subcellular localisation patterns, including patterns that were not previously annotated by the HPA (source).

10. **Ethical and legal considerations, data management:** An interview by the development manager at CCP refers to the following set of rules:

- It needs to be of an altruistic nature, something that helps the well-being of others.
- It needs to be thematically fitting for the game; immersion is a critical factor, and searching for exoplanets is a complete home run for a spaceship MMO.
- It needs to take a consistent time to solve; we want to have a clear promise to our players of the time they can expect to commit in order to complete a set amount of submissions.
- The dataset needs to be of critical scale/size; EVE players are always eager to take on challenges and thus their participation always exceeds expectations.
- It needs to fulfil a certain level of complexity as we don't want to undermine our players' capabilities.

11. **Sustainability considerations** (funding, community uptake, business openings): External funding (European Commission) and internal (own contribution by participating universities). Data generated by the dynamics of social participation in the MMRPG.

12. **Citizen science approach:** Collaborative.

7. Citizen science activities organised by Tartu University Natural Science Museum

1. **Website:** https://elurikkus.ee/en

2. **Outline:** Initiated by Tartu University, eElurikkus is a portal for the taxa found in Estonia, hosting data on 29,266 species and more than 4 million records. The aim of the portal is to provide a comprehensive resource on Estonian biodiversity by bringing together scientific, monitoring, and citizen science datasets. The portal provides public access to a wide variety of taxa occurrence types including specimens in scientific collections, observations, sounds, images, videos, references in literature and DNA-based observations. Data contributors are collecting institutions, individual collectors and community groups. In this framework, the National Science Museum has organised several citizen science activities, such as data collection of fungi Mushroom Foray, a marathon of nature observations with BioBlitz format, and a project of plant herbarium collection that also engaged school students.

3. **Main organisers:** Tartu University Natural Science Museum.

4. **Type of activity:** Data collection (main type of activity), collective intelligence, grassroots activities.

5. **Format:** Database portal.

a. **Participation modalities:** Eventually available by project. Nature Observation Marathon's process is explained here and the observation format used was BioBlitz; process of the plant herbarium collection project explained here.

b. **Location:** Online and offline in natural sites of Estonia.

c. **Duration:** Ongoing (for the databases).

6. **HE role(s):** Initiative, design, data processing.

7. **HE staff investment and their profile:** Not found. University staff are developing and managing the web-based database where all the data are gathered. University scholars carry out research on the data collected and analysed. Moreover, scientists from the university use these data in their teaching and scholar activities.

8. **Type of HE investment:** Technical, material and human resources. Tartu University (through the Natural Science Museum) contributes to developing the web-based database where people can share their data with scientists.

9. **Quality and impact of the achieved activity**: eElurikkus currently hosts 4,004,362 occurrences, 29.266 species, 6 data resources, and 6 data partners. The Nature Observation Marathon was awarded the Estonian Science Council's Science Popularization Award 2018 as the best new initiative.

10. **Ethical and legal considerations, data management:** Not found.

11. **Sustainability considerations** (funding, community uptake, business openings): Supported by Tartu University, collaborating with multiple data partners, interacting with civil society, investing in youth.

12. **Citizen science approach**: Contributory.

8. #DataOnTheStreets Rally and the Better Budget Dataquest

1. Websites: http://www.fiscaltransparency.net/use/dataonthestreets-international-rally/ and http://www.fiscaltransparency.net/use/better-budget-dataquest-for-sustainable-development/
2. **Outline:** On Open Data Day (ODD), GIFT, a global network that facilitates dialogue between governments, civil society organisations, international financial institutions and other stakeholders to find and share solutions to challenges in fiscal transparency and participation, invites citizens to participate in two main data collection events: a) In the #DataOnTheStreets Rally (#Rally), citizens use publicly accessible data generated by the government regarding investment projects, as well as the respective transparency platforms, to follow up on public construction. b) Based on Sustainable Development Goals (SDGs), the Better Budget Dataquest for Sustainable Development (BBD), organised for the first time in 2019, focuses on gender, inequality and environment. Citizens are invited to explore the open data of public expenditures and relate them to additional data and contextual information to present findings on the implications of the allocation and execution of the budget.
3. **Main organisers:** GIFT and GIFT's Stewards.
4. **Type of activity:** Data collection (main type of activity), analysis tasks, collective intelligence.
5. **Format:**

a. **Participation modalities:**

- The #Rally: Governments, through their Ministry of Finance, Public Works or similar department, and one or more civil society organisations launch an open invitation to participate in the #Rally. People register for the event and go through construction project datasets or mapping platforms published and select the ones they want to visit. Participants go out into the streets and check the projects, comparing what they see on the dataset and what they see on the streets. Participants document their findings through social media (Facebook or Twitter), posting creatively and engaging their own network. Judges, representatives from government and civil society choose the winners based on number of projects visited, creativity, engagement and, of course, extra points for data analysis. On Open Data Day, winners are announced.
- The BBD: Citizens with intermediate to advanced knowledge in the fields of data science, economics and journalism (or similar), form groups of up to five people to explore the spending dataset. By contextualising it with other data they are invited to come up with findings for one of the following categories: gender, inequality or environment. A multimedia piece, the start of a research project, a story or other creative ideas must be presented by the end of the event. Considering the insights, judges from government and civil society will decide the winners.

b. **Location:**

- The #Rally: Mexico, Chile, Colombia.
- The BBD: Argentina, Chile, Colombia, Costa Rica, Indonesia, Mexico, South Africa and Uruguay.

c. **Duration:** 2-4 weeks varying from country to country.

6. **HE role(s):**

- The #Rally: Not mentioned.
- The BBD: Co-conveners in the local events (in the cases of Costa Rica, Indonesia, South Africa).

7. **HE staff investment and their profile:** Not mentioned in either event.
8. **Type of HE investment:**

- The #Rally: Not mentioned.
- The BBD: Technical, material and human resources not explicitly mentioned.

9. **Quality and impact of the achieved activity:**

a. **Quality:** Both initiatives are compliant with the GIFT Principles. In both types of activities, the need to improve the publication of government data was palpable.

- The #Rally continued to encourage the population to use budget, public works and procurement open data to monitor public investment. It is noteworthy that in most of the publications, users indicate a connection between the data and the investments implemented, as well as positive effects derived from them, which, unlike tools solely oriented to the reporting of irregularities, support improving communication between government and society. In the specific case of Chile, it even allows improving communication between government, society and the private sector. However, it also allowed the detection of irregularities, if any, and channelling them to the corresponding authorities.
- Regarding the particular aspects of BBD, there was a growing interest of users in linking the budget and its non-financial performance beyond the execution of resources. This is significant because it implies that the results generated can lead to more specific observations that allow the improvement of the design of government programmes and the structure of spending. It also promotes the need to strengthen the discussion on open data to not only cover the budget and spending, but also its non-financial indicators, goals and progress.

b. **Impact:** Each of the events had its particular characteristics depending on the focus of the conveners and the context of the country. However, during the weeks of the event it was possible to reach more than 1,300 people (1,011 in the #Rally and more than 317 in the Dataquest) in 8 countries on 3 continents. With these activities the population reviewed 447 public construction works in the 8 countries where the #Rally was held and governments received proposals to improve the impact of public resources with a focus on sustainable development.

10. **Ethical and legal considerations, data management:** Both initiatives focus on generating a more informed, participatory and involved society.
11. **Sustainability considerations** (funding, community uptake, business openings): Both are initiated by GIFT, a long-term project with high-level international support and a prestigious profile. Furthermore:

- The #Rally was welcomed and supported by governments and important social stakeholders. However, efforts should focus on encouraging public participation as described above, in quality and impact.
- A 2nd edition of the BBD in the framework of Open Data Day 2020 is roughly outlined here.

12. **Citizen science approach:** Contributory.

9. iScape Living Labs

1. **Website**: https://livinglabs.iscapeproject.eu/

2. **Outline:** iSCAPE is an EU-funded project that aims to integrate and advance the control of air quality and carbon emissions in European cities through the development of sustainable and passive air pollution remediation strategies, policy interventions and behavioural change initiatives. A number of citizen science workshops take place in each of their iSCAPE Living Lab cities: Bologna (Italy), Bottrop (Germany), Dublin (Ireland), Guildford (UK), Hasselt (Belgium) and Vantaa (Finland). Citizens use data-collection kits (Smart Citizen Kits), to share data on air quality data and share them through the Smart Citizen platform. The short-term goal is to build an air quality monitoring community motivated to influence and change local policies around air pollution. The long-term objective is to have citizen scientists actively working and collaborating with the Living Labs.

3. **Main organisers:** A partnership of European institutions funded by the EU project iScape: University College Dublin, Ireland; Università di Bologna, Italy; University of Surrey, United Kingdom; Trinity College Dublin, Ireland; Finnish Metereological Institute, Finland; Universiteit Hasselt, Belgium; Technische Universität Dortmund, Germany; JRC – Joint Research Centre – European Commission, Institute for Environment & Sustanaibility; Institut D'Arquitectura Avancada De Calanyua – Fab Lab Barcelona, Spain; T6 Ecosystem, Italy; Nanoair Solutions, Spain; Future Cities Catapult, United Kingdom; Dublin City Council, Ireland; Agenzia Regionale Prevenzione e Ambiente dell'Emilia Romagna, Italy; European Network of Living Labs, Belgium.

4. **Type of activity:** Data collection (main type of activity), participatory experiment, collective intelligence.

5. **Format:**

a. **Participation modalities:** Framework developed around the following steps: 1. Preparation and promotion of the citizen science workshops 2. Delivering the first workshop. 3. Citizen scientists collecting data. 4. iSCAPE data scientists analyse and visualise datasets. 5. Delivery of the second workshop where the teams analysed their data and developed engaging stories. 6. Discussing and planning next steps for the citizen science community. 7. Long-term future engagement with the community.

b. **Location:** Bologna (Italy), Bottrop (Germany), Dublin (Ireland), Guildford (UK), Hasselt (Belgium) and Vantaa (Finland).

d. **Duration:** Not found.

6. **HE role(s):** Project management, monitoring, evaluation, consulting, research, observation, data collection.

7. **HE staff investment and their profile:** Scholars, project managers, PhD and post-doctoral students and researchers.

8. **Type of HE investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity:** 143 registrations and approximately 93 participants across the 6 Living Lab cities.

10. **Ethical and legal considerations, data management:** "iScape advocates for the effectiveness of openness and sharing, thus it strives to make data collected during the project as available as possible within the limit of personal privacy." More here, esp. pp. 14-15.

11. **Sustainability considerations:** (funding, community uptake, business openings): iSCAPE has received funding from the European Community's H2020 Programme.

12. **Citizen science approach:** Contributory.

10. Mosquito Alert

1. **Website:** http://www.mosquitoalert.com/en

2. **Outline:** Mosquito Alert is a cooperative citizen science observatory coordinated by public research institutions. Its main objective is to fight against the tiger mosquito and the yellow fever mosquito expansions, two invasive species vectors of global diseases such as Zika, Dengue and Chikungunya. The collected information complements the scientific work and allows public health managers to use this information to monitor and control the spread of mosquitoes in neighbourhoods and cities. The software used in the Mosquito Alert application is free and open source.

3. **Main organisers:** CREAF (Centre de Recerca Ecològica i Aplicacions Forestals), ICREA (Institución Catalana de Investigación y Estudios Avanzados) and CEAB-CSIC (Centro de Estudios Avanzados de Blanes)

4. **Type of activity:** Data collection (main type of activity), collective intelligence.

5. **Format:**

a. **Participation modalities:** With the Mosquito Alert app anyone can report a possible finding of tiger mosquito or yellow fever mosquito and their breeding places on the public road by sending in a photo. The photo records the GPS position along with other detailed information. Subsequently, a team of expert entomologists validates the photos received. The result of the validation is sent directly to the participant and published in the observation map. In the map, it is possible to consult and export all observations from 2014 to the present.

b. **Location:** While the initiative is indeed based in Spain and most findings are local to Spain, they invite participation from citizens all over the world. If you have a look at the map you can see that they have received contributions from citizens (scientists) from all over the globe (source).

c. **Duration:** Ongoing.

6. **HE role(s):** University staff belong to the evaluation committee (source).

7. **HE staff investment and their profile:** Several members of their team of experts are affiliated with universities (lecturers, PhDs, etc.) (source).

8. **Type of HE investment:** Scholar investment.

9. **Quality and impact of the achieved activity:** Mosquito Alert is a Member of The Citizen Science Office of Barcelona and The European Citizen Science Association (ECSA). Since 2014, there have been 67,113 accumulated app downloads, 70,233 citizen scientists, 13,992 tiger mosquito reports made, and 4,042 breeding site reports.

10. **Ethical and legal considerations, data management:** Mosquito Alert is an Open Science project. For this reason, the data and works collected are made public in an interactive online map. Part of the database is distributed to the public under licence CC0 in the platform Zenodo. Once validated by expert entomologists, all images collected by the users are shared through the GitLab platform to be used by other researchers.

11. **Sustainability considerations** (funding, community uptake, business openings): Supported by Obra Social "La Caixa", co-funded by Dipsalut and FECYT, sponsored by LOKIMIKA.

12. **Citizen science approach:** Contributory.

11. NASA's GLOBE Observer

1. **Website:** https://observer.globe.gov/

2. **Outline:** GLOBE Observer is an international network of citizen scientists and scientists working together to learn more about our shared environment and changing climate. Participants regularly submit observations through the GLOBE Observer application. Observations of Clouds, Mosquito Habitats, and Land Cover are accepted, with planned expansion to other types of data in the future. The cloud observations help NASA scientists understand clouds from below (the ground) and above (from space). There are several ongoing challenges, such as the "Fall Cloud Challenge", where participants enter up to 10 observations per day of clouds, dust, haze or smoke during a full month in 2019.

3. **Main organisers:** Supported by: NSF (National Science Foundation), NOAA (National Oceanic Atmospheric Administration) and the US Department of State. Further supported through NASA's network https://www.globe.gov/globe-community/community-map.

4. **Type of activity:** Data collection, collective intelligence.

5. **Format:**

a. **Participation modalities:** Participants should see training requirements under Quality Assurance below.
b. **Location:** Exclusively online.
c. **Duration:** Unlimited.

6. **HE role(s):** External evaluation; scholar validity. For instance, scholars from Oregon State University act as external evaluators for the GLOBE Observer team. University Corporation for Atmospheric Research (UCAR) is a network of more than 100 colleges and universities providing research

and training in the atmospheric and related sciences. UCAR assists the GLOBE programme with implementation.

7. **HE staff investment:** Mostly academic. Interns are also involved (source).

8. **Type of HE staff investment and their profiles:** Scholar, technical, administrative.

9. **Quality and impact of the achieved activity:**

a. **Quality:** Several Quality Assurance measures apply, depending on the level of involvement. Information is retrieved from the GLOBE data user guide available on the project website.

- Training: GLOBE requires training to ensure quality and consistency in data collection. GLOBE users must complete the necessary training either by attending a GLOBE workshop or by completing online eTraining modules and assessment tests to enter data via the GLOBE desktop data entry forms or through the GLOBE data entry app. The user must complete three modules and take the following corresponding assessment tests to become a trained GLOBE user via eTraining: a) Introduction to GLOBE; b) Introduction to a Sphere (Atmosphere, Biosphere, Hydrosphere, or Pedosphere); c) Protocol Module (from the same sphere as the Introduction module). The user can enter data for any of the GLOBE protocols after completing a workshop or the required eTraining modules and assessments.
- Completeness: A measurement must contain all required elements before it can be submitted and stored in the GLOBE database.
- Range and Logic Checks: Observations submitted to GLOBE must pass range and logic checks before the data are allowed in the database.
- Photo Approval: Photos submitted through the GLOBE Observer app are screened before being added to the public GLOBE database. Photos containing inappropriate content, faces, or personally identifiable information (e.g., automobile licence plate numbers) are removed or blurred.

b. **Impact:** Several GLOBE projects are running (related to clouds, water, plants, and other life in support of climate research) thus impact is depicted in each project website.

10. **Ethical and legal considerations, data management:** GLOBE promotes full and open sharing of its data for educational and scientific purposes.

11. **Sustainability considerations** (funding, community uptake, business openings): NSF (National Science Foundation), NOAA (National Oceanic Atmospheric Administration) and the U.S. Department of State, plus the network of member countries support the GLOBE initiative (source).

12. **Citizen science approach:** Collaborative.

12. Smartfin

1. **Website:** https://smartfin.org/

2. **Outline:** Scientists confirm that the way the ocean handles continued increases in heat and carbon dioxide will largely determine how the Earth responds to climate change. With the coastal zones being highly dynamic in terms of biodiversity and human activities, it becomes challenging and expensive

to measure the trends and effects of climate change in these areas. As a result, our understanding of climate change in our coastal zones remains incomplete. The Smartfin Project aims to unite the surfing community and the research community in an effort to fill this gap. The Project offers research-grade, data-collecting surfboard fins ("Smartfins") to its ocean-engaged members and encourages them to surf or SUP with the fins regularly to transfer useful nearshore data to the open cloud for oceanographic scientists to use in their research. The Smartfin Project is partnered with researchers at the Scripps Institution of Oceanography, a department of UC San Diego and one of the world's leading institutions for oceanographic research.

3. **Main organisers:** SmartFin is an initiative of Scripps Institution of Oceanography which has partnered with Surfrider Foundation, LostBird and Futures since 2016.

4. **Type of activity:** Data collection (main type of activity), collective intelligence.

5. **Format:**

a. **Participation modalities:** (Information available only on the San Diego pilot.): Each month the San Diego chapter of the Surfrider Foundation organises Smartfin events, including demo days, monthly committee meetings, and special events, to bring scientists, ocean activists, surfers and the general public together. Participants were asked to use the Smartfin at least twice a week and share their thoughts and feedback to Smartfin programme managers and engineers (more here).

b. **Location:** San Diego (initiative and pilot); multiple near-shore ocean locations all over the globe (data collection).

c. **Duration:** Ongoing.

6. **HE role(s):** Through the Scripps Institution of Oceanography (University of California San Diego): Design and implementation of the initiative; Research; Coordination.

7. **HE staff investment and their profile:** Scientists/Researchers.

8. **Type of HE investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity:**

a. **Quality:**
- Mission: An initiative about inspiring community-based environmental awareness and actions focused on global ocean health. The belief that underlies the Smartfin Project is that collaborative partnerships and open dialogue between experts, scholars and engaged, empowered citizens is the only way to affect the kind of large-scale, meaningful change necessary to combat society's most daunting challenges.
- Q&A: The San Diego pilot was conducted in 2017 to secure community engagement, prove data quality and test how effectively Smartfins could be used to fill in the geographical gaps between more traditional sensors.

b. **Impact:**
- Overall project: Data collected from a multitude of near-shore ocean locations all over the world.
- The San Diego pilot: 70 Smartfins were distributed; over 800 hours of data collected.

10. **Ethical and legal considerations, data management:** Data are open and accessible by location through an interactive map featuring on the website's home page.

11. **Sustainability considerations (funding, community uptake, business openings):**

- Smartfin's initiator and partners are proof that the initiative has backing from academia, civil society and the innovation-driven private sector.
- Furthermore, its website gives access to an online donation platform for contributions to be collected and reinvested back into furthering Smartfin's goals (more specifically, continued fin engineering, updates and improvements and sharing the impact of climate change through high-quality content).
- In 2019 new locations hosting active surfing communities and high-priority areas for oceanographic research have been added.

12. **Citizen science approach:** Contributor.

13. Europeana Transcribathon

1. **Website:** https://transcribathon.com/en/

2. **Outline:** Europeana Transcribathon is an online crowdsourcing initiative for the transcription and annotation of unique, unpublished material related to World War One. The aim is to create a vast and fully digital record of the written stories in Europeana 1914-1918 by allowing any person to transcribe, annotate and geo-tag their rich content. To engage citizens, special competitions that feature hand-picked selections of documents, called "runs". They are organised as face-to-face events or as online competitions based on a common theme.

3. **Main organisers:** Europeana, which is an initiative of the European Union, financed by the European Union's Connecting Europe Facility and European Union Member States.

4. **Type of activity:** Pooling of resources, data collection, analysis tasks.

5. **Format:**

a. **Participation modalities:** Several possibilities. Face-to-face events ("Runs") lasting one day, such as Transcribathon Cyprus, or a longer timeframe (eight-week-long Versailles Run). They can also be exclusively online (Europeana 1914-1918 online) or blended, such as the Love Letter Run, which includes documents containing personal love stories from WW1. It was launched as a face-to-face event at Valentine's Day 2017 and it has continued online after since.

b. **Location:** Local events and also on the Internet, through the online facility for transcriptions, featuring game-based elements.

c. **Duration:** Limited for the face-to-face thematic Runs (1 or 2 days) or unlimited (online transcriptions).

6. **HE role(s):** In particular, in Europeana Transcribathon 1914-1918, there is no HE institution directly involved. However, university staff members are involved on an individual basis as members of Europeana Network Association or Europeana Expert groups, cf. Europeana Pro.

7. **HE staff investment and their profile:** There is not any HE institution specifically designated as contributing. However, university staff are involved in the Europeana Network Association (currently 2000 members) and in the several Expert Groups (Europeana Tech; Education, Research, Collections, etc.)

8. **Type of HE staff investment:** Members of the Europeana Network Association and the Expert Groups work on a voluntary basis. They can cover technical or academic profiles.

9. **Quality and impact of the achieved activity**:

a. **Quality**: Regarding Transcribathon 1914-1918, the quality-assurance mechanism is not explicitly described. One reads "Your contribution will be reviewed by a Europeana cataloguer. When your contribution has been reviewed and accepted it will become visible for others" when creating an account to transcribe.

b. **Impact:** To date, more than 16,000 stories of WW1 have been generously contributed to Europeana 1914-1918 from the public. Scanned at over 180 Collection Days across 22 European countries and by uploads to the online portal, the archive exhibits over 200,000 personal items from these stories. Regarding Transcribathon in general, the following data are available: [Data as of 22/11/2019]: Document statistics: 1,729 Stories uploaded; 1,198 Stories started; 359 Stories completed; 54,019 Documents uploaded; 16,758 Documents in progress; 10,723 Documents started; 6,035 Documents in review; 1,486 Documents completed. User statistics: 2,176 Registered users; 1,885 Recruits; 133 Runners; 153 Champions; 5 Mentors.

10. **Ethical and legal considerations, data management:** Not mentioned. See also in relation to point 12 below.

11. **Sustainability considerations** (funding, community uptake, business openings): Europeana is a Digital Structure Infrastructure (DSI) supported by the European Union. As a pan-European initiative, Europeana will continue to connect the online collections of Europe's cultural heritage institutions.

12. **Citizen science approach:** Collaborative.

14. Flint Water Study

1. **Website:** http://flintwaterstudy.org/

2. **Outline:** In 2014, the city of Flint, Michigan, switched its water supply to the Flint River in an effort to save money. From this moment on, citizens complained about the smell, taste, and appearance of the water, but their complaints were ignored by experts and local politicians. At the end of summer 2015, in order to prove the high water risk, students and researchers at Virginia Tech provided Flint residents with water test kits and worked with them on collecting, analysing, and communicating the results, whereby they detected extremely high levels of lead and copper contamination. Based on these facts, the state and the federal government finally took action and President Obama signed an emergency declaration. All data, research, articles and updates are being stored in the Study's website.

3. **Main organisers:** The Virginia Tech Research Team, with the following collaborators and information sources: American Civil Liberties Union Michigan; Concerned Pastors for Social Action; City of Flint Water Service Center; Democracy Defense League; Michigan Department of Environmental Quality; Parents for Non-toxic Alternatives; "Water You Fighting For?" community.

4. **Type of activity:** Data collection.

5. **Format:**

a. **Participation modalities:** Residents were sent a sample kit and an accompanying instruction sheet. They were required to proceed with water sampling according to the instructions (here) and return the samples to Virginia Tech.

b. **Location:** In Flint (Michigan, US) and online.

c. **Duration:** Data collection: all 300 sample kits were sent out on August 14th and reached Flint on August 19th 2015. Of the sample kits, 84% had been returned and analysed by early September 2015. The overall initiative peaked in 2015 and 2016 and is still ongoing through the updates on the FlintWaterStudy website.

6. **HE role(s):** Initiation, coordination, principal investigation, implementation.

7. **HE staff investment and their profile:** Undergraduate and graduate students, post-docs/research scientists and one Virginia Tech staff member as members of the team; scholars and researchers as principal investigators.

8. **Type of HE investment:** Technical, human resources, (in part) material (cf. Sustainability below).

9. **Quality and impact of the achieved activity:** Of the sample kits, 84% (252/300) had been returned by early September 2015. Based on the results, the state and the federal government took action and President Obama signed an emergency declaration freeing up to $5 million in federal aid to immediately assist with the public health crisis.

10. **Ethical and legal considerations, data management:** Strong engineering ethics aspect, as the team members have also taken a graduate-level "Engineering Ethics and the Public" course at Virginia Tech. Interviews and interactions conducted with the community and the stakeholders were, therefore, grounded in current ethnographic research and tools developed around 'transformational listening'.

11. **Sustainability considerations** (funding, community uptake, business openings): The National Science Foundation supported the initiative with two research grants: a) RAPID Response (CBET-1556258) grant and b) the Bridging the Gap Between Engineers and Society: Learning to Listen (EEC-1135328) grant. Two fundraising campaigns, including SafeWater4Flint fundraising campaign and FlintWaterStudy Research Support Fundraiser were initiated. Further financial support was offered by professor and principal investigator Marc Edwards to advance scientific understanding.

12. **Citizen science approach:** Contributory.

15. Open Seventeen

1. **Website**: http://openseventeen.org/plastic/

2. **Outline:** O17 is a challenge-based, online interactive coaching programme that supports and rewards teams developing innovative and implementable solutions for the 17 UN Sustainable Development Goals (SDGs). An O17 coaching cycle starts with a call for projects to solve concrete challenges inspired by experts from UN agencies, international organisations and NGOs targeting one or more of the SDGs. The call might have a specific target audience, such as students, or be open to anyone. In the currently running the 3rd edition of O17, the challenge targets plastic pollution, and it is run in collaboration with UN Environment (UNEP). On successful completion, the most promising solutions will be offered travel grants to Geneva (Switzerland) to attend international events such as the WSIS Forum 2020 and AI for Good. O17 participants are encouraged to use the SDG Solution Kit, comprising tools adapted from existing open source solutions that can support a wide range of crowdsourcing projects for the SDGs, ranging from crowd-based data collection and classification to distributed volunteer computing to project design and community mapping tools.

3. **Main organisers:** Citizen Cyberlab, University of Geneva; Citizen Science Centre Zurich (University of Zurich and ETH Zurich); Governance Lab, New York University. With the support of Geneva Tsinghua Initiative.

4. **Type of activity:** Pooling of resources (main type of activity), data collection, collective intelligence.

5. **Format:**

a. **Participation modalities:** In O17, applicants submit ideas for projects that tackle the climate challenge and the most promising among them are selected and teams are formed. The teams receive interactive online mentoring and coaching from international experts and coaches to transform their ideas into viable projects. The initiative's 3rd edition runs from October (applications closed on 27th) through to December 2019. A total of 30 international undergraduate students from diverse disciplines and regions were selected and online coaching will take place over 5 weekly 2-hour interactive sessions in November and December. The coaching includes weekly homework and work with the virtual team on group assignments concerning each project proposal. On successful completion of the O17, participants may be eligible for travel grants to Geneva (Switzerland) to attend international events.

b. **Location:** Online.

c. **Duration:** Ongoing, 3rd edition currently running.

6. **HE role(s):** Initiators, coordinators, experts.

7. **HE staff investment and their profile:** Scholars, directors and researchers of the organizers' teams as co-founders and coordinators of the O17 project.

8. **Type of HE staff investment:** Technical, material, human resources.

9. **Quality and impact of the achieved activity**: According to Yves Flückiger Rector, University of Geneva and Nikhil Seth – Executive Director, UNITAR, Geneva: "...data that have been crowdsourced by civil-society ventures should be incorporated into the international process of monitoring the SDGs. To

address potential issues of data quality, initiatives such as the Open Seventeen Challenge are necessary to train organizers of crowdsourcing projects." (source).

10. **Ethical and legal considerations, data management:** O17 favours solutions that use crowdsourcing and open data. The SDG Solution Kit is openly accessible.

11. **Sustainability considerations** (funding, community uptake, business openings): The initiative is co-organised and supported by three high-credibility organisers.

12. **Citizen science approach:** Contributory.

16. Open source electric vehicle

1. **Website**: https://www.openmotors.co/tabbyevo/

2. **Outline**: TABBY EVO is an open source, ready-to-use, completely modular framework for the creation of complete electric vehicles, designed and engineered by OS Vehicle (currently Open_Motors). According to its founders, it can be used to bootstrap businesses (electric vehicle (EV) start-ups), to create one's own vehicle for educational purposes, and more. EVO is the 2nd, harder, better, faster and stronger version of the platform released in 2015. All the plans and blueprints can be downloaded in the Open Motors website's download section. Users are encouraged to improve the designs, work on them, and upload them to share their ideas with the community through the Open Motors forum.

3. **Main organisers:** Open Motors.

4. **Type of activity:** Collective intelligence.

5. **Format:**

a. **Participation modalities**: Because TABBY EVO is a hardware open source platform for electric vehicles, the source code is open to further development. It is also possible to contribute by offering new ideas, or improving the designs and uploading them to share with the community through the Open Motors forum. In this page, there is a call for contribution to the following hardware open source areas:

- FEM structural analysis.
- Dynamic analysis.
- Electromagnetic compatibility test.
- Chassis fatigue analysis.
- Crash test dynamic simulation for M1 type-approval.

b. **Location:** Open Motors community (currently unavailable).

c. **Duration:** Unlimited.

6. **HE role(s)**: Not mentioned.

7. **HE staff investment and their profile:** Not mentioned.

8. **Type of HE staff investment:** Not mentioned.
9. **Quality and impact of the achieved activity:**

a. **Quality**: The crowdsourcing and business dimension acts as quality framework.

b. **Impact:**

- Environmental impact: The platform brings a better solution for eco-friendly mobility because it is electric, it is NOT designed and engineered "for the dump" and it is perfect for eco-friendly services.
- Social impact: This hardware open source platform brings social innovation through a new approach to vehicle manufacturing (open source, electric, modular).
- Financial impact: The platform greatly reduces barriers to entry in the automotive industry, providing a cost-effective and faster R&D and manufacturing.

10. **Ethical and legal considerations, data management:** The source code is available under a GPL-3.0 licence.
11. **Sustainability considerations** (funding, community uptake, business openings): Open Motors is a B2B company whose revenue comes from the manufacturing and the sales of non-assembled finished vehicles. Open Motors also provides on-demand design and engineering services for complete personalisation, bringing together a rich ecosystem of entrepreneurs, developers, designers, and engineers. Other examples of vehicles cocreated in an open innovation fashion, include the Rally Fighter model, produced by Local Motors, a ground mobility company, and developed through its crowdsourcing platform, Launch Forth (this model is no longer on the market). It is believed that the open innovation approach adopted catalyses the car manufacturing field. As an example, in the flourishing market of electric cars, in 2016 Renault has developed POM, an open-source automotive platform and is now partnering with Open Motors to develop and sell this open-source platform readily accessible to the community.
12. **Citizen science approach:** Co-created.

17. DigiEduHack

1. **Website:** https://digieduhack.com/en/
2. **Outline:** DigiEduHack is an initiative by EIT, the European Institute of Innovation and Technology, under the European Commission's Digital Education Action Plan, led by EIT Climate-KIC and coordinated by Aalto University. The aim is to empower people to articulate and to engage, participate in and shape the future using digital technologies and education. Organisations willing to register as DigiEduHack hosts from all over the globe invite students, entrepreneurs, teachers, researchers and education professionals to co-create solutions to a specific digitalisation and learning challenge in a 24-hour hackathon. The DigiEduHack 2019 version simultaneously took place in 21 countries, with more than 1,700 participants solving 60 challenges. The result is hundreds of innovative solutions reinventing the future of education, which were submitted for online voting.
3. **Main organisers:** European Institute of Innovation and Technology (EIT)/EIT Climate-KIC; Aalto University

4. **Type of activity:** Pooling of resources (main type of activity), analysis tasks, collective intelligence.
5. **Format:**

a. **Participation modalities:** Once registered, host organisations work on defining the digital education challenges they want to tackle; they invite students, teachers, educators and staff, partners from companies and start-ups (or any other stakeholders) to work with them to envision ideas and design solutions for the challenges and participants are registered; the DigiEduHack lasts 24 hours and consists of the following steps: Welcome session; Inputs on the digital education challenge(s); Team formation, Ideation; Parallel workshops; Energising activities; Final presentations to the jury; Wrap-up and closure; Winning teams announced and prizes given. One month later the Global Award Contest takes place online and the best solutions are selected online by the general public.

b. **Location:** In cities of Europe, Asia, Africa and the Americas, and online.

c. **Duration:** 26 April - 3 October (DigiEduHack day) 2019. In November: Global Award Contest.

6. **HE role(s):** For Aalto University who, together with EIT, are the leaders of DigiEduHack: design and implementation of the entire set of DigiEduHack activities; hosting of the main event of October 3, coordination and monitoring of applications by local institutions who host DigiEduHacks locally, scientific consultation, networking and integration of external stakeholders (policy makers, business, schools).
7. **HE staff investment and their profile:** Academic (conceptual design, strategy, implementation and scientific monitoring of results, outreach) and technical (hosting of events, website-related work, reporting).
8. **Type of HE investment:** Technical, material, human resources.
9. **Quality and impact of the achieved activity:**

a. **Quality:** DigiEduHack offers participants the chance to take action to create real solutions for digital education challenges. It is an opportunity to explore challenges and form teams, find solutions and test them, and to present progress and win support.

b. **Impact:** DigiEduHack 2019 took place simultaneously in 21 countries, with more than 1,700 participants solving 60 challenges during the course of 24 hours. The result is hundreds of innovative solutions reinventing the future of education.

10. **Ethical and legal considerations, data management:** Not found.
11. **Sustainability considération**s (funding, community uptake, business openings): DigiEduHack is launched and supported by EIT. Global community response and uptake in 2019 were promising.
12. **Citizen science approach:** Co-created (challenges identified and tackled, local hackathons organised, local winners selection and online voting).

18. Climathon

1. **Website:** https://climathon.climate-kic.org/
2. **Outline:** Initiated by the European Institute of Innovation and Technology (EIT), Climathon is a year-round programme, with a solutions-hackathon at its core, translating climate action solutions into tangible projects, supporting climate positive businesses and start-ups and addressing local policy changes. Several challenges, such as the circular economy, waste management, extreme weather, energy, etc., are identified and tackled by Climathons. Recently a Young Climathon was initiated to host a one- to two-day climate hackathon where students work on a real climate challenge from an industry sector, city, company or school. Furthermore, in 2019 the Climathon Global Awards were introduced, to award citizens and cities for local climate innovation and to offer exposure and support to scale the selected solutions' impact.
3. **Main organisers:** European Institute of Innovation and Technology (programme initiator).
4. **Type of activity:** Collective intelligence (main type of activity), pooling of resources, analysis tasks, grassroots activities.
5. **Format:**

a. Participation modalities:

- Organisations can apply to become either City Organisers or Partners. It is also possible to join as individual participant.
- Any city in the world is eligible to organise a Climathon. Climathon events are organised by city authorities or municipalities, NGOs/ NPOs, community organisations/co-working spaces, educational institutions, SMEs or others. (Specific organising modalities and benefits here).

b. **Location:** All over the world (currently 125 cities, 52 countries, 6 continents).

c. **Duration:** Ongoing, running since 2016.

6. **HE role(s):** Main city partners (in limited cases); one university (Valencia) as partner of the Young Climathon.
7. **HE staff investment and their profile**: Not mentioned.
8. **Type of HE investment:** Not mentioned.
9. **Quality and impact of the achieved activity**: Climathon has grown to over 100 cities and 5,000 participants and with a global reach in the millions. At the Global Climathon Day 2019, Climathons were carried out in 125 cities, 52 countries, and 6 continents. (By 2022 they expect to unite over 1,000 cities, 100,000 participants; engaging 1 million citizens and reaching over 100 million and more).
10. **Ethical and legal considerations, data management**: Not found.
11. **Sustainability considerations** (funding, community uptake, business openings): A programme initiated and supported by the European Institute of Innovation and Technology (EIT). Further partnership and support: Impact Hub, OIKOS, Covenant of Mayors for Climate & Energy, Youth Action Net, Make Sense.
12. **Citizen science approach:** Collaborative.

19. AirCitizen

1. **Website:** http://aircitizen.org/
2. **Outline:** The AirCitizen project aims at giving citizens the ability to actively probe their close environment and the air they breathe, through: a) making mobile environmental stations in fablabs that include several low-cost sensors (i.e. temperature, relative humidity, pressure, NOx, ozone or fine particles PM10 and PM2.5); b) performing *in situ* measurements to evidence the spatial and temporal variabilities of the environmental parameters: in mobile measurement campaigns, with the help of climatologist-geographers, and in various places with a variety of environmental contexts; and c) contributing to the improvement of environmental knowledge by sharing the measurements in a database, thus allowing an online cartography of air pollution. AirCitizen is a collaboration between business and public sector institutions (research centres, universities, regional policymakers). Within the AirCitizen project, workshops are held, offering the opportunity to researchers, hackers and citizens to meet, discuss and exchange information.
3. **Main organisers:** Individual scholars and researchers, students at MSc Dynarisk (Paris 1, Pantheon-Sorbonne), students at the fablabSU and the workshops' participants as contributors. Collaborators include: Labo Citoyen Christophe Bailly; Carrefour numérique; Huma-Num; CIST - Collège International des Sciences Territoriales; PMC Lab; FabLab Sorbonne Universités; LabEx DynamiTE; Région Ile de France; PRODIG (CNRS); PHENIX (CNRS)
4. **Type of activity:** Data collection (main type of activity), analysis tasks, grassroots activities, collective intelligence.
5. **Format:**

a. **Participation modalities:** Participants are invited to join the project's workshops, the mobile measurement walks and campaigns and the sharing of measurements on a database.

b. **Location:** France (primarily Paris).

c. **Duration:** Ongoing.

6. **HE role(s):** Collaborators.
7. **HE staff investment and their profile:** Scholars; researchers; students.
8. **Type of HE investment:** Technical, material, human resources.
9. **Quality and impact of the achieved activity**: AirCitizen's workshops are successful prototypes of citizen science, during which researchers, hackers and citizens have the opportunity to meet, discuss and exchange information.
10. **Ethical and legal considerations, data management:** The project promotes environmental awareness and behavioural change regarding air quality.
11. **Sustainability considerations** (funding, community uptake, business openings): Not found.
12. **Citizen science approach:** Collaborative; (in part) Co-creative.

20. Citizen science in Helsinki's Central Park

1. **Website:** https://www.hel.fi/uutiset/en/helsinki/central-park-citizen-science
2. **Outline**: In a research project conducted by the City of Helsinki and Silviya Korpilo, researcher at the University of Helsinki, the aim was to further the planning of the Helsinki's Central Park in an increasingly sustainable direction. A total of 230 volunteers using the park gathered information concerning forest usage and development needs. The information was gathered through employing volunteers' smartphones and GPS data. As they roamed about in the forest, exercise applications on their phones collected data on their movements. The more data entered into the site, the more accurate the view Korpilo and the City of Helsinki gained concerning forest usage and development needs. The initiative served as the pilot study for MyDynamicForest, an ongoing research project and collaboration of the University of Helsinki, Aalto University, the City of Helsinki and citizens to map recreational use and movement in Helsinki's urban forests.
3. **Main organisers:** City of Helsinki; University of Helsinki.
4. **Type of activity:** Data collection (main type of activity), participatory experiment, collective intelligence.
5. **Format:**

a. **Participation modalities:** Study participants were invited to:

- Explore the forest while exercise applications on their phones collected data on their movements;
- Submit their route to the MyDynamicForest website in two different formats: 1) by adding a self-tracked GPS route that they had already collected using any sports tracking application on their personal smartphones; or 2) by drawing it digitally over an Open Street Map basemap;
- Answer a short questionnaire (after submitting a route) that examined their socio-cultural background, activities and route-choice motivations.

b. **Location:** Helsinki Central Park.

c. **Duration:** Several durations possible depending on investment.

6. **HE role(s):** Co-initiation, research, implementation, co-funding.
7. **HE staff investment and their profile:** Researchers.
8. **Type of HE investment:** Technical, material, human resources.
9. **Quality and impact of the achieved activity:** 599 respondents.
10. **Ethical and legal considerations, data management:**

a. Openly accessible research: an academic paper by (Korpilo, Jalkanen, Virtanen & Lehvävirta, 2018) released in the open-access journal PLOS ONE gives insights into the research findings of this citizen-driven project.

b. Data: The raw GPS tracks cannot be shared publicly due to ethical issues as a GPS track can reveal an individual's home or work location, and patient consent to share the data publicly was not gained. GPS tracking data from the visitor use study can be accessed in an aggregated and anonymised form from Zenodo. An aggregated visualisation of all GPS routes can be seen at the www.mydynamicforest.fi website.

11. **Sustainability considerations** (funding, community uptake, business openings): The project has now ended. The research was co-funded by Maj and Tor Nessling Foundation; Kone Foundation; Finnish National Agency for Education (CIMO); University of Helsinki, Faculty of Biological and Environmental Sciences (SK).

12. **Citizen science approach:** Contributory.

Chapter 4: Synthesis of findings and future directions

This chapter connects the conceptual framework (chapter 1) to the 20 use cases (chapter 3) by highlighting the variety citizen science can entail (4.1), by discussing the open innovation dimension (4.2) and by indicating roles HEIs can adopt (4.3). It ends with future directions in view to strengthening the academia-society relationship through citizen science (4.4).

4.1 Illustrating the variety of citizen science

The 20 citizen science use cases show how diversified public engagement into science can be, and how varied the forms citizen science activities can take, as the following synthesis reflects:

- From bottom-up, citizen-led public activities that turned into citizen science projects with the support of scholars [14] to institutionally-led science initiatives that seek contributions from citizens [5].
- From basic artefacts for data gathering [buckets, 14] to genuine artefacts [Smartfin, 12] and to most sophisticated platforms [Europeana's online transcription tool, 13].
- Various types of input gathered: litter [2], fauna and flora [7], open data [8], air [9, 19], mosquitos [10].
- From projects targeting mostly primary schools [3, 20], to online gamers [6], to HE students [2, 4] and to a very broad audience [10,19].
- From activities where university students co-create with and for citizens in local communities [2,4] to activities where students form international teams to address problems on international level [17, 18].
- From activities primarily targeting HE students to activities combining various stakeholder and professional groups [1, 19].
- From projects not involving HE [16] to university-driven ones [2,4].
- From projects affecting mostly local communities [20] to world change [11,15].
- From less applied, mostly open knowledge projects [14] to open innovation ones [1,16].

Regarding types of projects (item 4, "type of activity", based on the Sanz et al. typology, cf. 1.7), the indicative categorisation we applied to the 20 use cases illustrates the limitations of any attempt at strict categorisation, as, in several cases, a project belonged to more than one type (e.g. [6] and [18] possibly belong to four different types).This is highly significant for the nature of a project, that can contain several stages or forms of citizen engagement within the same project.

With respect to the citizen science approach adopted (item 12, based on the Bonney et al. (2009) typology, cf. 1.7), most of cases seem to belong either to collaborative or contributory approaches, with only a few cases adopting a co-created one. This finding corresponds to studies (English, Richardson & Garzon-Galvis, 2018; Strasser et al., 2019) who claim that citizen science is mostly initiated and driven by institutions and still with relatively little space for co-design and for engagement in the scientific process by scientists and citizens together.

Considering open data generated by the projects that we analysed, our team experimented with the idea of an analysis of the FAIR (Findable, Accessible, Interoperable, Re-usable) data principles (Wilkinson Dumontier, Aalbersberg, et al., 2016) of each project. However, this idea has not been taken further due to the extreme variety of practices, ranging from data not being findable, through all the various

possibilities and up to data being re-usable. We can assert that, in the majority of cases, data generated by the projects analysed are far from being FAIR-compliant. Although a more in-depth analysis would allow us to shed light into the nuances of open data availability and re-use, a first analysis shows that the Interoperable and Reusable data principles are the least explored in this sample of 20 citizen science projects.

4.2 Open Innovation

From our analysis of 20 use cases, the open innovation dimension (cf. 1.6) was demonstrable in two of them: Epidemium [1] and Open Source Vehicle [16].

- Epidemium [1]

Epidemium is built with the mission to rally a community around 21.000 open access databases related to epidemiology of cancer. The key concept is "big data epidemiology", that seeks to query a database already collected before the hypothesis is defined. The project demonstrates an interdisciplinary spirit: the teams registered to the Challenges comprised several volunteers-non experts working together with expert volunteers: data scientists, computer scientists and health professionals or medical researchers (Sitruk & Kazakci, 2018).

- For Open Vehicle [16]

The crowdsourced production of vehicles (TABBY EVO) in an open source fashion promotes openness, experimentation and open innovation, also understood as open source expansion. Other ground mobility companies experimented with open source vehicle manufacturing (cf. Local Motors' Rally Fighter) and then turned to a non-open source co-creation approach for their latest models. The TABBY platform seems to be the only one which still produces vehicles in an open source manner.

Both cases taken together lead to some reflections about open innovation with respect to its position in the citizen science landscape and the role HEIs play in it. First, the citizen science dimension is much more varied in Epidemium than in Open Source Vehicle. While in the latter the final product is an artifact, in the former there are open datasets, artifacts, and scientific publications. Second, Open Source Vehicle is situated in the extremes of citizen science (understood as achievement of a scientific result) and at the same time at the centre of a strong co-creation process.

Another feature worth discussing is the "open" dimension of open innovation. The TABBY EVO Open Vehicle is perhaps one of the rarest examples of open access and open-to-reuse data generated through the co-creation process, as is Epidemium. With regards to the involvement of HE members of staff, this is not stated in the Open Vehicle case, although Epidemium benefits from contribution of one HEI, along with public research centres in France. However, the majority of open innovation projects seem to adopt crowdsourcing as data generation method whereas the end results rarely conform to the principles of openness. End results remain copyright protected or owned by the initiators of the activity, which contradicts the principles of open (and citizen) science. Epidemium is the exception.

With regards to the role HEIs can play, although engaged in open science at various degrees, universities (either as a whole institution or as individuals working or studying) are often absent from open innovation projects. It is more than true that there is plenty of room for improvement for open innovation achieved through public engagement. The intellectual property issue raised above is most probably one of the key

factors impeding broader involvement. However, the two open innovation examples highlighted in this section illustrate that open innovation is not incompatible with open access (or other forms of openness). We thus believe that there is significant potential in HE engagement in open innovation projects, as there is often lack of specific scientific expertise at some stages of the projects. HE staff can thus contribute with specific expertise when needed to several components in the open innovation ecosystem, or, even more importantly, be at the initiative of an open innovation project. This also means that HE policy makers should become more aware of open innovation cycles and of their needs and opportunities for HE involvement.

Finally, the fact that these two projects are both initiated by institutions which are not universities, and the fact that in both the private sector is present (in Open Source Vehicle it is exclusive), tells us a lot about the need for HEIs to embrace cooperation with a range of stakeholders that are already active in the field. Expressed more forcefully, Open innovation is a reality and this without HEIs being necessarily present. A possible explanation is that technology lends itself more to co-creation, while in some cases academia still potentially holds an authoritative position to knowledge production and circulation. The situation is subject to change with awareness raising of open innovation unleashed potential in academia.

4.3 Roles adopted by HE institutions and their staff

The engagement of HEIs in the 20 use cases has been examined through parameters such as their role (item 6 of the typology applied), the investment of HE members of staff on the individual level and the profile of staff involved (item 7), and the type of HE investment (item 8). The degree of cooperation with other institutions within the project ("main organisers", item 3) also helps understand synergies that possibly have been put in place.

Regarding synergies, in each use case analysed cooperation with other institutions has been established, which is an observation showing the openness of HEIs to work hand in hand with other HEIs [5], or other types of institutions [10], or a combination of university and non-academic partners [13]. This openness is by far a positive sign reflecting willingness and also commitment to achieve the aims of the project at hand. We are therefore situated far from a mindset distinguishing "the tower" from "the cloud" in Katz's famous metaphor (2008) or "the cathedral" from "the bazaar" in Raymond's understanding (1999/2001). In the projects analysed in our study, HEIs do make an effort to strengthen the connection of academia to society through citizen science, either through cooperation with other HEIs (which can take the form of broad cross-European partnerships [17, 18] or international ones [15]), including non-academic partners in their strict majority, and engaging citizens in all of them.

Regarding roles of HE members of staff, we also observe a variety of functions adopted, with staff that initiates, implements and monitors the project [2] or acting on an ad hoc basis, as scientific advisers when needed within a project led by another institution [8, 11]. Furthermore, the initiation of the citizen science idea may come from the HE members of staff [20] or not [14]. Along the 20 cases, HE members of staff with different areas of expertise are engaged, depending on the needs of the project (technical, scientific, administrative) and in several combinations. This points to the need for better understanding and addressing the needs for upskilling HE staff to meet the requirements of open and citizen science (European Commission 2017b, Skarlatidou et al., 2019).

Moving a step further, based on the analysis of the current study, the INOS team has produced a set of recommendations regarding actions HEIs can take to strengthen the academia-society relationship

through citizen science. This attempt contributes to other studies in this direction (LERU, 2016; Mitchel et al., 2017; Wyler & Haklay, 2018, Teo, 2020). These recommendations are available as a separate open access publication on the iNOS website (Zourou & Tseliou, 2020).

4.4 The way ahead

Along with the institutional-led initiatives that seem to be the prevailing model in citizen science, this study wishes to emphasise the need for more citizen-led citizen science, or projects that emerge from real needs of communities. Both the Flint Water Study [14] and the Parenting Science Gang [42 of the Annex] demonstrate what can be done when citizens are empowered to be leaders and partners in science. And they are just two among many examples. They demonstrate the potential for citizen science – or more accurately, citizen-led science – to empower the disempowered and disenfranchised. This approach echoes the "extreme citizen science" adopted by the ExciteS team at UCL (Hackay, 2010) as a form of open science that empowers citizens to deal with issues that directly concern them, and an approach that enables communities – regardless of their location, background, culture or literacy levels – to take the lead in research that is directly relevant to them.

The engagement of citizens in moving from mere data collectors to owners of scientific methods and to decision makers together with scientists has a bright future. HEIs due to their social role that they already adopt, can take an active role to ease citizen participation, from the periphery to the centre of citizen science.

Annex

Each case contains a URL, an Outline (consisting of up to 100 words taken from the respective website), information regarding its status (completed, ongoing or annual event). The order of appearance is alphabetical.

1. #EUBeachCleanUp

Website:
https://ec.europa.eu/commission/presscorner/detail/en/ip_19_5609?utm_campaign=5b3a1cc4ea1aac122c01cc23&utm_content=5d8367b558cd6f0001e89e17&utm_medium=smarpshare&utm_source=linkedin

Outline: The European Union and the United Nations maximise global efforts to fight marine pollution in the world. Launched on 19 August, this year's campaign ran through October, culminating on Saturday 21 September, the International Coastal CleanUp Day, with actions taking place in over 80 countries, on all inhabited continents. The events are organised by EU embassies and UN offices across the world, jointly with local authorities, schools, NGOs and private companies.

Status: Ongoing

2. A Citizen Science Approach to Archaeology: Finnish Archaeological Finds Recording Linked Open Database (SuALT)

Website: https://researchportal.helsinki.fi/en/publications/a-citizen-science-approach-to-archaeology-finnish-archaeological-

Outline: The Finnish Archaeological Finds Recording Linked Open Database (Suomen arkeologisten löytöjen linkitetty avoin tietokanta — SuALT) is an ongoing citizen science project. SuALT will be a digital web service catering for discoveries of archaeological material made by the public; especially, but not exclusively, metal-detectorists. SuALT engages citizens by providing them with access to contextualised data regarding other related finds by linking data from different data sources in Finland and beyond. SuALT is a collaborative consortium project led by the Department of Cultures at the University of Helsinki, Aalto University, the Helsinki Centre for Digital Humanities at the University of Helsinki and the Finnish Heritage Agency.

Status: Ongoing

3. Aarhus University Hack (AUHack)

Website: https://auhack.org/index.html

Outline: AUHack is Denmarks's largest hackathon for students. Over a 36-hour period from April 5th to 7th, students interested in Information Technology will meet, form groups and work intensively to create prototypes and concepts. Several sponsors (mostly companies) set the cases (or challenges) to be solved

(https://auhack.org/cases.html). AUHack has been home to a wide variety of projects, from hardware projects to virtual reality games as well as services and applications.

Status: Ongoing (annual event)

4. Aquathon

Website: https://www.aquathon.io/

Outline: Aquathon corresponds to two inter-related citizen science events on the topic of water resources, taking place one week apart in Brest, where the theme is the ocean, and in Paris, where the theme is the river. For one week, the Aquathon brings together two age groups: half of the participants are young people and students, and half are adults (professionals and retirees). They co-create prototypes and test them in the field, with the long-term aim of restoring an active relationship to the aquatic element.

Status: Annual event

5. BirdLife International

Website: https://www.birdlife.org/

Outline: BirdLife International is a global partnership of conservation organisations who strives to conserve birds, their habitats and global biodiversity, working towards sustainability in the use of natural resources. Together there are 121 BirdLife Partners worldwide — one per country or territory — and is constantly growing. As the world's largest nature conservation partnership, BirdLife International has more than 10 million members and supporters. BirdLife Partner Environmental NGOs worked with over 4,000 local groups, and involved 1.9 million young people (under 18). An open data repository is available at http://datazone.birdlife.org/home

Status: Ongoing

6. Bucket brigades to monitor releases of catacarb from a petrol refinery

Website: http://archive.pov.org/fenceline/the-bucket-brigade/

Outline: A community in Contra Costa County, California, used a bucket brigade to monitor releases of catacarb from a Unocal refinery in 1995. The community's data spurred the installation of a fence line monitoring system and increased industry monitoring. This was the very first "bucket brigade". Bucket air-sampling technology was developed when personal injury lawyer Ed Masry engaged an engineer to develop a simple, affordable and accurate monitoring technique that citizens could use. This empowered communities living near toxic fume emitting sources to gather data and take action based on scientific results.

Status: Completed

7. Challenging RISK

Website: https://www.ucl.ac.uk/challenging-risk/

Outline: Challenging RISK is concerned with socially integrated mitigation of multiple structural risks in the urban environment. It aims to produce new knowledge regarding the performance of existing reinforced concrete (RC) structures subjected to earthquakes and fire hazards and to develop an integrated framework for performance-based assessment and structural mitigation. The proposed technical engineering solutions will be developed so as to account for the social context within which they are to be enacted. Part of the project focuses on community engagement through the use of citizen science techniques and the provision of tailored monitoring and data analysis tools to define "acceptable" performances, inform the technical programme of work and the means for effective implementation of mitigation strategies for multiple risks.

Status: Ongoing

8. Citizen Science Lab

Website: https://www.universiteitleiden.nl/en/citizensciencelab/citizen-science-lab

The Citizen Science Lab is an initiative led by Leiden University in The Netherlands, aiming to bring together researchers, citizens and societal organisations to create new knowledge for science and society. The Lab acts as the hub between different groups inside the university (scholars, students, teaching staff and decision makers) and outside the university (business and civil society), and is a partner in various European Union funded citizen science projects, such as Science Shops (https://www.scishops.eu/), EU-Citizen.Science (http://eu-citizen.science/) and others.

Status: Ongoing

9. Citizen Science Network at the University of Southern Denmark

Website:
https://www.sdu.dk/en/forskning/forskningsformidling/citizenscience/citizen+science+netvaerk

Outline: The overall goals of the Network, to which all faculties as well as the library belong, are to bring citizens closer to science and scientists closer to society, and to open up the research process to all citizens across all levels of education and social groups through communication, education and learning. Some of the initiatives carried out are: 'A Healthier Southern Denmark' — citizens vote for the funding of research; 'Active Living Area' — transforming 80 acres of land into a community driven citizen science area; 'Marine Tracker' — involving citizens in the tracking of marine wildlife; and 'Talentprogramme on Citizen Science' — a 20+10 ECTS initiative for Master's students.

Status: Ongoing

10. Clean Water Hub

Website: https://www.cleanwaterhub.org/

Outline: Healthy streams are vital to healthy communities. The goal of Clean Water Hub, an initiative by the Izaak Wolton League, is to monitor water quality at 100,000 more stream sites by 2022 and to improve water quality across the United States. Clean Water Hub helps people track water quality in local creeks and streams. Data is publicly available, as according to the website "sharing data encourages more connection and collaboration between partners and organizations. It allows for us to build on each other's monitoring efforts rather than repeating what's already been done".

Status: Ongoing

11. Co-creation for future learning environments at the University of Oulu

Website: https://www.oulu.fi/genz/node/62755

The Co-creation for future learning environments workshop is a one-day event organised by the GenZ project (https://www.oulu.fi/genz/), in collaboration with the Learning and Educational Technology research unit (LET) of the University of Oulu (Finland) and the City of Oulu's 6Aika Smart Learning Environments for the Future project (https://6aika.fi/en/project/smart-learning-environments-of-the-future/). 6Aika is a strategy for sustainable urban development, and is a joint strategy of the six largest cities in Finland: Helsinki, Espoo, Vantaa, Tampere, Turku and Oulu. In the workshop learning scientists, communication scientists and educational technology companies collaborated on products or demomstrations by companies and co-created new solutions for future learning environments.

Status: Completed

12. Creative Mornings

Website: https://creativemornings.com/

Outline: Creative Mornings is a breakfast lecture series for the creative community. Experts meet citizens and have engaging discussions. Attendees gather once a month. Several cities around the world organise Creative Mornings, and all events are presented on their main website. The Creative Mornings talks are recorded and posted online at https://creativemornings.com/talks. Recorded talks are in several languages and cover a wealth of topics.

Status: Ongoing

13. Crowd the Tap

Website: https://crowdthetap.org/

Outline: Crowd the Tap directs the power of crowds to protect tap water in the United States. Crowd the Tap is a project funded by the US Environmental Protection Agency (EPA) that promotes access to safe drinking water by creating a comprehensive national inventory of pipe materials that deliver drinking water to homes. This is the first project to engage and empower water consumers in creating a comprehensive inventory of water pipe infrastructure. This inventory will allow people to identify lead pipe hot spots in the US, which will inform lead pipe replacement projects.

Status: Ongoing

14. Cultural gems

Website: https://culturalgems.jrc.ec.europa.eu/

Outline: Cultural gems is a free open source web application developed by the European Commission's Joint Research Centre (JRC), to map cultural and creative places in European cities. The main purpose is to capture diversity in culture and creativity among European cities. Cultural gems includes data on selected cultural venues from OpenStreetMap as well as information provided by European cities, universities and other public and private organisations. Citizens are encouraged to add more Cultural gems in the spin-off project of the Cultural and Creative Cities Monitor, a web tool developed by the JRC.

Status: Ongoing

15. Cyclone Center

Website: https://www.cyclonecenter.org/#/

Outline: Cyclone Center is a Zooinverse citizen project and starts with the following problem regarding tropical cyclones: research is inconsistent regarding the wind speeds of tropical storms, making it difficult to understand how climate change has affected the nature and strength of cyclones. There are 300,000 satellite images of tropical cyclones since 1978. When these images are classified using the Dvorak technique, we can extract critical information about the storms. In this citizen science project volunteers, through applying a modified Dvorak technique, help interpret satellite images even more effectively than the best computers.

Status: Ongoing

16. Doing It Together Science (DITOs)

Website: http://togetherscience.eu/

Outline: In Doing It Together Science (DITOs), universities and research institutions work together with science galleries, museums and art institutions to engage people with citizen science in Europe. More than 500 innovative workshops, exhibitions, and activities are organised in nine countries across Europe. With this project the 11 European partners intend to show that citizen science is an accessible and fun way in which to explore the world.

Status: Completed

17. Enrich Europeana

Website: https://europeana.fresenia.man.poznan.pl/

Outline: Enrich Europeana is a crowdsourcing platform that specifically targets European cultural heritage. Enrich Europeana is an online citizen science initiative for the enrichment of digitised material from Europeana Collections. This initiative combines face-to-face transcribathons (see the 'Runs' tab of the website) with online ones (see the 'Discover/map' tab).

Status: Ongoing

18. Environmental Health Coalition in San Diego

Website: https://www.phi.org/news-events/?article_id=aijndrtqvfjd&p=54

Outline: In San Diego County, the Environmental Health Coalition and its academic partners trained promotoras (lay health workers) to be co-researchers and policy change advocates, to address disproportionate exposures to toxic air contaminants. Their efforts helped pass legislation to limit the operation of a truck-driving school adjacent to a local elementary school.

Status: Completed

19. Estonia is looking for primula plants

Website: https://www.nurmenukk.ee/

Outline: The collectively collected grassland data provides an overview of the state of Estonian wildlife in Estonia. Nearly 200,000 plants have already been observed and nearly 1,600 observations have been made (one observation covers several species). The initiative was started by the Estonian Fund for Nature and University of Tartu, and the community activities day "Let's do it!" is very well received. Several schools, collectives and people from all over Estonia have participated.

Status: Completed

20. Experimental Interaction Design workshops at Tallinn University

Websites: http://winterschool.tlu.ee/experimental-interaction-design/ and
http://winterschool.tlu.ee/gamification-workshop/

Outline: This is a short course approach deployed at summer and winter schools organised by Tallinn University. The Experimental Interaction Design workshops, gamification workshops and Open Society Technologies design workshops are open to all applicants (not only students), integrating learners from different disciplines such as art, medicine and others. The applicants engage with open innovation activities in the Open Labs of Tallinn University.

Status: Ongoing

21. Extreme Citizen Science: Analysis and Visualisation (ECSAnVis)

Website: https://www.geog.ucl.ac.uk/research/research-centres/excites/projects/extreme-citizen-science-analysis-and-visualisation-ecsanvis

Outline: ECSAnVis is a five-year, €2.5M project funded by the European Research Council, which aims for the development of geographical analysis and visualisation tools that can be used by non-literate individuals as well as any other community in a culturally appropriate manners, that further suit their needs and social practices. ECSAnVis builds on the ExCiteS project, which demonstrated how non-literate individuals as well as those with limited technical literacy can successfully participate in formulating research questions and collecting data important to them, with implementations for Pygmy hunter-gatherers, local NGOs and other local indigenous partners in the Congo basin, Namibia, the Brazilian Amazon and cases in the United Kingdom.

Status: Ongoing

22. FirstBuild

Website: https://firstbuild.com/

Outline: FirstBuild is a co-creation community that is changing the way products come to market. By letting a community influence the product from the very beginning, FirstBuild is able to quickly deliver better products that improve the lives of consumers. FirstBuild has ideated 454 prototypes out of which 15 products are on shelf. FirstBuild's microfactory is a collaborative makerspace where ideas come to life, and is open to students, engineers, artists, developers and entrepreneurs. The initiative is backed by General Electric Appliances.

Status: Ongoing

23. Fit4Food 2030

Website: https://fit4food2030.eu/

Outline: The FOOD 2030 platform connects stakeholders in the European food system at multiple levels (cities/regions, countries, and Europe) and makes research and innovation policies on Food and Nutrition Security more coherent and also builds the competences of current and future researchers, entrepreneurs, policy-makers, and society at large. The project organises City and Food labs, one of which (in Milan) is showcased in a European Union study (https://fit4food2030.eu/city-and-food-labs-are-showcased-in-new-report/).

Status: Ongoing

24. Foldit

Website: https://fold.it/

Outline: Foldit is perhaps the oldest and more renowned citizen science project, namely a crowdsourced computer game for a scholarly purpose. On the digital platform volunteers fold the structures of selected proteins as perfectly as possible, using the tools provided in the game. The highest scoring solutions are

analysed by researchers, who determine whether or not there is a native structural configuration that can be applied to relevant proteins in the real world. Scientists use these solutions to target and eradicate diseases and create biological innovations. A 2010 paper in the science journal *Nature* credited Foldit's 57,000 players with providing useful results that matched or outperformed algorithmically computed solutions.

Status: Ongoing

25. GBIF | Global Biodiversity Information Facility

Website: https://www.gbif.org/

Outline: The Global Biodiversity Information Facility is an international network and research infrastructure funded by the world's governments and aims to provide anyone, anywhere, open access to data about all types of life on Earth. So far (November 2019), there are almost 1,4 billion occurrences in the data repository, 47,000 datasets, 1,530 publishing institutions and 4,000 peer reviewed papers using data.

Status: Ongoing

26. Global Community Monitor

Website: https://gcmonitor.org/about-us/victories/

Outline: The Global Community Monitor (GCM), founded in 2001, aims to provide training and support to communities in the use of environmental monitoring tools in order to understand the impact of fossil fuel industry pollution. GCM's work focuses on disempowered "fenceline" communities harmed by serious air pollution from industrial sources and whose concerns are being ignored by relevant agencies and the responsible corporations. Over the past fifteen years, GCM has developed and pioneered the use of "bucket brigades" (a grassroots air monitoring program) as a method for communities to document and understand the impact of industrial pollution, to launch advocacy efforts against polluters and to effect changes in political decisions.

Status: Ongoing

27. Grande Expérience Participative — the Great Participatory Experience

Website: https://nuitdeschercheurs-france.eu/?GrandeExperience2019

Outline: Every two years in France, a Great Participatory Experience is organised within the European Researchers' Night, simultaneously in 12 cities, allowing a selected team of researchers to involve nearly 15,000 members of the public in a scientific experiment as part of their research. The results are made available as open data and the process is transparent, and presented through a web blog. The Great Participatory Experience invites the public to discover science "in the making" while contributing to a collaborative project to produce knowledge.

Status: Biannual event

28. IAQOS: Intelligenza Artificiale di Quartiere Open Source (Neighbourhood Artificial Intelligence—Open Source)

Website: https://iaqos.online/site/

Outline: IAQOS (Neighbourhood Artificial Intelligence—Open Source) is developing a new artificial intelligence that will *absorb* the knowledge and culture of the Torpignattara neighbourhood in Rome, and interpret it through logical associations of the terms that the machine is learning. To help people empathise with this artificial intelligence, the promoters used the metaphor of a new intelligent life. They celebrated the birth of this life and brought this new life with them into the neighborhood, in a pram. People interact with the computer in the pram, which then *learns* words, terms and associations from the interactions. IAQOS can learn and *speak* 40 different languages and interact on several topics relevant to the neighbourhood.

Status: Ongoing

29. Identiplante

Website: https://www.tela-botanica.org/outils/identiplante/

Outline: Identiplante is an open collaborative tool for plant identification. Anyone can post a picture or an observation of a plant and ask the community of telabotanists for advice regarding the determination of the plant. One can fill out an observation on the simplified form of the Online Book or mark observations with the tag 'To determine' in the interface of one's data management space. The picture will immediately be shared on the Tela Botanica network and the request for help will be broadcast in an email alert to the community. The repository is publicly shared.

Status: Ongoing

30. LEGO Ideas

Website: https://ideas.lego.com/

Outline: LEGO consumers can design their own LEGO sets either using LEGO bricks or 3D computer applications. Other users start to discuss the idea and can vote for it. Once the idea reaches a targeted vote, LEGO can consider it for a new product, and if successful a small part of the revenues go to the creator of the set.

Status: Ongoing

31. Litter Intelligence

Website: https://litterintelligence.org/

Outline: Litter Intelligence is a long-term programme that collects litter data, provides powerful insights regarding the problem and inspires widespread action for solutions. Led by the New Zealand charity Sustainable Coastlines, the programme works in close collaboration with the Ministry for the Environment, Department of Conservation and Statistics New Zealand. The citizen science component is present through local events for litter collection at New Zealand beaches; litter is further analysed and findings are openly shared at https://litterintelligence.org/data/.

Status: Ongoing

32. Louisiana Bucket Brigade

Website: http://www.labucketbrigade.org/content/supporting-fenceline-communities

Outline: The Louisiana Bucket Brigade is an environmental health and justice organisation working with communities neighbouring the state's oil refineries and chemical plants. The Louisiana Bucket Brigade uses grassroots action to create an informed, healthy society that holds the petrochemical industry as well as the government accountable for the true costs of pollution. As an example, in 2000, in Norco, Louisiana, a community living on the perimeter of a Shell chemical plant monitored toxic air pollutants, which led to an air quality study and resulted in an enforcement action.

Status: Completed

33. Low-cost sensors for air quality by citizens

Website: Information collected from several websites

Outline: Many low-cost sensors are entering the market. The *Purple Air* laser particle counter has six bin sizes and a wireless connection to transfer data to the cloud and visualise it on Google Maps (http://www.purpleair.org). Regarding air quality mapping and analysis platforms, Aclima (https://aclima.io/) has partnered with Google and the US EPA to map real-time air quality worldwide. On the user end, mobile phone apps are being developed to display real-time air pollution data, such as AIR by Plume Labs (https://plumelabs.com/en/air) and AirQuality by AirVisual (https://www.airvisual.com/).

Status: Ongoing

34. Mon projet pour la planète

Website: https://www.monprojetpourlaplanete.gouv.fr/

Outline: As part of his Climate in Action plan, Nicolas Hulot launched a call for projects termed My project for the planet. Every citizen is invited to support exemplary and innovative action to fight climate change in practice. In total, 419 projects, also supported by citizens, are eligible and were submitted to the vote of Internet users: 205 are related to biodiversity, 123 to the circular economy and 91 to energy. Each category has several initiatives related to agriculture. From April 12, 2018, until May 11, 2018, online voting was open. Projects that received the maximum number of votes received funding in order to

develop. The selected projects for funding appear at https://www.monprojetpourlaplanete.gouv.fr/project/plan-climat/selection/projets-retenus

Status: Completed

35. MOOC on Autism Spectrum Disorders with citizen science elements

Website: https://www.coursera.org/learn/troubles-spectre-autisme-diagnostic

Outline: This MOOC aims to offer free and accessible training to health and education professionals, but also families facing autism. In this MOOC, learners become familiar with the signs that lead to a diagnosis of autism, using short video sequences of children with ASD. In order to understand whether it is feasible to identify the behavioural characteristics of autism solely from the person's nonverbal behaviours, it then asks learners to view reconstructions of scenes with very short social interactions. Ultimately, this citizen science activity aims to inform the development of automated screening tools, and to develop better ways to train clinicians in the diagnosis of autism.

Status: Ongoing

36. mPING: crowdsourcing weather reports

Website: https://mping.nssl.noaa.gov/

Outline: Citizen scientists around the world can submit weather observations and view reports using the newly upgraded application. The United States National Severe Storms Laboratory is collecting public weather reports through a free application available for smart phones or mobile devices. The application is called mPING, for Meteorological Phenomena Identification Near the Ground. The Laboratory collects public weather reports, which are then immediately archived into a database at the University of Oklahoma and are displayed on a map accessible to anyone.

Status: Ongoing

37. National Audubon Society

Website: https://www.audubon.org/

Outline: Since 1905, the National Audubon Society has protected birds and the spaces they need and will need throughout the Americas, using science, advocacy, education, and on-the-ground conservation. The National Audubon Society's long-running Christmas Bird Count has informed more than 200 journal papers and data from the North American Breeding Bird Survey has been included in some 670 peer-reviewed articles thus far.

Status: Ongoing

38. Nature's Notebook

Website: https://www.usanpn.org/natures_notebook

Outline: Nature's Notebook is an off-the-shelf programme appropriate for scientists and non-scientists alike, engaging observers across the United States to collect phenology observations on both plants and animals. There are more than 15,000 other naturalists across the US using scientifically-vetted observation guidelines, developed for over 1,000 species, to ensure that the data is useful to researchers and decision-makers. Data is made available on the Phenology Observation Portal https://data.usanpn.org/observations/get-started.

Status: Ongoing

39. Open Data Hackathon Cyprus

Website: http://opendatacy.com/

Outline: This 2018 competition mostly targets computer programmers, analysts, designers and communication and marketing experts in developing applications based on the exploitation and reuse of the open data available through the Open Data Portal (https://www.data.gov.cy/). In 2018 the Open Data Hackathon was co-organised by Deloitte, the Public Administration and Personnel Department (PAPD) of the Ministry of Finance and Hack Cyprus. The PAPD, in collaboration with the Open University of Cyprus, offered users the opportunity to submit their open data applications and request new data. The data provided covers most public services and governmental departments and ministries in Cyprus.

Status: Ongoing (annual event)

40. Open science at Finnish Museum of Natural History

Website: https://www.helsinki.fi/en/news/higher-education-science-policy/finnish-museum-of-natural-history-receives-university-of-helsinki-open-science-award

Outline: The Finnish Museum of Natural History Luomus has been recognised for its extensive long-term work for open science. It was unanimously selected as the winner of the University of Helsinki Open Science Award 2019. The museum is acknowledged for its superb open science practices — a founding principle that runs through all of the museum's work. Luomus has developed and continues to maintain significant open science services and databases for both researchers and the general public. In addition, Luomus has a long tradition of organising and developing citizen science.

Status: Ongoing

41. Open4citizens

Website: http://open4citizens.eu/

Outline: Open4citizens involves citizens in a co-design process (hackathons), involving IT experts, public administrations, interest groups and start-up companies, in order to develop new services to improve urban quality of life. The aim of the project is to raise citizens' awareness of the opportunity offered by

open data and to create a new culture of innovation in public services. In each of the five pilot locations (Copenhagen, Karlstad, Rotterdam, Milan and Barcelona) physical or virtual locations (OpenDataLab) will be created, thus becoming reference points for citizens and interest groups who want to propose innovative applications based on open data.

Status: Completed

42. Parenting Science Gang

Website: http://parentingsciencegang.org.uk/

Outline: Parenting Science Gang is a ground-breaking, user-led citizen science project. It brings together over 2,500 parents who come up with questions they want to answer; they work out how they might answer these questions and design their own experiments. Parents get advice from professional scientists, however it is the volunteers who set the agenda and select which questions they want to answer. Among other successes, the group induced the United Kingdom National Health System (NHS) to change their guidelines on baby washing items.

Status: Ongoing

43. Participatory budget, City of Paris

Website: https://budgetparticipatif.paris.fr/bp/

Outline: Participatory budget/Budget participatif is an initiative undertaken by the City of Paris which allocates 100 million euro annually, from 2014 through to 2020, to fund projects submitted and voted for by citizens (open governance) through a crowdsourcing platform. The projects pertain to twelve thematic categories, such as Intelligent City, Mobility, Sport, Solidarity, Property, Education, Culture, etc. In 2016 more than 150,000 citizens took part, selecting 219 projects which are now being implemented by the City of Paris. The selected projects' progress can be monitored online.

Status: Ongoing

44. PatientsLIkeMe

Website: https://www.patientslikeme.com/

Outline: PatientsLikeMe is the world's largest personalised health network. Over 650,000 people living with 2,900 conditions have generated more than 43 million data points, creating an unprecedented source of real-world evidence and opportunities for continuous learning in the health sector. Everything members have shared empowers the community with personal agency, establishing PatientsLikeMe as a clinically robust resource that has published more than 100 research studies.

Status: Ongoing

45. Pieris Project

Website: http://www.pierisproject.org/

Outline: This is a global citizen science project that encourages citizen scientists to record information about *Pieris rapae*, or the white cabbage butterfly. A team of researchers sequence and analyse the genetic code of butterflies collected by citizens. The goal of the project is to create the most comprehensive collection of a single species of butterfly that will act as a powerful tool for studying how organisms adapt to changes in their environment. Thus, the project aims to create a global community of citizen scientists that help to undertake meaningful research which contributes to our knowledge of how human activities impact the planet's biosphere.

Status: Ongoing

46. Pint of Science

Website: https://pintofscience.com/

Outline: The Pint of Science festival aims to deliver interesting and relevant talks on the latest science research in an accessible format to the public — mainly using bars, pubs, cafes and other public spaces. They aim to provide a platform which allows people to discuss research with the people who undertake it, and no prior knowledge of the subject is required. They are a network of thousands of volunteers who are passionate about sharing discoveries and were established by a community of postgraduate and postdoctoral researchers in 2012. During May 2019, thousands of researchers across 400 cities and 24 countries shared their discoveries with others in their local pub, bar or cafe.

Status: Ongoing (annual event)

47. RAD@home

Website: https://radathomeindia.org/

Outline: RAD@home Astronomy Collaboratory is the first Indian citizen science research programme in astronomy. This zero-funded, zero-infrastructure collaboratory has been established as a platform wherein any BE/BSc undergraduate or graduate can undertake serious multiwavelength, extragalactic astronomy research by utilising the power of the Internet and social networks. This people-powered research has also received significant support from various Indian institutions such as Vigyan Prasar (Department of Space and Technology, Govternment of India), the UM-DAE Centre of Excellence in Basic Sciences (Mumbai), the Institute of Physics (Bhubaneswar), the Nehru Planetarium (New Delhi) and the Harish-Chandra Research Institute (Allahabad).

Status: Ongoing

48. Reef Life Survey

Website: https://reeflifesurvey.com/

Outline: Reef Life Survey divers explore underwater formations called transects, where they take pictures of the fish and invertebrate species. The project's 12,882 surveys have recorded more than 4,800 reef-dwelling species in 53 countries since 2007. Some 77 academic papers have been published, six of which appear in *Nature*. In 2018, Reef Life Survey divers identified a new population of the critically endangered red handfish (*Thymichthys politus*) on the Tasman Peninsula. With just one other known population of red handfish, consisting of no more than 40 individuals, in southeast Tasmania, the discovery led to the establishment of the government-supported Handfish Conservation Program.

Status: Ongoing

49. RinkWatch

Website: https://www.rinkwatch.org/

Outline: RinkWatch is a citizen science research initiative in the United States and Canada that asks people who love outdoor skating to help environmental scientists monitor winter weather conditions and study the long-term impacts of climate change. Launched by researchers at the Wilfrid Laurier University in January 2013, participants from across North America have submitted information about skating conditions of more than 1,400 outdoor rinks and ponds. In addition to contributing valuable data to environmental science, RinkWatch has become an online community for people who love making backyard and community rinks.

Status: Ongoing

50. Scientific Game Jam 2018

Website: about the event https://www.u-bordeaux.fr/Evenements/De-la-recherche/Scientific-Game-Jam-1re-edition-a-Bordeaux and about the outputs https://www.u-bordeaux.fr/Actualites/De-la-recherche/Les-jeux-de-la-Scientific-Game-Jam-2018

Outline: During a 2-day event at the University of Bordeaux, multidisciplinary teams develop games based on the research of participating PhD students. Seven teams of jammers organised themselves with or without game design, graphic design, programming, sound design and a scientist, to together develop a game in 48 hours, centred on the research themes of the doctoral student in the team. Seven topics were proposed, representing all fields of science: bioinformatics, law, psychology, palaeontology, toxicology, etc. This creative format for science outreach was first developed in Grenoble (France) and later replicated in Paris, Toulouse, and Nantes (France).

Status: Completed

51. Smithsonian Digital Volunteers: Transcription Center

Website: https://transcription.si.edu/browse

Outline: The Smithsonian Transcription Center seeks to engage the public in making the Smithsonian collections more accessible. They are working hand-in-hand with digital volunteers to transcribe historic

documents and collection records to facilitate research and excite learning in everyone. Since June 20013 the community of 13,730 'volunpeers' has collaboratively transcribed and reviewed 491,527 pages of field notes, diaries, ledgers, logbooks, currency proof sheets, photo albums, manuscripts, and biodiversity specimen labels.

Status: Ongoing

52. Species Observation System in Sweden

Website: https://www.artportalen.se/

Outline: Artportalen is a website for observations of Sweden's plants, animals and fungi. Anybody can report the species they have seen and search through over 53 million entries. Private individuals as well as professionals such as conservation officers and researchers have contributed. The initiative is developed and operated by the Swedish Species Information Centre at the Swedish University of Agricultural Sciences, on behalf of the Swedish Environmental Protection Agency.

Status: Ongoing

53. Strawbairies

Website: https://www.uantwerpen.be/en/projects/strawbairies/

Outline: This is a citizen science campaign in which traffic-related air quality in urban environments is monitored by means of strawberry plants. For the very first time this campaign is simultaneously organised in six European countries spread across Europe. Additionally, the project team assesses the pollination success of urban insects in all these cities and try to link this success to air pollution and the availability of urban green areas in neighbourhoods.

Status: Ongoing

54. Tartu 1857

Website: http://www.ra.ee/tartu1867/

Outline: The Tartu 1867 project involved citizens in open knowledge creation regarding the history of the city. The first population census took place in Tartu on the 3rd of March 1867 and the collected data was stored in the repository of the National Archive of Estonia. Based on that collection, the citizens were involved in digitising the resources and geo-tagging them. A public website was created where everyone can find information of the civic activity and urban geography of Tartu in 1867.

Status: Completed

55. The Community Collaborative Rain, Hall and Snow Network

Website: https://www.cocorahs.org/

Outline: The Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) is a non-profit, community-based network of volunteers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow). By using low-cost measurement tools, stressing training and education as well as utilising an interactive website, the aim is to provide the highest quality data for natural resource, education and research applications. CoCoRaHs teams are present in all fifty states of the United States.

Status: Ongoing

56. The Great Green Wall

Website: https://www.greatgreenwall.org

Outline: The Great Green Wall aims to grow an 8000 km new world wonder across the entire width of the African Continent: by 2030, the Wall aims to restore 100 million hectares of currently degraded land, sequester 250 million tons of carbon and create 10 million jobs in rural areas. Local communities are engaged in a wealth of activities (cf. project website). In terms of research, among other supporting organisations, the National Centre for Scientific Research of France (CNRS) has established a Human-Environment Observatory (OHMi) to study the impact of these plantations on the ecological, medical and social levels. The Klorane Botanical Foundation supports with planting, research (funding three doctoral theses) and the organisation of an academic event in Senegal. Many other institutions and civil society organisations are involved.

Status: Ongoing

57. The Citizen Science Competence Centre

Website: https://kodanikuteadus.wordpress.com/

Outline: This is a 3-year project between four schools in Tallinn and the Tallinn University. As part of the project the schools received Globisens labdiscs (https://www.globisens.net/), devices containing sensor technology which can be used to collect data regarding different aspects of the environment. Tallinn University provides teacher training that aims to establish triple relationships (university, school, regional stakeholders) for solving regional problems with citizen science methods and sensor-based technologies. In addition, citizen science-related learning scenarios will be developed together with the teachers. There is a supportive application to promote problematisation, data sharing and visualisation of data gathered by citizens (https://avastusrada.ee/en).

Status: Ongoing

58. Topcoder development community

Website: https://www.topcoder.com/case-studies/sunshot-catalyst/

Outline: The United States Department of Energy (DOE) launched a competition series called SunShot Catalyst to help cutting edge companies decrease time-to-market for innovative new solar solutions.

Participants were challenged to submit problem statements that can be solved through automation, algorithms, data and software. Through an open call for ideas that generated hundreds of submissions, the DOE curated top ideas for business models into a grouping of 17 unique finalists, to which access was given to the Topcoder platform and a budget of $25,000 per team. After consultation with experts, five startups were awarded cash prizes to kickstart their solar energy business.

Status: Ongoing

59. Topotek — the local archives project of the National Archives of Estonia

Website: http://www.ra.ee/projektid-ja-koostoo/coop/

Outline: The National Archives of Estonia participates in the creation of five web-based topotheques for the collection of historical photos and other documents from individuals. Resources are collected in a digital repository as well as through "Bring your history!" days in local communities. One of the project's objectives includes archival education. Activities called "Adventures in Archives" also encourage students and youngsters to explore archives by visualising studies in the archives, thus allowing them to experience the role of mediators of heritage as well as to try out different learning approaches to history, such as storytelling and moviemaking, involving students and teachers in an interdisciplinary approach.

Status: Completed

60. Topotheque

Website: https://www.topothek.at/en/

Outline: Topotheque is an open access platform that allows local communities to create and publicly share local, historically relevant material and knowledge. Topotheque is a regional and historical source of reference and already exists in a number of different European countries. This allows for a comparison of regional historical conditions on a European level, making the diversity and common grounds of every-day life tangible.

Status: Ongoing

61. Transcribe Bentham

Website: https://www.ucl.ac.uk/bentham-project/transcribe-bentham

Outline: Transcribe Bentham is an award-winning (Prix Ars Electronica 2011) participatory initiative which launched in 2010 and is a part of the Bentham Project. Its aim is to engage the public in the online transcription of original and unstudied manuscript papers written by Jeremy Bentham. At the latest count, volunteers have transcribed more than 20,000 pages of Bentham's writings at a high level of accuracy. Teaching and learning materials pertaining to the work of Bentham have also been produced.

Status: Completed

62. WeGovNow!

Website https://wegovnow.eu/

Outline: This European Union funded project addresses collective and participative approaches to tackle local policy challenges. WeGovNow! has developed and piloted a new type of civic engagement platform that supports communication and collaboration between citizens, civil society and public administrations. This platform provides a set of core functions, such as community networking and self-organisation (WeGovNow FirstLife), problem identification and tracking (WeGovNow Improve My City), democratic proposition development and decision making (WeGovNow LiquidFeedback), crowdsourcing of knowledge and ideas (WeGovNow Community Maps) and exchanges of volunteering opportunities (WeGovNow Offers & Requests).

Status: Ongoing

63. Wild Things on my Street: a public observatory of city plants

Website: https://www.tela-botanica.org/projets/sauvages-de-ma-rue/ and "Sauvages de ma rue" mobile app

Outline: The idea of Wild Things on my Street involves citizens in taking an inventory of plants in the cities in which they live. A mobile application is used for citizens to register plants they find near their homes, that they see in the street every day (under trees, in cracks in the pavement, etc.). The scientists of the National Museum of Natural History in Paris launched this appeal to the city's inhabitants in order to gain a better understanding of the city's biodiversity. The Mobile app "Wild Things on my Street" is available on the App Store and Google Play.

Status: Ongoing

64. Wofie

Website: https://www.wofie.aau.dk/

Outline: Wolfie is a 4-day workshop on innovation and entrepreneurship at Aalborg University, Denmark. Students work in mixed teams, develop an idea based on a theme, design a business model and pitch it to a professional jury. The first two days of the workshop focus primarily on innovation while the last two days focus primarily on entrepreneurship. Interdisciplinary teams across all four faculties of up to six students are created. On the last day all groups compete with each other, presenting their business concept to a preliminary jury. The final jury, the majority of which consists of business people, evaluates the individual presentations based on innovation, verification, business and conviction.

Status: Completed

65. XP Saint-Jean 2017

Website: www.fondation.univ-bordeaux.fr/projet/appel-a-projets-xp-saint-jean-2017

Outline: XP Saint-Jean is the result of a partnership between SNCF Network (the French national railway company) and its branch SNCF Gares & Connexions, (the public transport operator in Bordeaux), Keolis Bordeaux Métropole and the Bordeaux University Foundation, who acts as a project leader and a middleman between stakeholders and academia. It offers the opportunity for teaching staff and students to make the Bordeaux Saint-Jean train station an experimental place to test their ideas and projects in order to reinvent the passenger experience.

Status: Completed

References

All links last accessed January 31, 2020

Auerbach, J., Barthelmess, E. L., Cavalier, D., Cooper, C. B., Fenyk, H., Haklay, M., Hulbert, J. M., Kyba, C. C. M., Larson, L. R., Lewandowski, E., & Shanley, L. (2019). The problem with delineating narrow criteria for citizen science. *Proceedings of the National Academy of Sciences, 116*(31), 15336–15337. https://doi.org/10.1073/pnas.1909278116

Bezjak, S., Clyburne-Sherin, A., Conzett, P., Fernandes, P. L., Görögh, E., Helbig, K., Kramer, B., Labastida, I., Niemeyer, K., Psomopoulos, F., Ross-Hellauer, T. , Schneider, R., Tennant, J., Verbakel, E., Brinken, H, Heller, L. (2018). The open science training handbook. https://doi.org/10.5281/zenodo.1212496

Bonney et al. (2013). Citizen science. *Encyclopedia of Science Education*. https://doi.org/10.1007/978-94-007-6165-0_291-1

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C. C. (2009). Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education. A CAISE Inquiry Group Report. Center for Advancement of Informal Science Education (CAISE).

Bruns, A. (2008). *Blogs, Wikipedia, Second Life, and Beyond: From Production to Produsage*. NewYork: Peter Lang.

Chesbrough, H., Crowther, A. K. (2006, May 25), "Beyond high-tech: early adopters of open innovation in other industries". *R&D Management 36* (3), 229-236. https://doi.org/10.1111/j.1467-9310.2006.00428.x

Curtis, V. (2014, December 1). Online citizen science games: Opportunities for the biological sciences. *Applied & Translational Genomics, 3* (4), 90-94.

De Pourcq, K., Ceccaroni, L. (2018, October 5). On the importance of data standards in citizen science. Blog of the Citizen Science COST action. Retrieved from https://cs-eu.net/blog/importance-data-standards-citizen-science

Doing It Together Science (DITOs) consortium. (2017). Citizen Science and Open Science: Synergies and Future Areas of Work. DITOs policy brief 3. Retrieved from https://ecsa.citizen-science.net/blog/citizen-science-open-science-policy-brief-out

Dörler, D., & Heigl, F. (2019). Citizen Science in Austria. *Mitteilungen der Vereinigung Österreichischer Bibliothekarinnen und Bibliothekare, 72*(2), 317-327. https://doi.org/10.31263/voebm.v72i2.2836

Eitzel, M.V., Cappadonna, J.L., Santos-Lang, C., Duerr, R. E., Virapongse, A., West, S. E., Kyba, C. C. M., Bowser, A., Cooper, C. B., Sforzi, A., Metcalfe, A. N., Harris, E. S., Thiel, M., Haklay, M., Ponciano, L., Roche, J., Ceccaroni, L., Shilling, F. M., Dörler, D., Heigl, F., Kiessling, T., Davis, B. Y. and Jiang, Q. (2017). Citizen Science Terminology Matters: Exploring Key Terms. *Citizen Science: Theory and Practice, 2*(1), p.1-20. http://doi.org/10.5334/cstp.96

English, P. B., Richardson, M. J., & Garzón-Galvis, C. (2018). From Crowdsourcing to Extreme Citizen Science: Participatory Research for Environmental Health. *Annual Review of Public Health, 39*(1), 335-350. https://doi.org/10.1146/annurev-publhealth-040617-013702

Erasmus+. (2019). Programme guide. Retrieved from https://ec.europa.eu/programmes/erasmus-plus/resources/programme-guide_en

European Citizen Science Association (ECSA). (2015, September). Ten principles of citizen science. Retrieved from https://ecsa.citizen-science.net/engage-us/10-principles-citizen-science

European Commission. (2019). Open Science, factsheet, December 2019. Retrieved from

https://ec.europa.eu/info/files/open-science_en

European Commission. (2017a). LAB-FAB-APP: Investing in the European future we want: report of the independent High-Level Group on maximising the impact of EU research & innovation programmes. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/ffbe0115-6cfc-11e7-b2f2-01aa75ed71a1/language-en/format-PDF/source-77975731

European Commission. (2017b). Providing researchers with the skills and competencies they need to practise Open Science. Open Science Skills Working Group Report. Retrieved from http://ec.europa.eu/research/openscience/pdf/os_skills_wgreport_final.pdf

European Commission. (2016). Open Innovation, Open Science, Open to the World – a vision for Europe. Directorate-General for Research and Innovation. Retrieved from https://ec.europa.eu/digital-single-market/en/news/open-innovation-open-science-open-world-vision-europe

European University Association. (2017). Towards Full Open Access in 2020: Aims and recommendations for university leaders and National Rectors' Conferences. Retrieved from https://eua.eu/resources/publications/417:towards-full-open-access-in-2020.html

Figueiredo Nascimento, S., Cuccillato, E., Schade, S., Guimarães Pereira, A., *Citizen Engagement in Science and Policy-Making*, EUR 28328 EN. https://doi.org/10.2788/40563

FOSTER. (nd). Retrieved from https://www.fosteropenscience.eu/

Fritz, S., See, L., Carlson, T., Haklay, M. (Muki), Oliver, J. L., Fraisl, D., Mondardini, R., Brocklehurst, M., Shanley, L. A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campbell, J., Espey, J., Gold, M., Hager, G., … West, S. (2019). Citizen science and the United Nations Sustainable Development Goals. *Nature Sustainability, 2*(10), 922–930. Retrieved from https://www.nature.com/articles/s41893-019-0390-3

Göbel, C. (2019). Open Participatory Research — Four Challenges for Opening Science Beyond Scientific Institutions. https://doi.org/10.25815/qykn-de07

Haklay, M. (2015). *Citizen science and policy: a European perspective*. Woodrow Wilson International Center for Scholars.

Haklay, M. (2010). Extreme Citizen Science. In London Citizen Cyberscience Summit (2-3 September, 2010).

Heigl, F., Kieslinger B., Paul, K. T., Uhlik, J., & Dörler, D. (2019a, April 23). "Opinion: Toward an international definition of citizen science." *Proceedings of the National Academy of Sciences 116*(17), 8089-8092. https://doi.org/10.1073/pnas.1903393116

Heigl, F., Kieslinger, B., Paul, K. T., Uhlik, J., & Dörler, D. (2019b). Reply to Auerbach et al.: How our Opinion piece invites collaboration. *Proceedings of the National Academy of Sciences*, *116*(31), 15338–15338. https://www.pnas.org/content/116/31/15338

Herodotou, C. (2018). Citizen science and informal learning: A brief commentary. In Luckin, R. (Ed.), *Enhancing Learning and Teaching with Technology: What the Research Says*. UCL Institute of Education Press.

Herodotou, C., Sharples, M., Scanlon, E. (Eds.). (2018). Citizen Inquiry. Synthesising Science and Inquiry Learning. Routledge. https://doi.org/10.4324/9781315458618

Howe, J. (2006, January 6). The rise of crowdsourcing. *Wired magazine*, *14*(6), 1-4. Retrieved from http://www.wired.com/wired/archive/14.06/crowds_pr.html

Katz, R. N. (Ed.). (2008). *The Tower and the Cloud. Higher Education in the Age of Cloud Computing*. Educause.

League of European Research Universities (LERU). (2016, October). Citizen science at universities: trends, guidelines and recommendations. Advice paper. Retrieved from https://www.leru.org/publications/citizen-science-at-universities-trends-guidelines-and-recommendations

Loss, S. R., Loss, S. S., Will, T., & Marra, P. P. (2015). Linking place-based citizen science with large-scale conservation research: a case study of bird-building collisions and the role of professional scientists. *Biological Conservation, 184,* 439-445.

Mahr, D., Göbel, C., Irwin, A., & Vohland, K. (2018). Watching or being watched-enhancing productive discussion between the citizen sciences, the social sciences and the humanities. In S. Hecker, M. Haklay, A. Bowser., Z. Makuch, J. Vogel, & A. Bonn. (Eds.), Citizen Science: Innovation in Open Science, Society and Policy, 99-109. UCL Press. https://doi.org/10.14324/111.9781787352339

Miller, C. (2017). Engaging with societal challenges. In U. Felt, R. Fouché, C. A. Miller, & L. Smith-Doerr (Eds.), *The handbook of science and technology studies*, 909-14. MIT Press.

Mitchell, N., Triska, M., Liberatore, A., Ashcroft L., Weatherill, R., Longnecker, N. (2017) Benefits and challenges of incorporating citizen science into university education. *PLoS ONE*, *12*(11): e0186285. https://doi.org/10.1371/journal.pone.0186285

OpenAIRE. (nd). Retrieved from https://www.openaire.eu/openaire-and-eosc

Open and Collaborative Science in Development Network (OCSDNet). (nd). Open Science Manifesto. Towards an Inclusive Open Science for Social and Environmental Well-being. Retrieved from https://ocsdnet.org/manifesto/open-science-manifesto/

Open Knowledge Foundation. (nd). What is open? Retrieved from https://okfn.org/opendata/

Open Science Policy Platform (OSPP). (2018, April 22). Recommendations. Retrieved from https://ec.europa.eu/research/openscience/pdf/integrated_advice_ospp_recommendations.pdf#view=fit&pagemode=none

Paulin,D., & Haythornthwaite, C. (2016). Crowdsourcing the curriculum: Redefining e-learning practices through peer-generated approaches. *The Information Society, 32*(2), 130-142. https://doi.org/10.1080/01972243.2016.1130501

Raymond E. S. (1999/2001). *The Cathedral & the Bazaar. Musings on Linux and Open Source by an Accidental Revolutionar*y. O'Reilly Media.

Sanz, F. S., Holocher-Ertl, T., Kieslinger, B., García, F. S., & Silva, C. G. (2014). White Paper on Citizen Science for Europe. Socientize Consortium. Retrieved from http://www.socientize.eu/sites/default/files/white-paper_0.pdf

Schaefer T., Kieslinger B. (2019) Citizen Science: Different Scopes of Citizens' Involvement in Research. In: Carayannis E. (eds) Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-6616-1_200034-1

Scheliga, K., Friesike, S., Puschmann, C., & Fecher, B. (2018). Setting up crowd science projects. *Public Understanding of Science, 27*(5), 515-534. https://doi.org/10.1177/0963662516678514

Seltzer, E., Mahmoudi, D. (2012, December 10). Citizen participation, Open Innovation, and Crowdsourcing: Challenges and Opportunities for Planning. *Journal of Planning Literature, 28*(1) 3-18. https://doi.org/10.1177/0885412212469112

Shanley, L.A., Parker, A., Schade, S. and Bonn, A.. (2019a). Policy Perspectives on Citizen Science and Crowdsourcing. *Citizen Science: Theory and Practice, 4*(1), p.1-5. http://doi.org/10.5334/cstp.293

Shanley, L.A., Hulbert, J., Auerbach, J., Haklay, M., et al. (2019b). CitSciDefinitions, v1.2. https://doi.org/10.5281/zenodo.3552753

Sitruk, Y., & Kazakçi, A. (2018). Crowd-based data-driven hypothesis generation from data and the organisation of participative scientific process. In *DS 92: Proceedings of the DESIGN 2018 15th International Design Conference* (pp. 1673-1684).

Skarlatidou, A., Suškevičs, M., Göbel, C., Prūse, B., Tauginienė, L., Mascarenhas, A., Mazzonetto, M., Sheppard, A., Barrett, J., Haklay, M., Baruch, A., Moraitopoulou, E.-A., Austen, K., Baïz, I., Berditchevskaia, A., Berényi, E., Hoyte, S., Kleijssen, L., Kragh, G., Legris, M., Mansilla-Sanchez, A., Nold, C., Vitos, M. and Wyszomirski, P., 2019. The Value of Stakeholder Mapping to Enhance Co-Creation in Citizen Science Initiatives. *Citizen Science: Theory and Practice*, 4(1), p.1-10. http://doi.org/10.5334/cstp.226

Strasser, B., Baudry, J., Mahr, D., Sanchez, G., & Tancoigne, E. (2019). "Citizen Science"? Rethinking Science and Public Participation. *Science & Technology Studies, 32*(2), 52-76. https://doi.org/10.23987/sts.60425

Tauvel-Mocquet, O. (2018). « Dans un programme d'*open science*, la stratégie événementielle est essentielle »: Interview with Olivier de Fresnoye, coordinator of the programme Epidemium, France. *Entreprendre & Innover*, 38(3), 64-68. https://doi.org/10.3917/entin.038.0064

Teperek, M., Cruz, M. J., Verbakel, E., Böhmer, J. K., & Dunning, A. (2018, January 29). Data Stewardship – addressing disciplinary data management needs. https://doi.org/10.17605/OSF.IO/MJK9T

Teo, E. A. (2020). *State-of-the-art analysis of the pedagogical underpinnings in open science, citizen science and open innovation activities*. E. Triantafyllou (Ed.). INOS Consortium.

Turbé, A., Barba, J., Pelacho, M., Mugdal, S., Robinson, L.D., Serrano-Sanz, F., Sanz, F., Tsinaraki, C., Rubio, J.-M. & Schade, S., 2019. Understanding the Citizen Science Landscape for European Environmental Policy: An Assessment and Recommendations. *Citizen Science: Theory and Practice, 4*(1), p.1-16. http://doi.org/10.5334/cstp.239

Tweddle, J. C., Robinson, L. D., Pocock, M. J. O. & Roy, H. E. (2012). Guide to citizen science: developing, implementing and evaluating citizen science to study biodiversity and the environment in the UK. Natural History Museum and NERC Centre for Ecology & Hydrology for UK-EOF. Retrieved from http://www.ukeof.org.uk/documents/guide-to-citizen-science/view

Vélot, C. (2016). Scientists and civil society must move together toward a new science. *Frontiers in public health, 4*, 96. Retrieved from https://www.frontiersin.org/articles/10.3389/fpubh.2016.00096/full

Vohland, K., & Göbel, C. (2017). Open Science and Citizen Science – a symbiotic relationship?. *TATuP - Zeitschrift für Technikfolgenabschätzung in Theorie Und Praxis*, *26*(1-2), 18-24. https://doi.org/10.14512/tatup.26.1-2.18

Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. (2016) The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data 3*, 160018(2016). https://doi.org/10.1038/sdata.2016.18

Wyler, D., Haklay, M. (2018). Integrating citizen science into university. In Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (Eds.), *Citizen Science: Innovation in Open Science, Society and Policy*, 168-181. UCL Press. https://doi.org/10.14324/111.9781787352339

Zourou, K. (2020). Citizen-enhanced open science: some reflections. Retrieved from https://web2learn.eu/citizen-enhanced-open-science-some-reflections/

Zourou, K., Potolia, A. 2020, in press. Openness in a crowdsourced massive online language community. In C. Blyth, J. Thoms (Eds.) *Open Education and Foreign Language Learning and Teaching: The Rise of a New Knowledge Ecology*. Multilingual Matters.

Zourou, K. & Tseliou, A. 2020. *Academia permeating society through Citizen Science: recommendations for Higher Education Institutions.* INOS consortium. Retrieved from: https://inos-project.eu/

Further readings

The list of references below contains readings suggested by INOS team members with respect to the present study and it is only indicative. The topics covered are:

- Trends in open and citizen science and the role of Higher education in them
- Open science and open innovation
- Obstacles and opportunities in citizen science engagement (and the role of HEIs).

All links last accessed January 31, 2020.

Bonney, R, & Ballard, H. (2015). Can citizen science enhance public understanding of science? Public Understanding of Science, 25(1), 2–16.

Curtis, V. (2014). Online citizen science games: Opportunities for the biological sciences. *Applied & Translational Genomics*, 3, 90–94.

Cohen, C. (2015, winter). Identifying Opportunities in Citizen Science for Academic Libraries. *Issues in Science and Technology Librarianship*. https://doi.org/10.5062/F4BR8Q66

De Vaujany, F.-X., Bohas, A., & Irrmann, O. (2019). *Vers une éducation ouverte: Faire, réflexivité et culture pour une éducation-recherche*. Research Group Collaborative Spaces, No. 4. Retrieved from https://www.researchgate.net/publication/333673834_Vers_une_education_ouverte_Faire_reflexivite_et_culture_pour_une_education-recherche

Dosemagen, S., & Parker, A. (2019). Citizen Science Across a Spectrum: Building Partnerships to Broaden the Impact of Citizen Science. *Science & Technology Studies. Special Issue: Many Modes of Citizen Science*, *32*(2), 24–33. Retrieved from https://sciencetechnologystudies.journal.fi/issue/view/4926/506#page=26

Dunn, R. R., Urban, J., Cavelier, D., & Cooper, C. B. (2016). The Tragedy of the Unexamined Cat: Why K–12 and University Education Are Still in the Dark Ages and How Citizen Science Allows for a Renaissance. *Journal of Microbiology & Biology Education*, *17*(1), 4–6. https://doi.org/10.1128/jmbe.v17i1.1049

Esmaeilian, B., Rust, M., Gopalakrishnan, P. K., & Behdad, S. (2018). Use of Citizen Science to Improve Student Experience in Engineering Design, Manufacturing and Sustainability Education. *Procedia Manufacturing*, *26*, 1361–1368. https://doi.org/10.1016/j.promfg.2018.07.124

Farzan, R. & Kraut, R. E. (2013). Wikipedia classroom experiment: Bidirectional benefits of students' engagement in online production communities. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM.*, 783–792. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.299.4439&rep=rep1&type=pdf

Friesike, S. & Gassmann, O. (2015). Opening science: Towards an agenda of open science in academia and industry. *The Journal of Technology Transfer*, *40*(4), 581–601. https://doi.org/10.1007/s10961-014-9375-6

Gibson, T., Murray, S. J., Erdelez, S., Disney, B. A., & Greenspan, B. (2018). Digital humanities, libraries, and crowdsourcing: Foundations of digital textual technologies. *Proceedings of the Association for Information Science and Technology*, *55*(1), 808–810. https://doi.org/10.1002/pra2.2018.14505501126

Ignat, T., Ayris, P., Juan, I. L. i, Reilly, S., Dorch, B., Kaarsted, T., & Overgaard, A. K. (2018). Merry work: Libraries and citizen science. *Insights*, *31*, 35. https://doi.org/10.1629/uksg.431

Ignat, T., Cavalier, D., & Nickerson, C. (2019). Citizen Science and Libraries: Waltzing towards a collaboration. *Mitteilungen Der Vereinigung Österreichischer Bibliothekarinnen Und Bibliothekare*, *72*(2). https://doi.org/10.31263/voebm.v72i2.3047

Kosmala, M., Wiggins, A., Swanson, A., & Simmons, B. (2016). Assessing data quality in citizen science. *Frontiers in Ecology and the Environment*, *14*(10), 551–560. https://doi.org/10.1002/fee.1436

Oberhauser, K., & LeBuhn, G. (2012). Insects and plants: Engaging undergraduates in authentic research through citizen science. *Frontiers in Ecology and the Environment*, *10*(6), 318–320. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/110274

Overgaard, A., & Kaarsted, T. (2018). A New Trend in Media and Library Collaboration within Citizen Science? The Case of 'A Healthier Funen.' *LIBER Quarterly*, *28*(1), 1–17. https://doi.org/10.18352/lq.10248

Shah, H. R., & Martinez, L. R. (2016). Current Approaches in Implementing Citizen Science in the Classroom. *Journal of Microbiology & Biology Education*, *17*(1), 17–22. https://doi.org/10.1128/jmbe.v17i1.1032

Smith, J. E., & Rinaldo, C. A. (2015). Collaborating on open science: The journey of the Biodiversity Heritage Library. *Information Services & Use*, *35*(4), 211–216. https://doi.org/10.3233/ISU-150785

Zoellick, B., Nelson, S. J., & Schauffler, M. (2012). Participatory science and education: bringing both views into focus. *Frontiers in Ecology and the Environment*, *10*(6), 310-313. Retrieved from https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1890/110277

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