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The accreditation discussion paper

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Executive summary	This deliverable discusses the topic of accreditation in Citizen Science (CS) as it stands and highlights the potential for developing it in the future. The topic was already suggested in the preparation stage of CS Track's proposal as a result of discussions about CS and its relation to education, measuring the quality of CS projects, and the value it returns to participants as well as a desire to create policy recommendations in this sense. We aim to present issues related to accreditation in CS and describe their manifestations during the three years of our project's work. We refer to the way in which we preliminary stated our intentions vis-à-vis accreditation in the project's description of work (section 2), followed by an in-depth literature review (section 3), a synthesis and positioning of accreditation in the field of CS (section 4), and an account of accreditation-related findings in CS Track (section 5). Finally (section 6), we address the ways to incorporate accreditation in CS policy and suggest policy recommendations based on our work. An annex closes this deliverable, presenting (mainly through screenshots of web pages) a few examples of existing accreditation providers, based on the literature review conducted and an Internet search. The accreditation topic has not been extensively studied in the context of CS and thus its connection to the work conducted in CS Track has remained somewhat open-ended in some cases, inviting debate and further analysis. However, this also provides an opportunity to discuss accreditation from a fresh perspective, free from discipline-related preconceptions. Therefore, this discussion paper serves as an exploration of what accreditation means or can mean in CS, for whom it may be beneficial, and who is or should be responsible for accreditation-related practices.

Table of Contents

1. Introduction

This deliverable discusses the topic of accreditation in Citizen Science (CS) as it stands and highlights the potential for developing it in the future. The topic was already suggested in the preparation stage of our project's proposal as a result of discussions about CS and its relation to education, measuring the quality of CS projects, and the value it returns to participants as well as a desire to create policy recommendations in this direction.

To clarify the meaning of "accreditation" for the purposes of this deliverable (and our work in the project in general), we start from the dictionary definition. According to the online version of Oxford Advanced Learner's Dictionary (https://www.oxfordlearnersdictionaries.com), accreditation is an "official approval given by an organization stating that somebody/something has achieved a required standard". Two examples follow this definition: 1. a letter of accreditation 2. The Accreditation of Prior Learning scheme allows work experience to be added towards qualifications. A somewhat broader view of the term's definitions is provided by another online dictionary (https://www.dictionary.com), which posits accreditation as one of three actions or statuses (short examples omitted from the quote):

> "1. The act of giving official authority or approval, or the resulting status; certification.
> 2. The act of certifying an educational institution or program as meeting all official formal requirements of academic excellence, facilities, curriculum etc.; the status of being so certified.
> 3. The act of attributing or ascribing some quality, status, or action to a person or thing."

According to the latter source, words related to accreditation are, e.g. diploma, certificate, credential, license, passport, permission, permit, pledge, sanction, subpoena, summons, ticket, authorization, card, character, deed, docket, document, documentation, and endorsement.

The concept of accreditation presupposes, therefore, a quality verification against a threshold or standard attested by a person or organization believed to be in a position to confer it. On the other hand, there is a component of certification or the granting of some tangible proof by means of e.g. a written certification. Interestingly enough, both concepts – accreditation and certification – are more clearly distinguished in CS literature than they appear in the dictionary definitions. Certainly, they are not equivalent (e.g. a certificate of vaccination does not support the accreditation as captured here), although the denotation and connotations, when taken together, consolidate them in a similar way. Without putting unnecessary emphasis on the formal accuracy of the term, and in order to align the necessary meaning, we ascribe to accreditation throughout this document as defined above. Further in this discussion paper, we will present additional scholarly definitions of accreditation, on which we will elaborate as needed.

It is important to note that accreditation ends with the suffix -tion, indicating the result of an action. Accreditation is the result of receiving approval for established structures, typically an institution such as a university, regarding quality (Stufflebeam & Coryn, 2014). Accreditation can be a voluntary or compulsory method for quality improvement and accountability, i.e. transparency of an institution, which may enhance future support by stakeholders such as students and funders (Kumar, Shukla, & Passey, 2020; Sanyal & Martin, 2007). The process usually entails a self-evaluation by the institution, an examination by third-party experts, and evaluation and decision by an accrediting board (Stufflebeam & Coryn, 2014; Phillips et al., 2018). Accreditation in education is either institutional or programmatic and is usually valid for a predetermined time period. Institutional accreditation is

concerned with evaluating whether the overall resources and practices at the university are sufficient to the needs of, e.g., students. It can be geographical (i.e. local/regional, national, international) and the demands and focus for each can and often vary, but it typically concerns the overall quality of an institution. Programmatic accreditation in education refers to having a department or program with an institution accredited; however, this typically requires the institution to already have some sort of accreditation (Kumar, Shukla, & Passey, 2020; Phillips et al., 2018; Sanyal & Martin, 2007).

Accreditation for institutions can yield affordances and challenges to both the institution and its students. Regarding affordances, accreditation provides a systematic method for comprehensively evaluating the institution and its activities. Earning accreditation affirms good practices and leadership, which provides quality assurance for stakeholders, enhances mobility of students via credit recognition, unifies and streamlines research plans, objectives, and pedagogical practices, which enhance overall learning outcomes. Students graduating from an accredited institution can have their education and thus certain skills verified, increasing their competitiveness when job hunting or applying for a higher level of education such as graduate school (Kumar, Shukla, & Passey, 2020; Phillips et al., 2018; Sanyal & Martin, 2007).

However, there are also challenges. Accreditation is typically not permanent because it does not automatically guarantee quality, so it requires periodic follow-up evaluations and further investment, which may be subject to bias and corrupt practices (Shufflebeam & Coryn, 2014; Phillips et al., 2018). Institutions may face limitations with, e.g. terminology, infrastructure, resources, goals etc. In some cases, there is the possibility that the requirements for one form of accreditation can conflict with another (Phillips et al., 2018). This is particularly challenging for developing countries that already lack the necessary human resources for establishing the necessary means for accreditation (Sanyal & Martin, 2007). In addition, accreditation can be connected with institutional ranking, so it is likely that competition among students will also increase, raising the issue of balancing inclusiveness and diversity among the overall student body (Kumar, Shukla, & Passey, 2020).

The need for accreditation in CS may depend on the demand of citizen scientists and project initiators. There can be demand, for example, from motivated citizen scientists, who view accreditation (and eventual awards) as the expected tangible result for their efforts (Peter et al. 2021; West and Pateman, 2016). Another form of demand may come learning institutions wishing to streamline their syllabi with learning-intensive participation of their pupils or students in CS projects (Cedefop, 2015; Roche et al., 2020). Satisfying this demand, there are certain stakeholders that view accreditation as a natural complement to CS project participation, providing a quality check.

Citizen scientists who engage in CS frequently (e.g. every week) and extensively (five or more years) are more likely to be active in several CS projects in one or more research fields (e.g. biology, health etc.) (Peltoniemi et al., accepted for publication). While separate accreditation for each research field may be relevant and necessary, long-term citizen scientists could also be accredited in a way that allows recognition across project fields. However, if the skills, competences, knowledge etc. of citizen scientists are to be accredited across projects, it requires the creation and sharing of their profile. The study by Herodotou et al. (2020) may be one example of such profile creation. In their study, Herodotou et al. (2020) created engagement profiles of users on the CS platform of Zooniverse to better understand how participants select a project as well as their participation behavior (frequency and level of contribution) within a project. While user profiles provide useful information to project stakeholders, sharing data between project organizers raises important issues regarding privacy and data storage.

CS projects occur in a variety of research fields and thus include a variety of learning environments. CS projects can be launched in formal learning environments such as schools, non-formal learning

environments such as museums and libraries, and situational or informal learning environments such as the workplace (e.g. colleagues chatting in the break room). Nonetheless, each learning environment has their own affordances and limitations for learning depending on the availability of learning resources (e.g. tutoring), materials (e.g. beakers, iPads), infrastructure (e.g. physical buildings and their classrooms, learning management systems). Accordingly, the significance of accreditation for CS across these environments may vary (Cedefop, 2014; OECD, 2020; Kloetzer et al., 2021; Peltoniemi et al., accepted for publication).

Schools, for instance, are inherently considered as accredited learning environments and its activities (e.g. sports events, chemistry workshops) have more potential at being supported (e.g. financially, socially) by the local community. Thus, CS projects in schools will naturally benefit since the school customarily accredits and issues certification. In contrast, museums and libraries provide short-term activities based on experiential learning such as workshops, which are often made possible through crowdfunding or support from other third parties. Accreditation may be a way to enhance the organization and implementation of CS projects in such environments by enabling key stakeholders to better utilize resources such as training and funding. Informal or situational learning at the workplace or at home is spontaneous and unstructured, which means CS projects struggle to maintain the participation of citizen scientists. However, the learning experience may be profound and thus encourage participants to verify their experiences through taking a qualification test. In this sense, accreditation is already included, but only when desired by the participant (Cedefop, 2014; Cedefop, 2015; OECD, 2020; Peltoniemi et al., accepted for publication; Roche et al., 2020).

Overall, with this deliverable, we aim to present issues related to accreditation in CS and describe their manifestations during the three years of CS Track's project work. We refer to the rather diffuse way in which we preliminarily stated our intentions vis-à-vis accreditation in the project's description of work (section 2), followed by an in-depth literature review (section 3), a synthesis and positioning of accreditation in the field of CS (section 4) and discerning its manifestations within CS Track (section 5). Finally (section 6), we will address the ways to incorporate accreditation in CS policy and suggest policy recommendations based on our work.

We acknowledge that the topic of accreditation has not been extensively discussed in the context of CS and thus its connection to the work conducted in CS Track has remained somewhat open-ended in some cases, subject to debate and further analysis. However, at the same time, this also provides an opportunity to discuss accreditation from a fresh perspective, free from discipline-related preconceptions. Therefore, this discussion paper serves as an exploration of what accreditation means or can mean in CS, for whom it may be beneficial, and who is or should be responsible for accreditation-related practices.

Note - Throughout this document, we make use of the terms 'citizen scientist', 'volunteer' and 'participant' interchangeably to refer to people engaged in citizen science projects.

2. Accreditation in CS Track's description of work

The topic of accreditation appears several times in CS Track's description of work (DoW). When addressing the innovative potential of the project, in section 1.4.3, we mentioned that we see potential in three dimensions: (1) the use of analytics; (2) the resulting provision of innovative knowledge services, especially those related to recognition and/or accreditation; and (3) the promotion of communities of interest and practice in CS. The concept of accreditation as a kind of 'knowledge service' is further elaborated a few lines below in the same section: "*[among others,] the institution of the knowledge base and good practices to support recognition and accreditation of participation in a CS activity […] can build on analytics (with data from all sources considered in this project) [...]. Accreditation (in principle, but not exclusively, in connection with the science learning extent associated with a given CS activity) is an important such service, due to its expected impact and game changing character. In fact, things will look quite different, in society and in the economy, after accreditation of participation in CS will be enabled and used as a standard matter. Our project will innovate in making this possible*". The above is complemented in section 3 of the project proposal ('Implementation'), where we stated that the triangulation of all the data collected by CS Track "*will result in policy recommendations with respect to accreditation of informal learning as well as best practices to support the activities on the run*."

Accreditation, therefore, is presented in the DoW as a "service" that will be feasible building on the data and information that will become accessible *because of* the advances brought about by the CS Track project. Accreditation, which is seen as closely related to recognition (such as the definitions discussed in the introduction), is not defined with much precision here. Yet, it is clear that its field of application may be as broad as one would wish, focusing on individuals, CS projects, specific activities or processes within those projects, etc., as all these – together or separately – carry the seed for positive impact.

The DoW operationalizes our work on the accreditation, by defining a concrete task and deliverable for this purpose within WP4 (Analysis and policy recommendations). In this WP's description, "*create accreditation practices for CS activities*" is listed among its objectives. Task T4.5 makes this more explicit: "*In [previous tasks] we build models to identify how different factors (e.g. gender) are associated with the development of CS activities. Our models also identify factors explaining the variations in participants' CS paths, roles and skills. Thus, we expect to find new evidence on how to determine accreditation practices for CS. The applicability of the new evidence is expected to be high in view of the approach taken. Creating a guide to accreditation methods will include sample CS-Track accreditation practices already in practice and proposed links to formal national, regional and sector-specific accreditation procedures already in place that can be adopted for use with CS-Track*."

The close link between accreditation and policy in CS Track is demonstrated by the fact that the topic of accreditation appears again in the description of the next task, T4.6 – "*Formulating the policy recommendations*" (essentially, the ultimate target of WP4 and the CS Track project). Among other things, this task involves "*seek[ing] to determine accreditation practices for CS activities. Special attention will be on how this form of CS activities can be accredited (in line with MoRRI indicators). A triangulation of the data will result in policy recommendations with respect to accreditation of citizen science activities as well as best practices to support the activities in their development*." We should keep in mind that the term "activities" has, in the DoW, a rather broad scope, covering also CS projects and not only isolated actions or processes within or related to them.

Thus, both aforementioned tasks (T4.5, T4.6) clearly state a link between accreditation and policy (and policy recommendations), each of which should not be seen as complete without the other. We expect, building on this deliverable, to formulate policy recommendations *about* accreditation, capitalizing on the developments the latter could permit or foster at the individual, CS project and CS field levels, among other perceived benefits.

Specifically regarding the present deliverable (D4.5 of WP4), it was not described in the DoW with much detail. It was only mentioned that it would be a "discussion paper" (more precisely: "*The accreditation discussion paper – determine accreditation practices for the CS activities*"), and as such, we feel it appropriate to direct the discussion to the content that would render it the most informative and useful for the project – the present scope of accreditation within CS and the potential for growing this practice in the future. In sum, we approach the accreditation subject in this discussion paper with relative flexibility, as it arises from the CS literature as well as building on the findings of the project. As the DoW does not require us to adopt one particular definition or use of accreditation, we choose to broaden the scope and include many variations and opportunities for accreditation in CS. This may include (as will be elaborated further), the preparation of an individual for a CS project, or, during a CS project, to the future education or life of the same individual, or to a process taking place in a project, or even to the entire CS project that engages an individual or hosts that process.

3. Accreditation in Citizen Science research literature

This section is dedicated to a literature review of the accreditation subject in the context of CS. In the annex, we also present a short and partial overview of existing accreditation providers, based on the preceding literature review and an Internet search.

Our aim in conducting this literature review principally was to shed light on the following three questions:

- How is accreditation conceived in CS?
- Who seeks (and wants to benefit from) accreditation and who provides accreditation as a "service"?
- What is being accredited – a person, an activity, or a project?

Collecting this information would, so we hoped, allow for a better understanding of how other actors in the field (e.g. researchers, CS projects, institutions of different kinds) approach the issue of accreditation – an understanding which could then, in turn, inform our own investigation of the topic. However, our literature review on the topic of accreditation has yielded a scanter harvest than expected: relatively few articles, many of them written and thematically situated in a limited geographical area – that of the British Isles. It appears that accreditation has not (yet) reached the status of a central research topic when addressed specifically in the CS area. Moreover, the approach taken by most of the publications we reviewed is anecdotal (i.e. describing a specific example) rather than analytical, without any apparent intention to carry out a systematic, theory-grounded study.

In light of the relatively small number of relevant publications, we have decided to include a short summary of the key literature (four) we identified.

Citizen Science – Motivations, Progression and Accreditation (April 2016), prepared by The Conservation Volunteers (TCV) as part of the Scotland Counts project, has proved quite strategic for CS Track in practically establishing the role and importance of accreditation in the CS realm. Scotland Counts "aims to provide an insight into citizen scientist motivations [and] progression routes and investigates whether formal accreditation would benefit CS participants and add value to the data collected (p. 3)". Based on a survey distributed to various CS stakeholders and practitioners, the paper examines the motivations and drivers behind the involvement in CS activities, as an attempt to understand what attracts volunteers / citizen scientists and what would encourage them to sustain their participation over an extended period of time. Motivations identified by the project as central to volunteers include a desire to learn and develop new skills, engage in social interactions, enjoy the outdoors and "giv[e] something back to society" (ibid). Some of these motivations have direct links to progression, new career opportunities and learning, while others may be of a more social or personal nature. The authors therefore acknowledge that not all motives for getting involved in CS necessarily relate to progression and accreditation.

Progression, a central topic in this report, is defined as actions capable of contributing to one's preparation for life, similarly to primary or secondary education. Seen this way, it is not surprising that progression is closely linked with formal accreditation, "with certification of competency, authority, or credibility" (ibid). Accreditation appears, therefore, as a logical result of (and response to) the citizen scientists' motivation to learn and progress. In other words, progression is both an essential form of motivation and the moving force behind accreditation.

As an example of formal accreditation in the field of CS, the authors name OPAL – Open Air Laboratories, a UK citizen science network initiated and led by the Imperial College London, which ran from 2007 until 2019. In 2016, OPAL, in cooperation with Queen's University Belfast, launched a two-day course on conducting environmental surveys using the OPAL CS framework and methodology. Participants could choose between three levels of accreditation, the highest of which was issued directly by Queen's University Belfast. While the registration fee was negligible (£5), the amount of homework required to obtain a certificate was not. Although the course is no longer being offered in its original form, Queen's University Belfast still lists OPAL CS surveys as one of the activities eligible for their DegreePlus/Future Ready Award programme. This programme provides students with formal recognition for extracurricular experience with the aim of improving their employability.

However, the TCV report points out that accreditation services such as the OPAL course also have drawbacks in terms of administrative burden and cost – a concern that is raised in several of the publications we reviewed. In fact, the authors suggest that mandatory accreditation might discourage organizations and individuals from engaging in CS due to lack of time, staff capacity or financial resources. The survey respondents overall expressed a 'keen interest' in creating accreditation opportunities for citizen scientists, both as a motivational factor and because it could potentially lend greater authority to CS-generated data. At the same time, they opined that accreditation should be offered on several different levels and remain an optional add-on rather than a default aspect of participation.

A second source – ***Integrating Citizen Science into accredited courses and awards in Scotland*** (TCV, 2014) reviews CS-related awards and accreditation opportunities in Scotland. It showcases "some of the available routes for volunteers to achieve recognition through curricular and extracurricular CS activities and also identifies further research options for wider inclusion of CS in courses." (p. 1) The report mentions and seems to be related to (an early release of) the previously surveyed report. It intends "to ascertain the potential to increase CS activity through linking it more effectively with recognised awards and accreditation" (ibid.), finding that "the ongoing integration of CS into learning through the [aforementioned] Scotland Counts and other projects raises a need to identify and explore the potential for achievement of awards and accreditation *through participation in CS activity*" (ibid.)" [italics are ours.] The authors provide a list of courses and study programmes accredited by the Scottish Qualification Authority (SQA) that already incorporate CS in some way. They also suggest additional opportunities for the integration of CS into officially accredited qualifications – for instance in schools or in the further education sector.

The third paper referring to accreditation in CS is ***Recruiting and Retaining Participants in Citizen Science: What Can Be Learned from the Volunteering Literature?*** (West and Pateman, 2016). Similarly to the previously discussed sources, it inquires into the factors that prompt people to take part (and stay engaged) in CS projects and thus strongly focuses on the topic of motivation. In other words, this paper addresses accreditation, along with various types of reward systems, as a potential motivational factor for citizen scientists. Indeed, rewards can be seen as a kind of less formal, shorter-term, partial approximation to accreditation. "Rewarding project participants is [a] way of motivating them to continue their involvement by showing them they are valued" (p. 6), and can be done for instance by thanking them, offering badges or awards, handing out discount vouchers, or involving them in project management and decision-making. The article furthermore argues that "**[a]ccreditation**, where participants receive formal recognition of the work they do, can be mutually beneficial: For participants it can provide evidence of increasing their skills and personal development, and for the organization, accreditation can help to attract and retain more effective and skilled participants." (ibid.) On the other hand, the authors also point out that the additional effort and paperwork associated with accreditation may put off potential participants – particularly since surveys show that

some citizen scientists already feel that their project is too bureaucratic. They conclude by stating that a "'one size fits all' approach to training and support does not work because it does not draw on individuals' strengths and motivations, i.e. different volunteers will require different levels and methods of support, and the support given needs to be tailored to the individual […]" (p. 7).

Citizen science and policy: A European perspective, by Muki Haklay (2015), is another source that makes reference to the accreditation subject. In Chapter 4 (*The professionalization of citizen science*) the author states that over the past few years, researchers and other stakeholders have realized that, in order to support CS initiatives and guide them towards success, best practices need to be defined and communicated. Moreover, as the field of CS is expanding and maturing, he believes that "there is a growing need to provide continuing professional development (CPD) to practitioners and, potentially, accreditation." (p. 54)

This paper draws our attention to two potential uses of accreditation in CS: One is the possibility of making the professional scientists the targets of training and accreditation. As we have observed in our (and others') research, the professional scientists often do not only lead a CS project's scientific work, but also are responsible for creating and maintaining a productive relationship between the project's team and participants; This is done through community management and internal communications, coordinating the participants' efforts, organizing outreach and public relations, procuring resources, equipment and funding etc. The skills and know-how required to live up to these "non-scientific" tasks also have to be acquired and nurtured for some. In other words, accreditation might also be needed on the part of professional scientists to prepare them for the role as a CS project coordinator. Haklay's call for the definition and implementation of best practice standards in the field of CS points towards another possible form of accreditation – namely the assessment and certification of a CS project's quality or level of professionalism.

As the author points out, three organizations – the Citizen Science Association (CSA), based in the US and founded in 2013; the European Citizen Science Association (ECSA) also founded in 2013 and coordinated by Natural History Museum in Berlin, Germany; and the Citizen Science Network Australia (CSNA), established in 2014 – already support CS practitioners by sharing guidelines and handbooks, organizing webinars and offering Massive Open Online Courses (MOOCs). It may not be a big leap to move from providing these resources and learning opportunities to offering accreditation to those CS projects or practitioners that make use of them and apply the lessons learned in their own work.

Understood in the sense of 'certifying that a CS project meets a certain set of criteria or quality standards', the term 'accreditation' is quite closely related to, but not synonymous with, project 'evaluation'. As explained in the introduction, organizations seeking some form of accreditation typically have to undergo a rigid, formalized evaluation by third-party experts or authorities. Simply put, evaluation is typically a mandatory step in accreditation processes. For further comments on the relationship between accreditation and evaluation, please refer to chapter 4 and, specifically, to subchapter 4.3, which provides additional examples of evaluation frameworks that could potentially inform project-level accreditation in CS.

Since there already is a rather substantial body of literature dedicated to the topic of evaluation in CS, a comprehensive overview would be beyond the scope of this discussion paper. We will thus only reference two recent and often cited publications as well as an additional source.

In ***The science of citizen science*** (Vohland et al., editors, 2021), a comprehensive edited volume that addresses various aspects of CS, the word "accreditation" itself does not appear. However, one entire chapter (Ch. 25, Evaluation in Citizen Science: *The Art of Tracing a Moving Target*, by Schaefer et al.) is devoted to the related concept of 'evaluation'. The authors build on the *citizen science evaluation*

framework of Kieslinger et al. (2018), which proposes indicators for the evaluation of CS projects in three dimensions: scientific, participants-related, and socio-ecological/economic. The following table is quoted from Vohland et al. (2021, p. 498) and, in turn, from Kieslinger et al. (2018):

Table 1. Citizen science evaluation framework developed by Kieslinger et al. (2018), quoted from Vohland et al. (2021, p. 498).

	Process and Feasibility	Outcome and Impact
Scientific dimension	Scientific objectives, data and systems, evaluation and adaptation, cooperation and synergies	Scientific knowledge and publications, new research fields and structures, new knowledge resources
Participant dimension	Target group alignment, degree of involvement, facilitation and communication	Knowledge and science literacy, behavior and ownership, motivation and engagement
Socio-ecological and economic dimension	Target group alignment, active involvement, collaboration and synergies	Societal impact, ecological impact, wider innovation potential

While this framework is geared towards the evaluation of CS projects (and not of individual researchers or volunteers involved in such projects), a closer look at its components also reveals potential links between project-level evaluation and individual-level accreditation. For instance, considering its potential to increase motivation and encourage learning, offering accreditation to the participating citizen scientists could serve as an evaluation criterion in the participant-related dimension of 'outcome and impact'. Conversely, several of the evaluation criteria Kieslinger et al. (2018) list in the column 'process and feasibility' could also be relevant to the accreditation of professional researchers intending to initiate or lead a CS project. In short, this comprehensive CS evaluation framework opens up a spectrum of possibilities of combining in different ways and with different priority the elements of the table when addressing projects, individuals, scientists, citizens, preparation before, during or after the project etc., as targets of evaluation and/or accreditation.

Evaluation theory, models, and applications (Stufflebeam and Coryn, 2014), another source we consulted, deals with evaluation in a general sense, without any specific focus on CS. It nevertheless sheds some light on concepts that interest us in this deliverable. First of all, it provides a narrower, but also more precise and detailed definition of 'accreditation' than the dictionaries quoted in our introduction. In the paper's glossary, accreditation is "a process administered by an accrediting association to examine the quality of an institution (or section of an institution) or institutional program against externally based, professional accrediting standards, and to decide on whether to certify that institution based on the level of quality. Typically the accreditation process includes the subject institution's self-study, a subsequent examination by a visiting panel of experts, and the accrediting association's eventual decision either to provide some level of accreditation for a given period of years or to deny accreditation (p. 727)." According to this approach, accreditation is granted to an institution (say, in our case, a CS project) by another institution (e.g. institutions like those cited in the aforementioned paper by Muki Haklay, or those mentioned in the annex). In other words, accreditation in this sense would not be granted by a CS project to the citizen scientists volunteering in it. It takes place on the level of projects (or organizations), not on the level of individuals. Important elements in this approach to the concept of accreditation are evaluation and quality assessment

informed by generally accepted, professionally endorsed standards – something that is only beginning to emerge in the field of CS.

Stufflebeam and Coryn also draw attention to a form of accreditation that is not mentioned in any of the other publications we reviewed – namely the accreditation of products, services and personnel that could potentially "put the public at risk" if they do not comply with professional safety and best practice standards. This type of accreditation is, in all likelihood, only relevant to relatively few CS projects, for example in the field of citizen health science or patient science.

The ***European guidelines for validating non-formal and informal learning*** (Cedefop, 2015) are not geared specifically towards CS or towards the accreditation subject in particular; indeed, neither of these terms appears in the text. There are, however, conceptual proxies, as 'assessment' and 'certification' are two of the four phases of validation proposed by the authors (together with and preceded by 'identification' and 'documentation'). Both connect seamlessly to the accreditation idea, since accreditation requires assessment and typically results in certification. Furthermore, chapter 4 (Validation Contexts) contains subchapters that address Validation in Enterprises and Validation in the Voluntary Sector, the latter of which brings us quite close to the domain of CS.

But even the section on validation in the private sector raises two points relevant to this discussion paper. On the one hand, the authors argue that competence assessments in the workplace can increase motivation, help generate new ideas by stimulating self-reflection, and facilitate employee retention. The concepts of motivation and retention (of the employee/learner here, of the citizen scientist in a CS project) and of self-reflection are readily transferable to CS in general and to the issue of accreditation in particular.

On the other hand, the authors also highlight a major drawback of internal competence assessments within companies: The results (e.g. certificates) often cannot be used outside of the company context and are thus of limited value to the individual employee. In other words, they are ill-suited to the task of increasing the "visibility of prior learning". The challenge of ensuring the practical usability of assessment (or accreditation) results outside of the original context in which they were generated – something that certainly should not be taken for granted – is as relevant for CS as it is for any other organizational setting.

The aforementioned section on Validation in the Voluntary Sector affirms that "[t]he voluntary (or 'third') sector plays an important role in promoting validation of non-formal and informal learning" (p. 43). In addition, while many argue that "learning experiences from voluntary work should be valued in their own right and not assessed according to standards developed for formal education and training (ibid.)", others feel that such learning experiences can be 'highly relevant' for both formal education and employability and should therefore be eligible for formal certification (if desired by the individual in question).

This emphasis on the importance of accreditation and certification in relation to progression in learning and in life and to the role of external organizations in facilitating accreditation is clearly in line with the other publications we reviewed.

As **concluding remarks**, and in an attempt to summarize the literature we examined, we would like to provide the following points, some of which have been raised by more than one of the reviewed authors in their contributions:

- Many of the publications we reviewed do not simply assume that there is a need for accreditation in CS. Rather, they examine what motivates citizen scientists to seek accreditation and how they (and the projects they participate in) can actually benefit from it.

- In most cases, the focus is on accreditation in the sense of formalizing acquired skills of participants, rather than in the sense of certifying the quality of certain CS projects. “Accreditation of skills for citizen scientists” is, therefore, the usual motto.
- Motivation(s), engagement, retention are all terms that recur throughout the sources reviewed. We may safely state that accreditation fulfils its role when it is designed and implemented in a way that increases the participants’ motivation and thus promotes long-term engagement.
- Progression – in studies/career, in obtaining a desired job – is largely seen as a key motivation behind accreditation for individual citizen scientists.
- While accreditation is certainly deemed important, the publications we surveyed argue that it should be kept optional and flexible (in terms of required time commitment etc.), since the individual participants’ needs and motivations may differ.
- The fact that accreditation has a cost – both for the accredited individual or project and for the accrediting entity – is taken up by more than one source. The ensuing questions about cost-benefit ratios and the possibility that accreditation may not always result in a net gain have attracted researchers’ attention. The result is a call for careful planning of the way the accreditation is implemented to ensure its sustainability.
- Accreditation of scientists in the sense of preparing them for the role of CS project leader – particularly with a view to the non-scientific aspects of that role – is mentioned only by one of the publications we reviewed.

The above have implications on policy construction, design, and implementation, which will be demonstrated in section 6.

4. Positioning accreditation in the field of Citizen Science

As made clear from the introduction and literature review, accreditation in CS can take many forms and be directed towards different outcomes and stakeholders. It can be internal or external orientated, involve individuals or groups, and provide personal or institutional benefits. As such, accreditation in CS can be seen as a spectrum of opportunities.

Generally speaking, accreditation helps formalize activities, as it demands a set of metrics and indicators which need to be met in order to reach the accreditation standard. In that sense accreditation is different to evaluation, as evaluation is a more holistic examination of an activity or program which involves its characterization of and identification of strengths and limitations. The benefits for accreditation lie in the advancement of processes geared towards meeting the goal defined. It can foster a culture of quality, safety and accountability and promote communication between people involved in a program. In the context of CS, accreditation is theorized as a motivational factor for increased participation, a way of acknowledging those participating and/or as an approval method for projects.

Below, we provide an outline of the possibilities for accreditation within CS, integrating the information presented previously into a coherent structure. We summarize the different actors and beneficiaries of accreditation, discussing what is accredited, for whom, and by whom. We then suggest a two-dimensional framework for CS accreditation based on the actors involved in accreditation and the topic of accreditation, and use this framework to scrutinize existing models of accreditation from education and evaluation contexts.

4.1 Accreditation of what? For whom? By whom?

There are a number of bodies that can be subject for accreditation in CS. These may include full CS projects or specific activities within a CS project, training processes, learning materials and communication methods. People may also be accredited for their participation in a CS project, for the skills or knowledge they gained and for their time investment and contribution to the project.

The benefit of the accreditation process will depend on what is being accredited and for what purpose. For example, if a CS project is being accredited for its quality and management, the project itself will benefit from the recognition of its practices. This may encourage more participants to join a project, may attract collaborations and may assist in future funding schemes. Alternatively, if a participant is being accredited for his or her skill development, this may be used by the participant for personal progression opportunities, or as a sense of achievement and recognition. Bodies who perform the accreditation may be the CS projects themselves, CS associations, universities or other external institutions or projects.

Integrating the literature on this topic and the great diversity in accreditation options, we have identified five types of accreditations currently discussed in CS:

1. **Training of citizen scientists** – in this context, accreditation is referred to as an instructional process within a particular CS project. Participants engage in training on the specific topic and learn the knowledge and skills required in order to complete the tasks allocated for citizen scientists.

2. **Participants' learning and competences** – this accreditation process serves as an acknowledgment of the skills and knowledge gained from volunteer participation in CS. This is often acquired through extended participation in a project and, as a result, gaining experience and familiarity. To a certain degree, this accreditation type is similar to a certification process providing verification of an individual's abilities.
3. **Recognition of participants** – Recognition has been raised as a major motivation for participation in CS, often predicting future engagement and participation in a project. This accreditation, therefore, is suggested as a method to acknowledge participant's contribution to a particular project and express gratitude for their sustained efforts.
4. **Training of scientists** – This type of accreditation refers to those leading CS projects and discusses their skill and training both as experts in their corresponding scientific field and in leading CS projects.
5. **Quality of projects** – Different to the accreditation types discussed above, this type does not directly involve individuals, but rather a CS project itself. In this context, a project may be assessed based on its activities, management, community engagement and outcomes. Consequently, this may lead to greater appreciation of the project quality and management.

Based on these accreditation types, we offer a framework for CS accreditation which describes the spectrum of opportunities for accreditation within CS constructed across two pillars:

- Individuals involved in the accreditation process – this may include citizen scientists, practitioners working in or leading CS initiatives or scientists.
- The entity, activity or outcome which is subjected to accreditation – this may include a project, the tasks within a project, or skills and other learning outcomes.

We have clustered each of the above accreditation types on a two axes plot, based on these two pillars. This plotting provides an articulation of the individual and subject dimensions of each accreditation type and its main focus (Figure 1). For example, accreditation type 2 – *Participants' learning and competences*, is plotted on the high right corner of the plot, indicating the individual participant level and the learning outcomes which are subject for accreditation. On the other hand, accreditation type 5, *Quality of projects*, is plotted on the lower left corner of the plot, indicating the professional, project-based accreditation requirement.

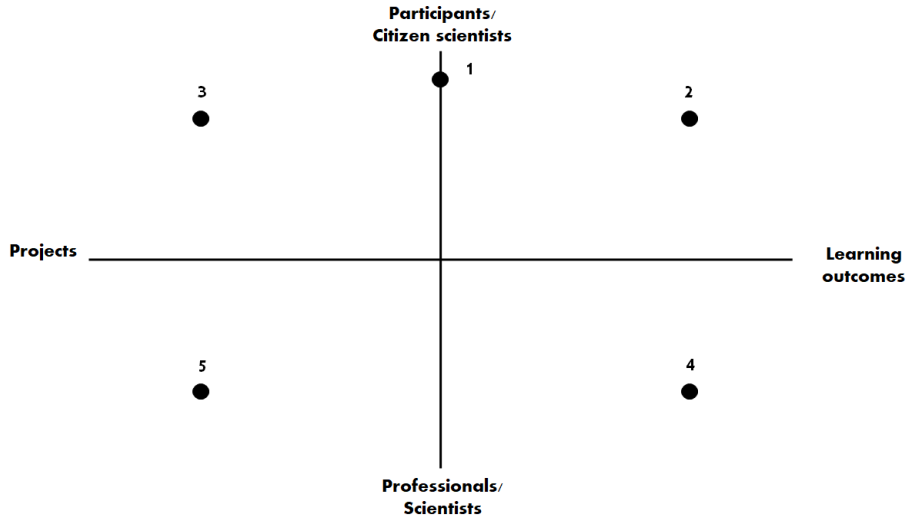


Figure 1. Plotting accreditation types across two pillars – Individuals involved in the accreditation process, the topic of accreditation. Numbers in the plot relate to the five types of accreditation.

Looking at the clusters created in the accreditation plot, it is clear that a great diversity exists among the topics, items, people, and subjects for accreditation within CS. Additional possibilities may exist, which can be further plotted against the dimensions in this plot to reveal their similarities and differences to the existing five accreditation types. Furthermore, each individual project or accreditation entity can be placed on this plot and clustered according to their accreditation characteristics and requirements.

4.2 The connection between accreditation and education

The biggest strength and, perhaps, greatest challenge of CS projects is that the characteristics of the project and its members are diverse. Projects and their participants represent a variety of demographics, which means that there is a myriad of, e.g. motivations, skills, experience, ages, and socioeconomic classes (Lorke et al., 2019). This diversity implies that not all volunteers may have sufficient skills to, e.g. perform data collection accurately. Likewise, not all project designers necessarily have the expertise to design and manage a CS project and to recruit volunteers that possess the necessary skills or expertise demanded in the project (Lorke et al., 2019). Accreditation can be used to address these challenges, provided that education is supplemented.

Not all projects set aside the time and resources for training and the projects that do include training, are often limited in scope, content, resources, and staff (Roche et al., 2020; Lorke et al., 2019). According to Lorke et al. (2019), the first step is to provide the necessary information and training that addresses the "core, operational, and engagement needs" of three key audiences of CS project training: participants, facilitators (those who train or lead groups of participants in CS), and designers of projects (p. 6).

Core needs focus on addressing fundamental questions relating to the nature of and purpose of the project. In this context, training (or education) would provide scientific background of the project to participants and facilitators and define scientific topics for project designers. Regarding operational needs, education focuses on the practical concerns of the project. For participants and facilitators, this includes understanding the data and technical practice regarding the tools, platforms etc. used in the project. For project designers, this addresses the actual design of the different tools, platforms as well as outlining the teaching methods needed in dissemination. Regarding engagement, education enables better enjoyment, communication, and enhances the organization and facilitation of other forms of recruitment and engagement for participants, facilitators and designers alike. Education regarding recognition means that designers incorporate it into the project and facilitators provide it to the participants who are made aware of it (Lorke et al., 2019; Roche et al., 2020).

In this section, we look at the case of SciStarter (https://scistarter.org/) in promoting accreditation through education in relation to the five types of accreditation defined above (Figure 1): training of citizen scientists, participants' learning and competences, recognition of participants, training of scientists, and quality of projects.

SciStarter is an online platform that allows participants to browse through and join different CS events and projects that have been uploaded to the platform. The training tools on SciStarter relate to the first type (training of citizen scientists). SciStarter offers study learning modules that cover specific topics related to the project and general information on the field of CS itself. When a module is completed, a badge is awarded to acknowledge the learning and competences of participants, which is the second type (participants' learning and competences). Once certain modules are completed, participants can complete modules specific to the tasks found within the project. Participants can be

recognized for their contributions to projects by promoting their completed badges online, reflecting the third accreditation type (recognition of participants). The facilitation tools relate to the fourth accreditation type (training of scientists) as projects can host and plan orientations to facilitators of projects. SciStarter also allows its users to enter the portals of other CS projects directly through their website, which not only enhances the interaction in the CS community and recruitment of participants for projects, but also for the integration of project-specific tools and modules that complement the badges and thus education obtained within SciStarter. Regarding the fifth accreditation type (quality of projects), SciStarter does not seem to have a clear system in place to assess the overall activities, management, community engagement and outcomes of a project; at the same time, one could argue its features and tools, when taken together, can enhance the quality of outcomes at the project and participant levels.

Additional expressions of the accreditation-education connection are CS courses available in a number of academic institutions around the world, for example:

- MOOC "A Roadmap to Citizen Science Education by BRITEC": Teachers in Spain and Portugal can get a certificate upon completion of this course that counts as 'valid continuous professional development' (i.e. it is useful from a career-planning perspective) – A Roadmap to Citizen Science Education | European Schoolnet Academy
- CS program for first-year students at Bard College (US): Here, the students themselves are considered 'citizen scientists'. There is no collaboration with people outside of the college, so this may not count as 'proper' CS – Citizen Science Program at Bard College
- The new MSc Ecology and Citizen Science at UCL (UK): In this new study program, students are involved in an active CS project (sort of like an internship) – UCL MSc Citizen Science – University College London
- The MA program 'Digital Humanities' at Leipzig University (Germany) occasionally includes seminars and practical training on CS

As these programs are intended to educate university students about CS. They represent a training opportunity for (future) scientists which relates to the fourth type of accreditation.

4.3 The connection between accreditation and evaluation: Perspectives from MoRRI indicators and other evaluation models

As explained in chapter 2 of this deliverable, CS Track's DoW states that the consortium would seek to develop an approach to accreditation "in line with MoRRI indicators", which were, at that point in time, the most up-to-date evaluation framework relevant to the work of CS Track. The 36 MoRRI indicators were designed in 2015 by the EU-funded project MoRRI (Monitoring the evolution and benefits of Responsible Research and Innovation) for the purpose of assessing the implementation and impact of six dimensions of Responsible Research and Innovation (RRI) – gender equality, science literacy and science education, public engagement, open access, ethics, and governance – in research-performing organizations (Ravn et al., 2015). More recently, the MoRRI consortium used this same set of indicators to conduct the first systematic survey of the state of RRI in Europe (MoRRI project consortium, 2018). As research has progressed steadily over the intervening four years, the present subchapter will take into account not only the MoRRI indicators, but also insights generated by the follow-up project Super MoRRI and other recent studies.

Since the MoRRI project was geared towards evaluating research-performing institutions and organizations, the framework it developed cannot be directly applied to participants in CS, but to projects instead. In other words, it is relevant only to only the last of the five types of accreditation

that we distinguished for the purpose of this deliverable. Moreover, the MoRRI indicators are tailored specifically to a traditional institutional context. As a result, many of them cannot reasonably be adapted to CS projects, which function quite differently in several respects. For instance, CS project leaders are typically employed by universities, research institutes, NPOs etc. and work in CS as part of (or sometimes in addition to) their 'normal' jobs. The participants, on the other hand, generally do not depend (primarily) on the project for their livelihood or professional development. All MoRRI indicators related to gender equality in the labor market – i.e. wage gap, glass ceiling index, gender-balanced recruitment committees etc. – are thus not applicable in CS.

Other indicators concern research funding infrastructures and are therefore not relevant to CS projects as they normally receive funding rather than granting it to others. Most of the indicators connected to the RRI dimension of 'public engagement' would be pointless when applied to CS projects, since CS is by definition a way of engaging the public in scientific research. Lastly, a few of the 36 MoRRI indicators require complex calculations and/or information that may not be readily available in CS projects (e.g. National ethics committees' index or Dissimilarity index) and would therefore create a significant administrative and bureaucratic burden for CS project coordinators. Still, ten of the 36 MoRRI indicators could potentially be adapted for use in CS, and as a measure for assessing project performance (Table 2, below).

Table 2. List of MoRRI indicators that could potentially be adapted for use in CS

MoRRI indicator	Modified MoRRI indicator, adapted to CS	Comments
GE1 'Share of research-performing organizations with gender equality plans'	Existence of a gender equality plan at the project level	This could be relevant particularly with regard to the recruitment and training of volunteers, since professional scientists are usually already subject to the gender equality plan of their employer.
GE2 'Share of female researchers by sector'	-Percentage of female citizen scientists -Percentage of female project coordinators/professional scientists	However, this indicator might not make sense in very small teams, which are quite common in CS.
GE10.1 'Share of female authors'	Percentage of female authors in project publications	Again, this might not make sense in very small teams.
SLSE3 'Science communication culture'	Science communication efforts or public outreach beyond the CS activities themselves	Such as didactic materials produced in the project context, public events to present research results etc.
PE1 'Models of public involvement in science and technology decision-making'	Involvement of citizen scientists in project-related decision-making	This may not be feasible or desired in purely contributory projects.

PE2 'Policy-oriented engagement with science'	Existence of policy-oriented research questions or goals	For instance in connection with conservation efforts, urban development and planning etc.
OA1.1 'Share of open access publications'	Percentage of open access publications	However, some CS projects may not produce academic publications at all, or only in the form of MA/PhD theses.
OA2 'Data publications and citations'	Availability of project results in the form of (disaggregated) datasets	This may not always be possible due to privacy and data protection concerns.
E1a 'Ethics at the level of research-performing organizations'	Explicit commitment to a code of conduct	This could be ECSA's Ten Principles of Citizen Science or a more elaborate set of rules.
GOV1 'Use of science in policy making'	Active sharing of project results with policy-makers	Whether the data then actually informs policy decisions is often impossible to ascertain.

The follow-up project Super MoRRI, which was launched in 2019, has narrowed down the list of indicators it inherited from MoRRI by developing and applying new assessment criteria. The main goal was to eliminate redundancies, improve conceptual precision and validity, and ensure feasibility, i.e. to reduce the resources needed to collect the required data. Only six of the original 36 indicators were found to meet all these criteria (namely share of female researchers, dissimilarity index, glass ceiling index, gender wage gap, share of female authors, share of open access publications). Another 19 indicators were considered potentially useful but in need of revision or fine-tuning (Woolley et al., 2021). On the other hand, Super MoRRI has introduced a few new indicators designed to help contextualize the issue of RRI. Many of these are based on Eurobarometer data and intended to measure interest and trust in science among the general population. The rest are mostly geared towards investigating economic or conditions for RRI on the national level with the help of official statistics and budgetary data (Losinno et al., 2021). Only one of these indicators could perhaps be adapted for use in a CS context – namely 'percentage of publications classified as industry co-publications', which could be reinterpreted as 'cooperation with industry or small-medium enterprises (SMEs)'.

To sum up, although a few MoRRI and Super MoRRI indicators could potentially be modified for use in a CS context, the majority are ill-suited for this purpose in terms of epistemic aim, unit of analysis and required data. This problem of limited compatibility could be avoided by drawing on a framework designed specifically for the CS community. One such framework was developed by the Horizon 2020 project MICS: Measuring the impact of citizen science, which has recently published a list of impact indicators and an interactive web platform that project coordinators can use to assess their own project's impact. The MICS consortium has created a tool that allows CS projects to accredit

themselves by answering a series of questions. Based on these answers, the application calculates a score which projects can then mention on their website, in funding applications etc. This tool directly corresponds to type 5 accreditation as it provides a way for projects to assess their activities, management, community engagement and outcomes.

The MICS platform works with a set of 10 indicators that cover five domains of impact – society, governance, the economy, science and technology, and the environment. Thanks to the large number of questions – 200 in total – this evaluation model is both more comprehensive and more fine-grained than the ones proposed by MoRRI and Super MoRRI (Ceccaroni et al., 2022). A detailed summary would therefore go beyond the scope of this report. The main points are, however, reflected in Figure 2.

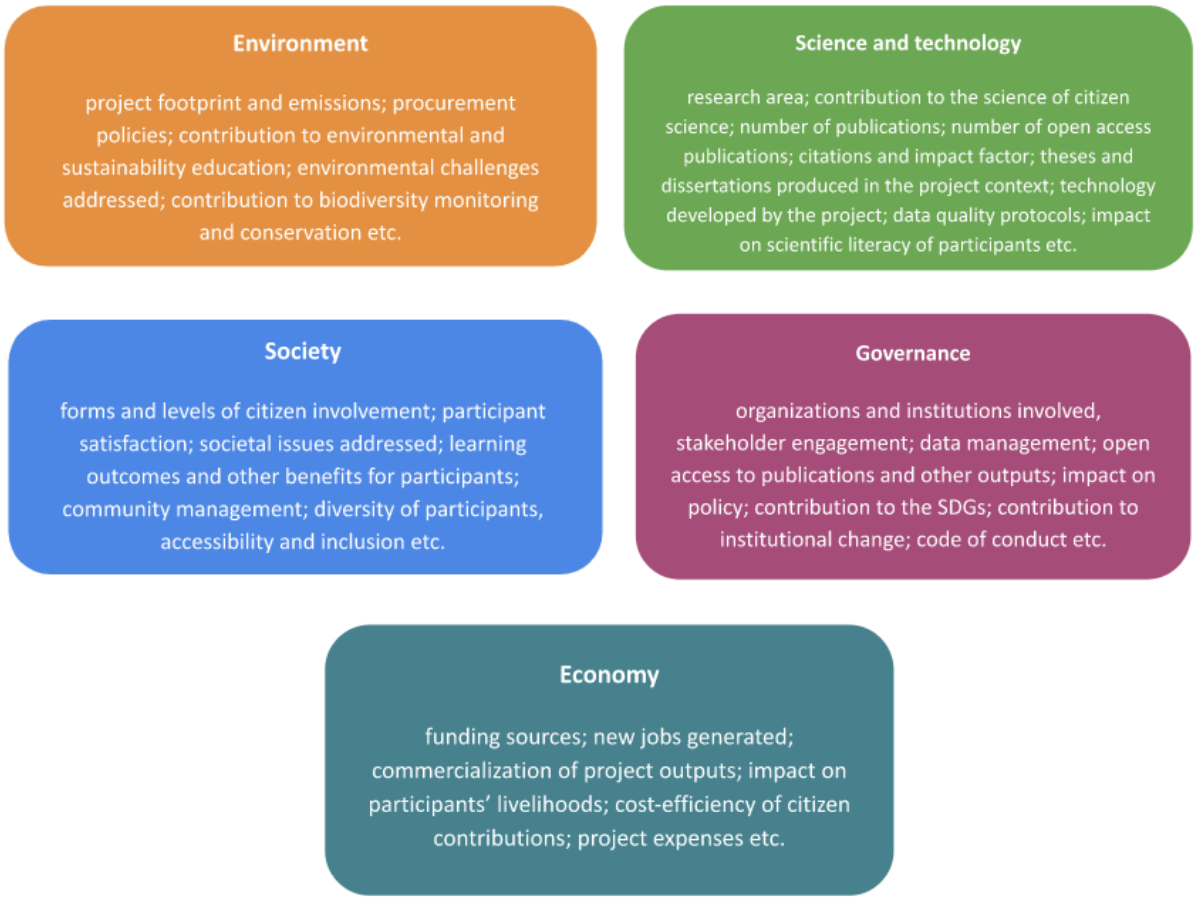


Figure 2. Examples of project characteristics covered by the five impact domains included in the MICS evaluation framework

Of course, since this self-evaluation tool relies entirely on the testimony of project coordinators (without any external, independent validation) the reliability of its results is difficult to gauge. How well it works in practice and how much demand there is for this kind of service within the CS community remains to be seen. Nevertheless, the fact remains that, unlike the other two approaches introduced, the MICS framework was developed specifically with CS projects in mind. Accordingly, it addresses numerous aspects not covered by the MoRRI and Super MoRRI indicators (Table 3).

Table 3. Comparison of the three frameworks regarding the evaluation criteria they encompass

Evaluation criterion	**MoRRI**	**Super MoRRI**	**MICS**
Gender equality	✓	✓	✓
Science communication / outreach	✓		✓
Citizen involvement in decision-making	✓		✓
Open access	✓	✓	✓
Diversity and inclusion			✓
(Potential) impact on policy	✓		✓
Code of conduct	✓		✓
Cooperation with industry / SMEs		✓	✓
Societal impact			✓
Benefits for participants			✓
Data management and data quality protocols			✓
Forms of participant involvement			
Internal communication and community management			✓
Stakeholder engagement			✓
Cooperation with public authorities and other institutions			✓
Contributions to the SDGs (the United Nations' Sustainable Development Goals)			✓
Funding, economic impact etc.			✓
Contribution to the science of CS			✓
Environmental footprint			✓
Contribution to environmental education, conservation etc.			✓

Despite their many differences, all three frameworks have the same obvious limitation: They are based on a top-down approach. They are only for the assessment of projects (accreditation type 5) as opposed to individual participants (accreditation type 1-3) or CS practitioners (accreditation type 4). This means that the entire pillar defined above, describing the individuals involved in accreditation, cannot be assessed using these frameworks. In addition, they share at least one blindspot. None of them treat the provision of formal accreditation to participants as a quality criterion for projects.

Notwithstanding, evaluation on the project level could potentially also have an impact on the accreditation of individual citizen scientists. While CS currently does not play a significant role in formal education or on the labor market, this is quite likely to change in the near future. Once that happens, a certificate or some other form of accreditation issued by a CS project that has been evaluated positively using a well-established and widely accepted set of indicators will undoubtedly carry more weight and authority than any certification awarded by a project lacking such credentials. In other words, accreditation from a project that has gained some kind of formal quality label will in all likelihood be more helpful in finding employment, earning a promotion, or obtaining credit points or university degrees. Evidently, this consolidation of project quality assessment with individual accreditation, integrates the evaluation and the education connection to accreditation and ultimately covers all five accreditation types described in this report.

5. Accreditation-related findings from CS Track

Since the goal of CS Track is to broaden our knowledge of the CS landscape by observing and analyzing existing CS projects (De-Groot et. al., 2022), this section will discuss the manifestation of accreditation in CS from the perspective of CS Track's research and findings. As might be expected, after reading the previous sections of this discussion paper, concrete references to "accreditation" have proven difficult to find in the projects' observational and analysis work conducted. It seems as if the relatively few appearances of the accreditation subject in the research literature (as mentioned in the opening to section 3 above) has a mirror image in the CS Track findings and the projects it analyzed. Yet, while not referring directly to accreditation, many of the findings suggest accreditation would be a useful way to train and acknowledge different CS stakeholders. The five types of accreditation identified in section 4 serve as a useful framework for identifying and differentiating implicit notions of accreditation in CS projects. To more thoroughly examine this idea, we have carried out an in-depth investigation of our database, in search of the accreditation dimension. This significantly contributed to our understanding of how accreditation is approached in other CS projects and its explicit and implicit manifestations. This process also informed us of methodological issues for the detection and identification of accreditation practices and for shaping our recommendations in the last section of this deliverable.

A possible reason for the scarce emergence of the accreditation subject could be that, as it seems, accreditation is seldom seen as a goal in itself: in general, a (CS or other) project is not initiated with the aim of accrediting something or somebody – be it the project itself, its participants or its internal processes. Accreditation appears as a complementary option which – if and when addressed – serves important purposes, but generally *comes after* the direct project goals, scientific or social, and it is not always documented and made visible to external observers. As we pointed out previously in this discussion paper, in many to most projects, a formal step for the integration of accreditation is not taken. This is because accreditation entails an effort and cost, thus its formalization and eventual certification do not always materialize to the satisfaction of those that aspire to benefit from them. Certainly, this state of affairs calls for policy action intended to affect, among other elements, the perceived cost-benefit balance (see section 6).

Accreditation through the volunteer moderating function

While there is seldom direct reference to accreditation in the CS Track findings, accreditation-related elements nevertheless appear indirectly. One form of indirect reference relates to project structures on which accreditation practices could be built – although it has not always been clear whether those practices eventually developed into accreditation in the analyzed cases. An example is the in-project interaction among different actors. From the analysis of our large survey results, such interconnections and exchange between participants ("talking and interacting with others") within CS projects appears to be the most important source of learning (Sabel et al., 2022a).

Interactions between volunteers and scientists – as demonstrated in our studies – would benefit from featuring *a moderating function*. This is highlighted in two separate but converging findings in our project that are relevant here: (1) the analytics work of CS Track (exchange analysis of online forums in CS projects), which highlighted the importance of a moderator's role in knowledge-building discourse for a CS project (Amarasinghe et al., 2021); and (2) Based on the analysis of participation and "volunteer trajectories" in the collaboration with CS projects, we have identified changes of

status, typically from normal volunteer to moderator, in a process that ran on more or less explicit, official trails (Krukowski et al., 2022). The presence of moderators facilitating the interaction appears as a catalyst for channeling the discussion – and with it the learning, the mutual understanding and appreciation of the participants in their respective roles etc. – in favorable directions for the project and for those involved in it. As above, this finding has implications for possible policy recommendations – namely, promoting the presence of moderators in CS projects; building on CS for fruitful combinations of formal and informal educational settings; featuring discussion-based learning productively; etc. – we will refer to these more specifically in the policy section to follow.

What may still be needing some elaboration is the accreditation dimension of the moderator role in CS projects. On the one hand, the transition to the role of moderator can be assumed as a kind of internal acknowledgement – a recognition of a volunteer's contribution – fitting the third type of accreditation. The promotion of a volunteer to a moderator status acknowledges his or her contribution to the project and consequently their gained knowledge in the project field, which, in turn, could be the basis for accreditation and certification (second type of accreditation).

An additional point to consider is that accreditation of the moderating function and skills, in the form of certification (type 2), may be more straightforward to implement than the accreditation of other abilities or achievements. This is because the role of the moderator entails preparation, knowledge, training and experience (and often also some innate aptitudes, e.g. leadership). Thus, if a particular volunteer has served as a moderator in one project they may be able to serve in a similar role in a different project, independent, to some extent, of the scientific topic of the two projects. In other words, the mere, informal record of having served as “CS project moderator” may convey a trustable message of value for third parties, which is the essence of type 2 accreditation and certification.

Accreditation through analysis of project descriptions

An additional research direction approached by CS Track, was the analysis of CS projects represented by their project descriptions and that can yield associated research areas and SDGs. Whilst not explicitly a quality assessment measure for projects, these could be used to support accreditation of projects and certification of their research profile, corresponding to type 5 accreditation. The same techniques allow for analyses of skill requirements, including general, scientific and soft skills that participants would be likely to acquire or improve in the project work, corresponding to type 2 accreditation. Significant work has been conducted in CS Track on these subjects, using analytics methods that can be applied in the same way to extract different types of items (research areas, SDGs, skill requirements). Regarding skill requirements and potential learning outcomes, a paper entitled "Identifying Learning Dimensions in Citizen Science Projects" will shortly be published in the proceedings of Aarhus University’s Engaging CS Conference, which was held in April this year (Oesterheld et al., 2022). Additional work is being prepared for publication by the project’s team members on skill requirements. Regarding the SDGs analyses, Hoppe et al. (2022) presented an abstract for interactive presentation in the recent ECSA conference in Berlin. Technical aspects of the extraction of SDGs from project descriptions are planned to be the subject of our publications also in the near future. A summarized account of the research done on SDGs can be found in section 4.2 of CS Track’s deliverable D2.2 and has been published as an article in the CS Track eMagazine (Santos et al., 2022).

An accreditation-oriented analysis of CS Track database

Although we have been aware of the fact that projects from our database show evidence of the potential learning and skills that might be developed in CS projects, a deeper and more orderly analysis

concentrating on the accreditation subject is necessary.

Our approach to this was to focus on the approximately 5,000 projects included in the CS Track database. As this database, compiled as part of the project's work, has served as the empirical basis for many of our investigations, we can justifiably consider it also a suitable ground on which to base *our* understanding of the matter, learning about the presence (or absence) of accreditation or its elements (i.e. characteristics) in CS projects. Extracting this information, however, is a complex task. The results we present and discuss here only represent an initial glance regarding the vast potential of investigating this database as well as an invitation for more research in the future, which would build on more detailed and refined observations, probably using other or additional tools.

The approach we adopted for this investigation has been, first, to filter the database (DB) – more precisely, *the project descriptions* (i.e. one of the categories of information included in the DB for each project), for the presence of relevant keywords – accreditation, certification, evaluation, diploma and course. As project descriptions are brought into the DB from several CS platforms and websites, they appear in different languages. We thus created sets of keywords in different languages – English, German, French, Spanish, Italian and Finnish – some common languages used in the projects' descriptions. As passing the first filter does not necessarily imply that a given project actually deals or intends to deal with accreditation[1], a second verification step was needed. This step involved reading all project descriptions derived from the first filtering round to verify the presence of accreditation elements. This served for a refinement of the initial selection of projects, which were then analyzed in further detail. Below we present, very briefly, the results we obtained from this process, discussing the preliminary analysis and discussion.

Our initial filtering process[2] yielded 218 projects (4.4 % of all projects in the DB) as potential carriers of accreditation elements. Reading the projects' descriptions from the initial filtering permitted a further reduction to a set of 61 projects (about 1.2 % of the DB). These were divided into two subsets: The first, 42 projects in total, contains projects that demonstrate visible indications of the presence of accreditation. While there is a large internal variance in the extent and validity of this "indication", in most cases, we can safely state that accreditation in those projects represents, at least, a credible intention (even if sometimes it appears only insinuated or implicitly stated). The second sub-set, 19 projects in total, contains projects with implications for accreditations as explicit indications of accreditation are missing. Here, the connection with accreditation still exists but it may be supported more by wishful thinking than by the explicit content. Examples may be projects that do not mention preparation or training of any sort (nor do they mention accreditation, of course) but it is clear from the context that preparation and training are definitely needed and, if provided, would create distinct opportunities of accreditation.

Before we address the qualitative analysis of this exploration, a few important comments to contextualize the search performed. On the one hand, the absolute and relative number of projects in which accreditation activities, of any kind, were detected is certainly small. While this may sound surprising, it may also be a reflection of the points we have made throughout this discussion paper, namely, the very small pre-existing research base, on CS and accreditation. On the other hand, we may have underestimated the number of projects featuring accreditation by the choices we made for keyword searches. In fact, a simple refinement of the keywords could result in obtaining more projects

[1] For example, some of the key words may have been used, in a project's description, in a context that does not relate to accreditation; also, the word "course", for example, may have appeared only as "discourse" in the text. Etc.

[2] Thanks to Miriam Calvera, of the UPF team in CS Track, for assistance in extracting information from the database.

potentially related to accreditation. Using, e.g. the phrase "cred" instead of "accreditation" could have yielded many more project descriptions as it would include words such as "accredit", "accrediting", "credit" etc., all of which could hint to the presence of accreditation elements in a project[3], and similarly for other keywords employed. Obviously, the analysis of an expanded filtering choice and resulting project descriptions would have demanded additional work and time investment, clearly beyond our possibilities. Furthermore, it is not necessarily the case that this enlarged selection will enable further insight and learnings on the subject.

Qualitative analysis of accreditation-related project descriptions

Quoting even the abridged excerpts we prepared from the descriptions of the 61 projects found to show accreditation indications would surely be informative, but it would much exceed the scope of this paper (the raw material is available upon request). Instead, we shall refer to some interesting results from the analysis and to some initial reflections on those results through bulleted paragraphs (which are below). As was said before, the information used came from the project descriptions, which are, sometimes, too short and not very enlightening (Golumbic & Oesterheld, 2022). It is possible that, in some cases, accreditation-relevant information exists elsewhere (e.g. in other parts of the websites), but of course we could not verify this here.

- The words "accreditation" or "certification" are rarely used, though the texts of the descriptions often disclose some actions reflecting this sense. "Course" was the most used keyword by far, but further analysis of descriptions including this keyword did not indicate the existence of accreditation in most cases.
- We found that all standard (and some not quite standard) subjects addressed in CS projects are represented in this sample. Some examples of topics addressed include: monitoring and preserving the natural environment (in its myriad manifestations); birds, butterflies, bees (watching, monitoring, keeping); socio-economic activities for the public sake (national, regional, urban); fighting misinformation and fake news; cultural projects (transcribing original texts; learning to make scientific contributions to Wikipedia; etc.); medicine, health; history; earth and planetary sciences, weather; astronomy, cosmology; etc.
- Of the five types of accreditation introduced in section 4.1, only the first three seem to be represented in our selection, i.e. Training of citizen scientists, Participants' learning and competences and Recognition of participants (citizen scientists). No cases of Training of scientists or of Assessing the quality of projects were detected (which does not mean, of course, that a future refinement in our methods would not reveal these).

Below we provide some more specific and detailed findings based on the type of accreditation.

Training of citizen scientists

Note: some of the quotes below have been anonymized for ethical considerations. We use [name of project / organization / foundation] to indicate these occurrences.

- Some projects explicitly indicate training opportunities that may result in accreditation of participants. Quoting one of our excerpts, we start with a classic example we found of accreditation + certification for CS: "[Name of organization*;* which leads or hosts several marine CS projects] *is pleased to announce a joint venture with [name of foundation], a certificate in Marine Citizen Science. It consists of two modules, Part I: Basic (non-marine citizen science skills) and Part II: Marine Life ID 'fishinars' administered independently through*

[3] Extending this exercise to other languages would have generated some complications, though.

[name of foundation]. (…) Each module may be taken together or independently, but both must be completed to receive the certificate. (…) The course will be free of charge, but there will be a small, nominal fee for the certificate."

- Even if it is not written explicitly in the projects' descriptions, judging from other details provided, some training is certainly needed/expected in most cases examined. The – explicit or implicit/tacit – participation in training sessions, courses and similar, and the fact that this participation readily sets the basis for accreditation, raises the question of whether assumed training could be more ubiquitous than we see at first glance. Earlier, we referred to the fact that accreditation not being – in general – the main reason for launching a CS project and not appearing as one of its *declared* objectives, might well take place (to some degree) also when it is not mentioned. This may be the case in a project's description as well.

Participants' learning and competences

- As indicated, many projects offer some form of training to participants, alluding to its learning potential. The question is what learning takes place as a result of this training and how it is acknowledged. In some cases, the connection is shown quite explicitly: "Ringing of birds gives the opportunity […] to take samples that allow, for example, to study the dispersal of pathogens […] How to become a ringer? To ring wild birds requires extensive knowledge in identification and behavior. The certification process takes at least 4 years"
- In their websites, some projects send volunteers to "read more" about what will be done. While learning can take place from this reading, it is not a formal preparation or training. Clearly, only on this basis, accreditation or learning cannot be reasonably assumed to take place, calling for some further evidence.
- In some cases project descriptions refer to a connection of the CS project with a school or course hinting at the learning potential of the projects. This synergy allows schools to complement their curriculum with informal educational elements, on the one hand, and the CS project to grant accreditation in a cost-effective way, on the other hand.

Recognition of participants

- Further down in the "tacitness" scale, there are projects that promise a prize to volunteers achieving outstanding results in their participation. These prizes, normally accompanied by a diploma or other document, and sometimes granted by a university hosting or backing the project, identify their holders and are much publicized in the project's website and elsewhere. With a clear aim to stimulate good work, they are a form of accreditation and recognition – depending on the case, for individuals, teams, classes etc.
- One of the selected cases proposes a combination of training and a mentoring program, in a framework that leads to (or at least permits) accreditation, even if not explicitly stated: "*[name of CS project] has teamed up with the [name of 3 organizations] to establish a number of bird monitoring sites (…) To make sure the data is meaningful we are looking for observers (…) to take stewardship of a site to be surveyed at least seasonally (…). In addition to undertaking surveys we are looking into developing a mentoring program – teaming beginner birders with experienced birders is a great way to build confidence and share knowledge across our community. Confidence in bird identification skills is key in retaining new volunteers (…)*" We witness, here, the creation of a new "role" in CS projects, that of the mentor; earlier in this section, we mentioned other roles whose significance became apparent in our research in the project (e.g. that of moderators of the scientists-volunteers interaction).

An interesting finding to note are institutions – external to or operationally separate from CS projects – that grant accreditation. In all cases, the targets or beneficiaries are individuals who participate or intend to participate in CS projects, not the projects themselves (i.e. it is not their quality as CS projects what is evaluated/accredited – for example). This was found in 4-5 cases. Another interesting use of CS in accreditation is incorporating a CS project within a larger accreditation program, such as a course or workshop. For example, a CS project in which participants test the effectiveness of washing hands, which is linked to an online microbiology course.

6. Accreditation and CS policy

Policy proposals are understood as "a written advice that is prepared for a group or person that has the authority to make an influence on policy decisions" (CARDI). In the specific case of CS Track, policy proposals constitute advice on actions to be taken that maintain and promote CS engagement in the process of science understanding and science making.

In the context of this particular document, the scope of policy recommendations is no other than to highlight parameters related to accreditation that directly or indirectly, individually or in connections, contribute to the improvement of the current state of affairs in the field of CS. The content of this subsection is complementary to that of D4.4 (Policy Recommendations for using CS TRACK results), and to a relative extent contextualizes the document's theory, creation, operational and value related issues perspective to policy on which the deliverable is structured. The challenge in addressing policy on/for accreditation in CS is on the interrelation between the issues/parameters that are in need of policy considerations, something that is clearly demonstrated from the discussion in the previous sections of this document.

The knowledge base used for the discussion on the policy dimension here is the result of research conducted throughout the lifecycle of the CS Track, including focused work conducted for this particular discussion paper, aiming at the development of knowledge and the identification and promotion of good practices on and for the pertinent parameter of accreditation. As such, the process to articulate coherent policy proposals on/for accreditation follows the model of evidence-based policy (Pawson, 2006).

The rather limited discourse on accreditation in CS literature and descriptions of CS projects, as indicated elsewhere in this document, might be due to the lack of maturity (institutionalization) of the field and/or the diverse nature of the type of activities undertaken by CS endeavors. To this effect, it is reasonable to propose further a process-product evaluation natured by research actions, so as to define the types and levels of CS activity to which accreditation can play a catalytic role towards improvements in the field.

At its current state, it appears that, while the topic of accreditation is, from an evaluative perspective, product-oriented, the discourse seems to be oriented towards processes, lacking a holistic approach to the topic under discussion. The notion of certification and progression routes appears to play a central role in participants' engagement in CS activities.

The elements that come to interplay around the theme of policy on accreditation range from attention to participants' motivational factors to requirements for standards and from agency development to project level training. Among the elements/terms that appear in the review conducted are: good practices, training of CS related tasks, training of CS activities, recognition, motivation, moderation function, effort, costs, progression routes, accreditation bodies, standards for participants, standards for projects, professional endorsed standards, certification, evaluation criteria, levels of accreditation, short courses, blogging, confidence, funding agencies, duration, and priority. These are either components towards a comprehensive accreditation perspective and/or implications for or by the subject under discussion.

The multiplicity of elements/issues/factors raised in this paper appear to require attention at different policy levels. There are also aspects that require attention at the macro level with implications on the meso and micro levels and vice versa (see deliverable D4.4, section 5, for a detailed explanation

regarding the micro, meso and macro perspective; briefly, macro level refers to the policies governing the field of CS as a whole. Meso refers to the field's activities (projects, platforms, associations, researchers of CS), and micro perspective refers to policies affecting the individual actors of the field).

The subsection below is the result of a consolidation approach of the various elements embedded and interacting within the topic of accreditation. It presents a set of ten policy priorities and briefly outlines their justification (with details found in the preceding discussion chapters). The level (micro, meso, macro) for policy consideration is provided for each of the ten priorities and included are short statements for policy action.

Policy priorities

#1 Institutional-ization of accreditation within the CS field	Justification / Dependences	The overall assessment of the CS Track on accreditation points to the direction that accreditation has an added value for the field. As, according to the literature, accreditation produces a benefit to somebody – to individuals, projects, the CS field, which can translate to social value, increasing this value is undoubtedly a legitimate target for high level policy consideration.
	Policy level addressed	Macro level with implications on the meso level.
	Policy action recommended	Establishment of "agency" to design policy at the evaluation, monitoring and funding levels so as to facilitate accreditation capabilities and promote accreditation practices in CS endeavors and in/or other organizational structures related to the CS area.
#2 Setting of standards for accreditation -projects -professional scientists -citizen scientists / participants / volunteers	Justification / Dependencies	Current research within CS Track suggests that, overall, the topic of accreditation in CS lacks a cohesive ecosystem to which projects, professional scientists, and citizen scientists can refer in addressing their needs and goals when designing or participating in a project respectively.
	Policy level addressed	-Projects: Meso level, -Professional scientists: Meso level, -Citizen scientists: Micro level with effects on the meso level.
	Policy action recommended	Establish a comprehensive system of accreditation that applies to projects, professional scientists and citizen scientists
#3 Recognition of citizen scientists' participation in CS activities	Justification / Dependencies	The possibility for recognition, whether through forms such as rewards or certification, are important for citizen scientists and may sustain their participation in CS activities leading to improved outcomes at the individual (e.g. learning) and project levels (improved data quality/quantity).
	Policy level addressed	Meso at the level of activities, micro at the level of the individual.
	Policy action	Integrate different forms of recognition as a primary component

	recommended	in the design template of CS activities in which citizen scientists participate
#4 Progression routes and enhancement of the moderation function	Justification / Dependencies	Progression – at school, in obtaining a desired job – is a key motivation behind the participation and active engagement of citizen scientists in CS projects. Accreditation, in this context, becomes an enabling factor to realize the citizen scientists' will to learn and progress. Moderators of the communication between scientists and citizen scientists in CS projects join, as central players, this process connecting interaction, learning and progression. A policy action to facilitate and propagate the moderating function among CS projects will thus contribute to learning and to consolidate the role of accreditation in CS-instigated progression routes.
	Policy level addressed	Micro for the individual, meso at the field and projects levels.
	Policy action recommended	Promote the presence of moderators in the forums (or other arenas where communication takes place in CS projects) through the creation of a bank (a directory) of duly prepared moderators, which would be put at the disposal of projects and/or offered the possibility to join CS projects of their choice. They could get a payment (or other benefit) for their participation in projects, funded in full or in part by the institution designated for that purpose in the policy decision. Institutions could be public authorities (e.g., dependences of ministries of industry, science, etc.), or non-public bodies like associations in the CS field (e.g. ECSA), which would take care of the preparation of the moderators (directly or involving third parties, e.g. universities) and the provision of all related information to planned or running CS projects.
#5 Recognition of alternative learning paths	Justification / Dependencies	In today's world it has been recognized that "learning" is acquired in multiple forms, it can be of different types and occurs in diverse settings and situations. Citizen scientists enter the field with their own tacit and prior knowledge that directly or indirectly govern and contribute to the manner of engagements in CS endeavors. In parallel, citizen scientists, through their engagement in CS activities gain knowledge which derives from formal and informal means, especially interaction among participants and between participants and professional scientists which at the current phase is at an unrecognized state. Visibility of prior knowledge and visibility of the knowledge gain through social and topic specific interaction serves not only as a motivation factor for CS engagement but further contributes to the transfer of the field's added value to external to CS settings.
	Policy level addressed	Meso level with implications on the micro level.

	Policy action recommended	Actions should be put in place so as to ensure recognition and subsequently validation of the different citizen scientists learning perspectives. Such actions can be associated with CEDEFOP's approach(es) to the validation of informal and non-formal learning. Projects, platforms, associations should eventually be equipped with a set of European Guidelines for validating participants' knowledge from diverse and alternative learning paths.
#6 Fostering awareness development on the significance of CS activities and its potential impact to society	Justification / Dependencies	Although interest in CS has grown steadily over the past few years, it is still something of a niche phenomenon. Creating accreditation opportunities could help address this problem. By issuing/awarding certificates that can also be used in non-CS settings (e.g. when applying for a job, collecting credit points towards a university degree etc.), accreditation for individual citizen scientists could boost the visibility of CS in these contexts. Specifically, this kind of individual-level accreditation could draw attention to the educational potential of CS, the contribution of citizen scientists to environment protection and policy-making etc. Accrediting CS projects, on the other hand, could play a key role in increasing trust in the data and other outputs generated by these projects (and additionally lend greater authority to the certificates issued by them to individual participants).
	Policy level addressed	Meso level with implications on the macro level.
	Policy action recommended	Promote accreditation (for both CS projects and individual participants) that results in certificates which can also be used in non-CS contexts (i.e. that mirror standard formats used outside of CS and contain enough background information on the project's goals, methods and activities to be comprehensible also for those unfamiliar with CS). This would involve surveying widely used accreditation formats and compiling guidelines for CS practitioners on how to produce certificates which conform to these standards.
#7 Community building of CS projects driven by good practice examples practices	Justification / Dependencies	Accreditation (be it of individuals, organizations or programs) typically involves evaluating the entity to be accredited against a set of standards which are widely accepted in the relevant professional community. It is this broad consensus which (in combination with the accrediting institution's prestige) lends weight and authority to accreditation results. In the field of CS, such shared best practice or quality standards are only beginning to emerge.
	Policy level addressed	Meso level.

	Policy action recommended	Promote the codification of best practice and/or quality standards for CS projects. This work could for instance be coordinated by the ECSA working group 'Sharing best practice and building capacity' and result in a much more detailed and comprehensive version of the ECSA Principles of Citizen Science.
#8 Development and implementation of a quality assessment framework	Justification / Dependencies	In order to formalize accreditation as a common CS practice, a quality assessment framework should be developed and implemented. This should be done both on the individual and project level which would both benefit from a more structure approach
	Policy level addressed	Meso level with implications on the macro level.
	Policy action recommended	Institutions involved in CS such as CS associations, centers within universities etc. should work to develop frameworks of quality accreditation based on predefined quality criteria. This will help projects design themselves toward these goals. In turn these institutions can also be those who grant such accreditation.
#9 Budgetary considerations for the different types and forms of accreditation	Justification / Dependencies	The implementation of accreditation implies an economic cost, which, depending on factors such as who or what is being accredited, or by whom, may represent a burden on participants, projects and/or external organizations. Based on the current knowledge base we can safely hypothesize that at least in some cases accreditation involves, from the economic point of view, a (positive) "externality". This is a situation in which the producer of a service does not receive the full benefit of its supply, as part of it may be accrued by others and/or by society in general, who may not, or only partially, be paying for that service (similarly, in some respects, to the social benefits of education). As a result, projects or other institutions may not be spending or investing the amount needed for accreditation to take place to its full (desired, economically efficient) extent. This results in accreditation practices that are less widespread than optimal for society. Policy could mitigate this problem by putting funds at the disposal of some institutions (e.g. ministries of industry, science, education) to help suitable CS players - including CS projects and/or participants of theirs with qualifications to be determined, CS umbrella organizations, universities, etc. - financially when providing or acquiring accreditation, thus increasing its use.
	Policy level addressed	Macro level with implications on the meso level and effects on the micro level.
	Policy action recommended	Financially support projects that engage in accreditation for their participants, or external organizations that provide these services at all levels and stages: training or courses and subsequent accreditation of individuals, capacity-building for

		moderators for projects in different disciplinary fields, evaluation and accreditation of projects, etc. The administration of the funds, the determination of criteria for their distribution and the implementation of the funding programs will be done by dedicated entities. These could be public or non-public, depending on the origin of their seed funds and/or the dependence of their staff. At the public level, national ministries, or even the EC or the SwafS program could take the lead in accreditation-targeted funding. ECSA or similar organizations could hold the function at a non-official level (although in this case the funds could be of public origin). There may be many variations in the actual implementation of the above, which is given as an example.
#10 Enhancement of the connection between training / learning and accreditation	Justification / Dependencies	While many CS projects incorporate some level of training in their projects, what learning results from these activities is not always known. Furthermore, accreditation of this process is not a common practice, with many of these learning outcomes never even investigated
	Policy level addressed	Meso level.
	Policy action recommended	Tying the process of learning through CS to a clear assessment program which recognizes participants' learning should be promoted. Acknowledging this learning can be done through certification, achievement of badges or promotion in the level of expertise within a project (to become curator, or moderator).

References

Amarasinghe, I., Manske, S., Hoppe, H. U., Santos, P., & Hernández-Leo, D. (2021). Using network analysis to characterize participation and interaction in a citizen science online Community. In D. Hernández-Leo, R. Hishiyama, G. Zurita, B. Weyers, A. Nolte, & H. Ogata (Eds.), *Collaboration Technologies and Social Computing* (pp. 67–82). Springer International Publishing. https://doi.org/10.1007/978-3-030-85071-5_5

CARDI: 10 Guidelines for Writing Policy Recommendations. Retrieved (December 5, 2022) from https://www.lenus.ie/bitstream/handle/10147/221377/Factsheet.pdf?sequence=1&isAllowed=y

Ceccaroni, L., Parkinson, S., Woods, S., Sprinks, J., Wehn, U., Scrieciu, A., Balaz Kozak, Gumiero, B., Joyce, H., Naura, M., Janes, M., & Williams, C. (2022). *The impact of citizen science on society, governance, the economy, the environment and science*. MICS Measuring Impact of Citizen Science. https://doi.org/10.5281/zenodo.7124259

Council of the European Union. (2012). *Council recommendation of 20 December 2012 on the validation of non-formal and informal learning. Official Journal of the European Union, C 398,* 22.12.2012, pp. 1-5. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:398:0001:0005:EN:PDF

De-Groot R, Golumbic YN, Martínez Martínez F, Hoppe HU and Reynolds S. (2022). Developing a framework for investigating citizen science through a combination of web analytics and social science methods—The CS Track perspective. *Front. Res. Metr. Anal.* 7:988544. https://doi.org/10.3389/frma.2022.988544

Dictionary. (n.d.). Accreditation. In *Dictionary.* Retrieved (December 11, 2022) from https://www.dictionary.com/browse/accreditation

European Centre for the Development of Vocational Training (Cedefop). (2014). *Terminology of European education and training policy: A selection of 130 terms* (2nd ed.). Luxembourg: Publications Office. https://dx.doi.org/10.2801/15877

European Centre for the Development of Vocational Training (Cedefop). (2015). *European guidelines for validating non-formal and informal learning.* Luxembourg: Publications Office. Cedefop reference series; No 104. https://dx.doi.org/10.2801/008370

Golumbic, Y., & Oesterheld, M.. (2022). *Writing citizen science project descriptions that spark interest and attract volunteers – a ten-step guide*. https://doi.org/10.5281/zenodo.7004061

Haklay, M. (2015). Citizen science and policy: A European perspective. *Washington, DC: Woodrow Wilson International Center for Scholars*, *4*. https://www.wilsoncenter.org/sites/default/files/media/documents/publication/Citizen_Science_Policy_European_Perspective_Haklay.pdf

Herodotou, C., Aristeidou, M., Miller, G., Ballard, H., & Robinson, L. (2020). What do we know about young volunteers? An exploratory study of participation in Zooniverse. *Citizen Science: Theory and Practice*, 5(1), 2:1-14. http://doi.org/10.5334/cstp.248

Hoppe, H. U., Schulten, C., Santos, P., Calvera, M., DeGroot, R., & Golumbic, Y. (2022). Between exoplanets and planetary health: Viewing Citizen Science through the SDG lens. Proceedings of ECSA 2022. ECSA 2022, Berlin. https://2022.ecsa-conference.eu/files/ecsa/Bilder/ECSA2022_Conference_Proceedings.pdf

Kieslinger, B., Schäfer, T., Heigl, F., Dörler, D., Richter, A., & Bonn, A. (2018). Evaluating citizen science: Towards an open framework. In A. Bonn, S. Hecker, M. Haklay, A. Bowser, Z. Makuch, & J. Vogel (Eds.), *Citizen Science: Innovation in Open Science, Society and Policy* (pp. 81–96). UCL Press. https://www.jstor.org/stable/j.ctv550cf2.13

Kloetzer, L., Lorke, J., Roche, J., Golumbic, Y., Winter, S., & Jõgeva, A. (2021). Learning in citizen science. In K. Vohland et al. (Eds.) *The science of citizen science* (pp. 283-308). Springer. https://doi.org/10.1007/978-3-030-58278-4_1

Krukowski, S., Amarasinghe, I., Gutiérrez-Páez, N. F., & Hoppe, H. U. (2022). Does Volunteer Engagement Pay Off? An Analysis of User Participation in Online Citizen Science Projects. In L.-H. Wong, Y. Hayashi, C. A. Collazos, C. Alvarez, G. Zurita, & N. Baloian (Eds.), *Collaboration Technologies and Social Computing* (pp. 67–82). Springer International Publishing. https://doi.org/10.1007/978-3-031-20218-6_5

Kumar, P., Shukla, B., & Passey, D. (2020). Impact of accreditation on quality and excellence of higher education institutions. *Revista Investigacion Operacional*, *41*(2), 151-167. https://eprints.lancs.ac.uk/id/eprint/141916/

Lorke, J., Golumbic, Y. N., Ramjan, C., & Atias, O. (2019). *Training needs and recommendations for Citizen Science participants, facilitators and designers*. COST Action 15212 report. http://hdl.handle.net/10141/622589

Losinno, M. G., Ryan, T. K., & Mejlgaard, N. (2021). *D2.2: 1st Responsible Research and Innovation Monitoring Report*. SUPER MoRRI – Scientific understanding and provision of an enhanced and robust monitoring system for RRI. https://super-morri.eu/findings/

MoRRI project consortium. (2018). *The evolution of Responsible Research and Innovation in Europe: The MoRRI indicators report*. Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI). https://www.technopolis-group.com/wp-content/uploads/2020/02/The-evolution-of-Responsible-Research-and-Innovation-in-Europe-The-MoRRI-indicators-report-D4.3.pdf

Oesterheld, M., Schmid-Loertzer, V., Calvera-Isabal, M., Amarasinghe, I., Santos, P. & Golumbic, Y. (2022). Identifying learning dimensions in citizen science projects. In proceedings of Engaging Citizen Science Conference 2022, *PoS(CitSci2022)* 070. https://pos.sissa.it/418/070/ [forthcoming]

Organisation for Economic Co-operation and Development (OECD). (2020). *Recognition of non-formal and informal learning*, Home, 5 November 2020. Available at: https://www.oecd.org/education/skills-beyond-school/recognitionofnon-formalandinformallearning-home.htm (Last accessed 20 April 2022).

Oxford University Press. (n.d.). Accreditation. In *Oxford Learner's Dictionary*. Retrieved (December 11, 2022) from https://www.oxfordlearnersdictionaries.com/definition/english/accreditation?q=accreditation

Pawson, R. (2006). *Evidence-Based Policy: A Realist Perspective*. SAGE.

Peltoniemi, A. J., Kauppinen, H., Lampi, E., Lämsä, J., Sabel, O. Hämäläinen, R. How citizen scientists learn: Exploring learning perceptions through an international survey. Accepted for publication.

Peter, M., Diekötter T., Kremer K., & Höffler T. (2021). Citizen science project characteristics: Connection to participants' gains in knowledge and skills. *PLoS ONE,* 16(7): e0253692. https://doi.org/10.1371/journal.pone.0253692

Phillips, S. D., Kevin Kinser, Kinser, K., & Project Muse. (2018). *Accreditation on the edge: Challenging quality assurance in higher education*. Johns Hopkins University Press.

Ravn, T., Nielsen, M. W., & Mejlgaard, N. (2015). *Metrics and indicators of Responsible Research and Innovation. Progress report D3.2*. Monitoring the Evolution and Benefits of Responsible Research and Innovation (MoRRI). https://www.technopolis-group.com/wp-content/uploads/2020/02/Metrics-and-indicators-of-Responsible-Research-and-Innovation-%E2%80%93-Progress-report-D3.2.pdf

Roche, J., Bell, L., Galvão, C., Golumbic, Y. N., Kloetzer, L., Knoben, N., Laakso, M., Lorke, J., Mannion, G., Massetti, L., Mauchline, A., Pata, K., Ruck, A., Taraba, P., & Winter, S. (2020). Citizen science, education, and learning: Challenges and opportunities. *Frontiers in Sociology*, 5(December): 1–10. https://doi.org/10.3389/fsoc.2020.613814

Scotland Counts. (2016). Citizen science – Motivations, progression and accreditation. The Conservation Volunteers (TVC). https://www.tcv.org.uk/wp-content/uploads/2014/11/citizen_science_motivation_report.pdf

Sabel, O., Hämäläinen, R., Peltoniemi, A., Kauppinen, H., Nissinen, K., Lämsä, J., & Lampi, E. (2022a). D4.3. Models to identify background factors associated with the CS activity. A CS Track project output. https://doi.org/10.5281/zenodo.6005548

Sabel, O., Peltoniemi, A., Weeber, K., Räty, P., Sipiläinen, K., Hämäläinen, R., Strähle, M., Urban, C., & Kikis-Papadakis, K. (2022b). *D4.4. Policy recommendations based on CS Track results*. A CS Track project output. https://10.5281/zenodo.7390898

Santos, P., Amarasinghe, I., Calvera, M., Schulten, C., Hoppe, U., Roldán Álvarez, D., Martínez Martínez, F. (2022) Mapping Sustainable Development Goals to Citizen Science projects. CS Track's eMagazine. Dec. 2, 2022. https://cstrack.eu/format/reports/mapping-sustainable-development-goals-to-citizen-science-projects/.

Sanyal, B. C., & Martin, M. (2007). Quality assurance and the role of accreditation: An overview. *Report: Higher education in the world 2007: Accreditation for quality assurance: What is at stake?* http://hdl.handle.net/2099/8095

Schaefer, T., B. Kieslinger, M. Brandt, and V. van den Bogaert. (2021). Evaluation in citizen science: The art of tracing a moving target. In K. Vohland et al. (Eds.) *The science of citizen science* (pp 495–514). Springer. https://doi.org/10.1007/978-3-030-58278-4_25

Stufflebeam, D. L., & Coryn, C. L. (2014). *Evaluation theory, models, and applications* (Vol. 50). John Wiley & Sons.

The Conservation Volunteers, TCV. (2014). Integrating citizen science into accredited courses and awards in Scotland. https://www.tcv.org.uk/wp-content/uploads/2014/11/IntegratingCitizenSciencewithAccreditationAwardsinScotland.pdf

Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., & Wagenknecht, K. (2021). *The science of citizen science*. Springer. https://doi.org/10.1007/978-3-030-58278-4.

West, S., & Pateman, R. (2016). Recruiting and retaining participants in citizen science: What can be learned from the volunteering literature? *Citizen Science: Theory and Practice*, *1*(2), 15. https://doi.org/10.5334/cstp.8

Woodcock, J., Greenhill, A., Holmes, K., Graham, G., Cox, J., Oh, E. Y., & Masters, K. (2017). Crowdsourcing citizen science: Exploring the tensions between paid professionals and users. *Journal of Peer Production*, *10*, Article 10. http://peerproduction.net/issues/issue-10-peer-production-and-work/peer-reviewed-papers/crowdsourcing-citizen-science-exploring-the-tensions-between-paid-professionals-and-users/

Woolley, R., Otero-Hermida, P., Mejlgaard, N., Ryan, T., Rommetveit, K., Strand, R., & Klippe, W. van de (2021). *D1.2: A Monitoring Framework for Responsible Research and Innovation. Strategic Development Plan 2020-24*. SUPER MoRRI – Scientific understanding and provision of an enhanced and robust monitoring system for RRI. https://super-morri.eu/findings/

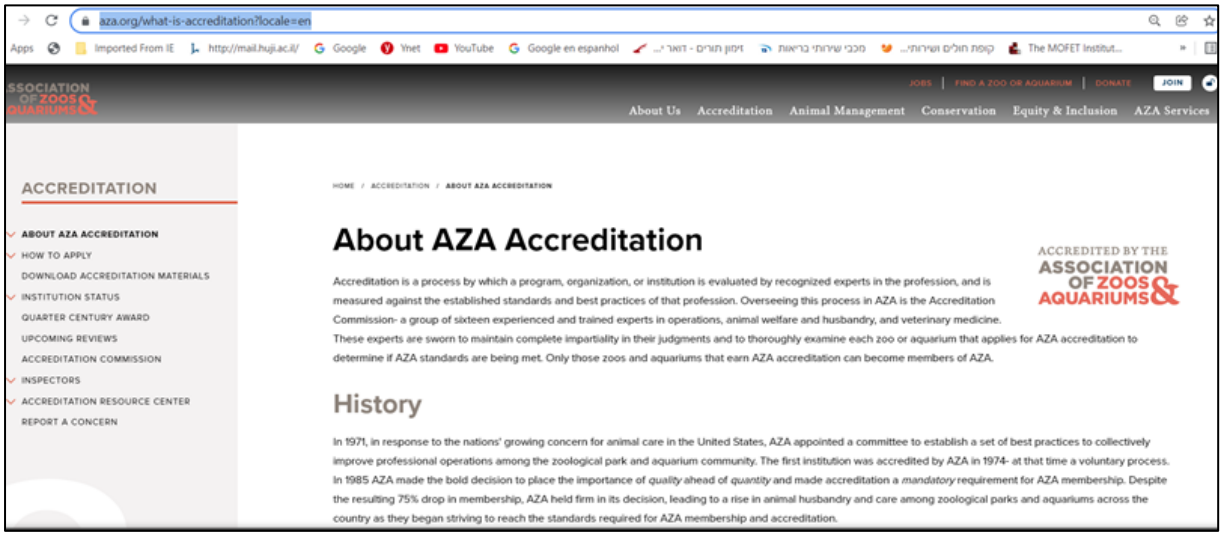
Annex: ACCREDITATION SERVICES PROVIDERS

NOTE: This Annex includes graphic material related to the subject of this deliverable - sample screenshots taken from websites of different organizations dealing with or connected to accreditation in Citizen Science. The material has been selected with the purpose of illustrating some of the passages included in section 3. of this deliverable, the review we made on existing research literature. Thus, the sole purpose of including the mentioned material in this deliverable is to serve an academic research purpose. All the rights on the material belong to the respective organizations.

As we have seen in the literature review above, institutions external to the projects are often assigned an important role in the accreditation process, especially (but not only) when "the accredited" is a project – or a process within a project – and not a specific individual. Also, sometimes, these or other accrediting institutions are themselves the providers of knowledge – in the form of courses – which will permit individuals to be accredited, e.g. to launch or participate in certain kinds of CS projects. In the following paragraphs we show some examples of all these types; there are many more of course.

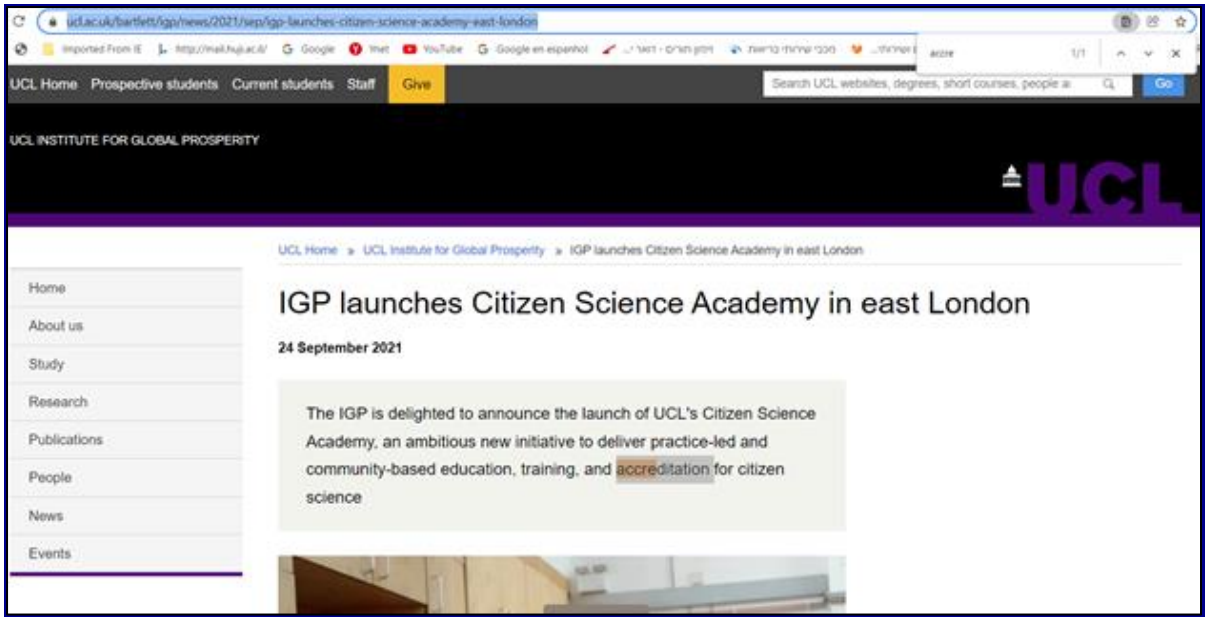
AZA (the Association of Zoos and Aquariums, https://www.aza.org/) is "a non-profit organization dedicated to the advancement of zoos and aquariums in the areas of conservation, education, science and recreation. AZA represents more than 235 facilities in the United States and overseas, which collectively draw more than 200 million visitors every year". The Association gives accreditation to institutions of different kinds in its field of expertise, and it is well-known specifically in the CS area. The following link and screenshot relate to the accreditation arm of AZA:

https://www.aza.org/what-is-accreditation?locale=en



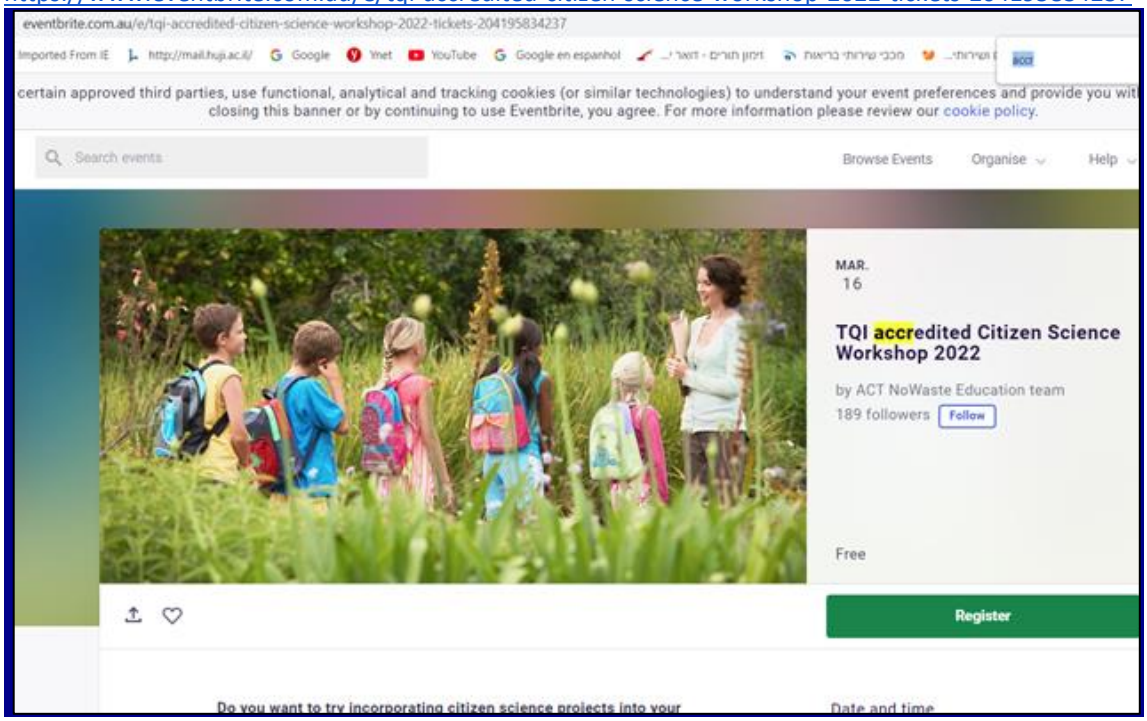
IGP, the UCL-affiliated Institute for Global Prosperity is also active in the CS field. Prof. Henrietta L. Moore, Founder and Director of the Institute, summarizes the Institute's vision as follows: "*Prosperity isn't just about improving GDP. You also need to fight inequality, promote social cohesion, safeguard the environment, and provide education, health and decent employment, giving people hope for the future.*" Consistent with this vision, the Institute has recently launched a Citizen Science Academy in London.

https://www.ucl.ac.uk/bartlett/igp/news/2021/sep/igp-launches-citizen-science-academy-east-london



TQI, the Australian Teacher Quality Institute, often includes CS-related courses and accreditation in its programs. This is one of them (recently concluded):

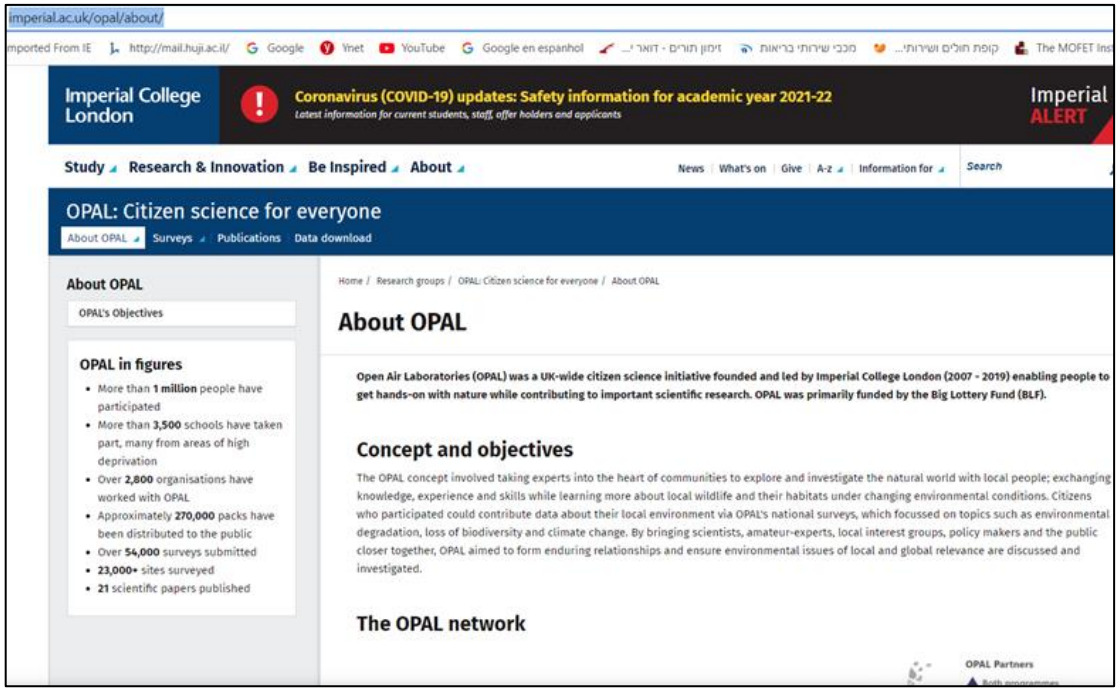
https://www.eventbrite.com.au/e/tqi-accredited-citizen-science-workshop-2022-tickets-204195834237



The OPAL initiative (mentioned in the context of Section 3. when referring to the paper Citizen Science – Motivations, Progression and Accreditation (April 2016)), led by the Imperial College London, was

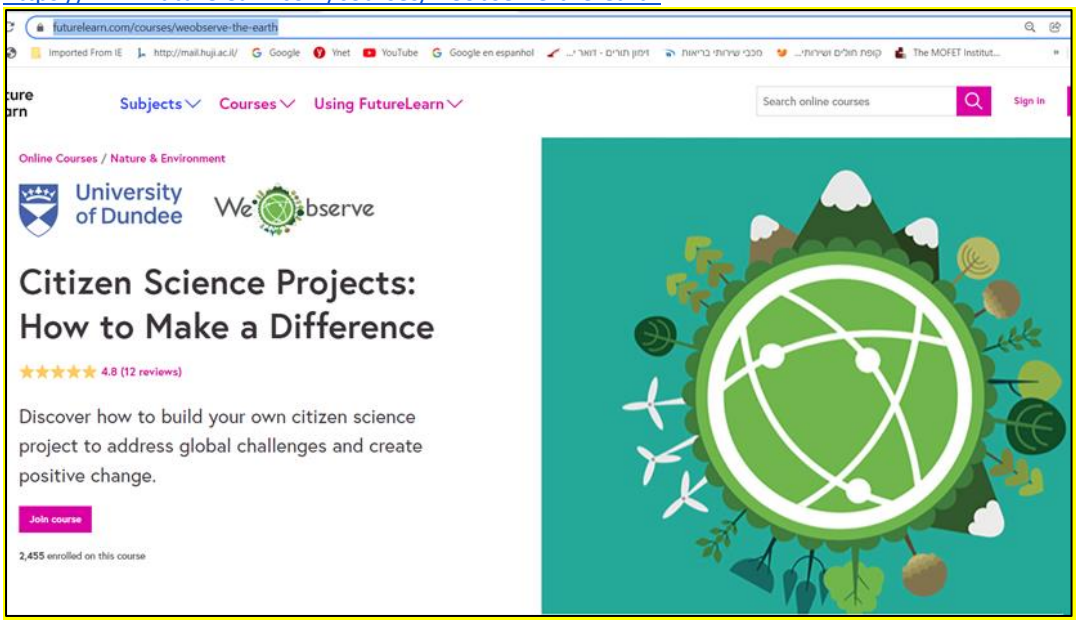
(apparently, until 2019) another example of an accreditation provider to participants in its associated CS projects.

https://www.imperial.ac.uk/opal/about/

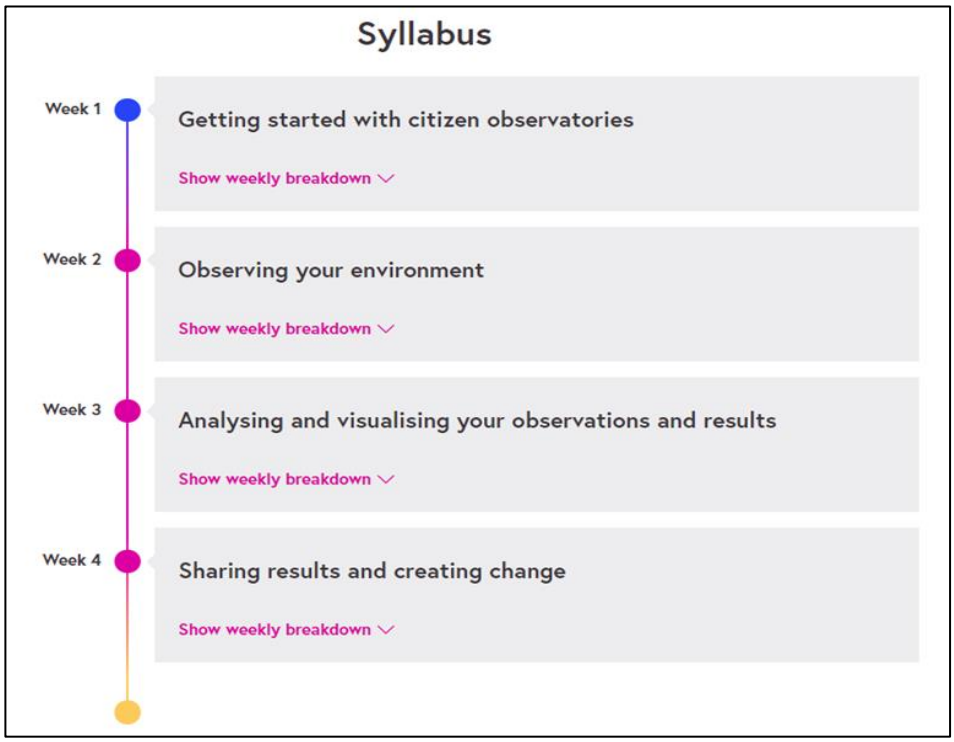


The University of Dundee provides courses "for anyone interested in citizen science and citizen observatories, and learning about how to design a citizen science project", along with the corresponding accreditation. Accordingly, the typical expected participants in a course are actual or would-be CS projects' initiators, although in principle also CS projects' participants of all types could benefit from it.

https://www.futurelearn.com/courses/weobserve-the-earth



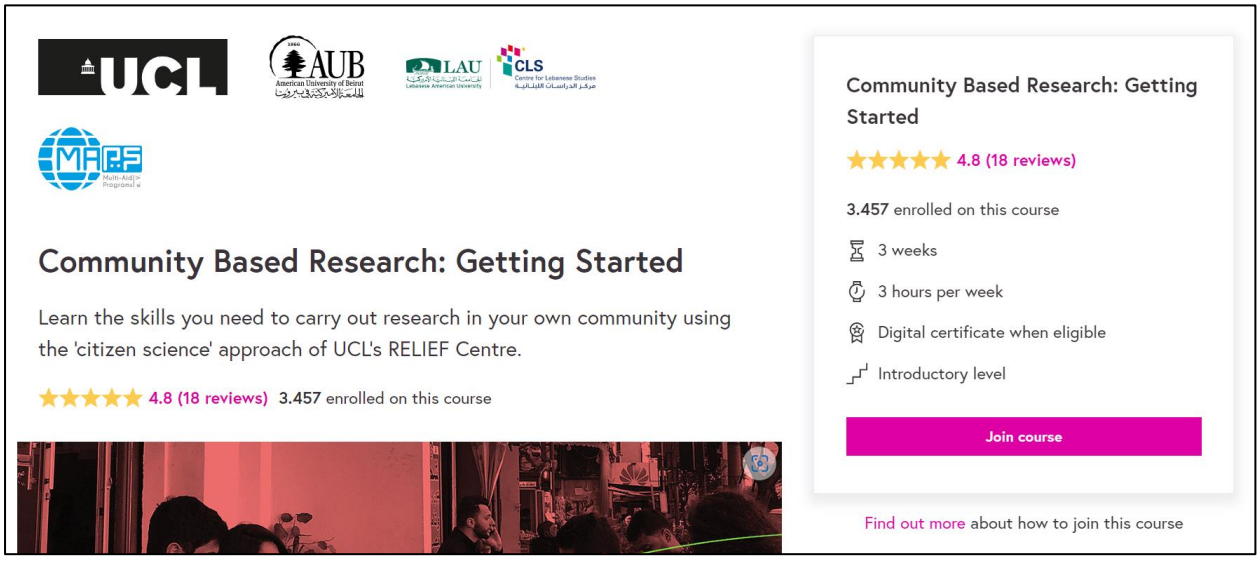
Below is a sample syllabus from the same website:



Two related courses also organized by the University of Dundee in cooperation with Grow Observatory ('Citizen Science: Sensing the World' and 'Citizen Science: From Soil to Sky') are currently not offered, but have in sum already reached around 10.000 participants.

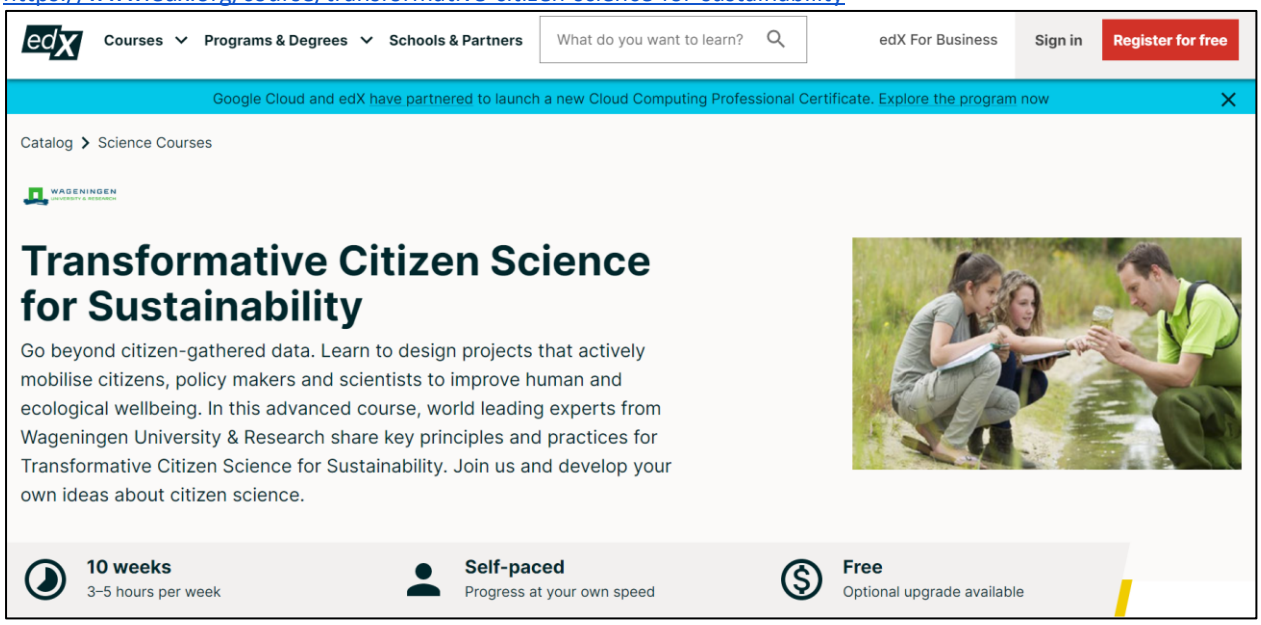
On the same digital education platform (FutureLearn), the **University College London** offers a course entitled 'Community Based Research: Getting Started', which aims to enable the participants "to carry out research in your own community using the 'citizen science' approach of UCL's RELIEF Centre."

https://www.futurelearn.com/courses/community-based-research

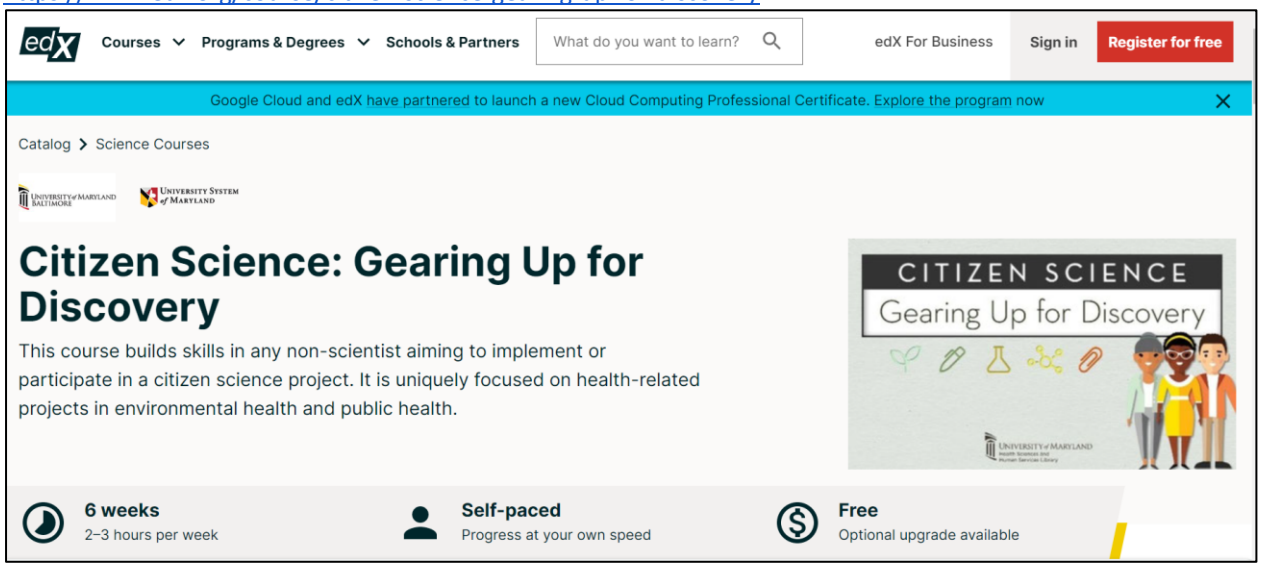


The MOOC (massive open online course) provider **edX**, which was launched jointly by **Harvard University and MIT**, currently has two CS-related courses in its portfolio: 'Transformative Citizen Science for Sustainability', a course developed by Wageningen University, focuses on the skills needed "to design projects that actively mobilize citizens, policy makers and scientists to improve human and ecological wellbeing." 'Citizen Science: Gearing Up for Discovery' by the University of Maryland is geared towards non-scientists intending to either initiate or join a CS project in the fields of environmental or public health.

https://www.edx.org/course/transformative-citizen-science-for-sustainability



https://www.edx.org/course/citizen-science-gearing-up-for-discovery



The Scottish Qualification Authority (https://www.sqa.org.uk/sqa/79197.html) gives accreditation and the authority to award qualifications – also, but not only, in the CS area – to institutes and organizations to deliver a course that conforms to a syllabus set out by SQA.