PROCEEDINGS OF SCIENCE

# How to get citizen science data accepted by the scientific community? Insights from the Plastic Pirates project

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Data resulting from citizen science investigations are often questioned as most participants do not (yet) have a thorough scientific education. This is especially true for projects taking place in schools, and conducting citizen science in this context is further complicated by different motivations of participants and a busy school curriculum. Herein we present strategies to ensure quality of data generated by the citizen science project Plastic Pirates in which schoolchildren investigated litter pollution at and in rivers. We show how formulating concise research questions, offering accompanying educational material, employing data quality mechanisms in the field (photographs, standardized sampling methods and self-evaluation) as well as transparently detailing which datasets were excluded from analysis was vital to accomplish the acceptance of resulting citizen science data by the scientific community.

*Engaging Citizen Science Conference 2022 (CitSci2022)*
*25-26 April 2022*
*Aarhus University, Denmark*

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# 1. Introduction

The accumulation of plastics in the environment causes significant harm to wildlife, ecosystems, and the economy [1, 2] and is a concern for human health [3]. Most research has been conducted on plastics in the marine environment, and the occurrence and distribution of litter in other environments has been comparatively understudied [4], even though it is estimated that approximately 80 % of litter originates from land-based sources [5].

Involving the general public in the research of this environmental problem has the potential to provide valuable data on these understudied environments as well as on a scale unobtainable with other means [6, 7]. However, involving people without a formal scientific education in research processes causes concerns about the quality of the resulting data [8, 9]. The dimensions of data quality are manifold and are defined differently depending on the focus of the research project [10]. Generally, data quality is characterised by many different aspects, such as sufficient quantity of data, completeness, being standards-based as well as by being free of errors [11, 12]. However, so far no "one-size-fits-all" approach exists with regard to data quality as the definition depends on the respective stakeholder [12]. Meanwhile, there are various recommendations for ensuring data quality in citizen science, for example, having low thresholds for participation, using standardised data collection protocols to ensure comparability between datasets, training of participants previous to samplings, dividing the data collection process into different tasks to reduce complexity and revising results and/or samples by project coordinators and getting in contact with participants for clarification [13-15, 6, 8]. Within the project Plastic Pirates different data quality mechanisms were successfully implemented in order to process and analyse the data collected by the participants. The Plastic Pirates are investigating litter pollution at and in rivers, building on a previous project by Rech et al. [16]. Since the start of the citizen science project in 2016, more than 18,000 schoolchildren, together with teachers and youth group leaders, have examined rivers throughout three countries in more than 1200 sampling events (https://www.plastic-pirates.eu/en/results/map).

The objectives of the project are to increase the scientific literacy of young people by giving the participants insights into scientific ways of working, and to raise their environmental awareness. Further, resulting scientific data on litter pollution allows a wide-ranging recording of this environmental problem and the identification of potential litter sources. To ensure high quality of these citizen science data we divided the data verification mechanisms of the Plastic Pirates into four steps: (1) planning and involvement of participants in study design, (2) motivation and training of the participants, (3) data collection and ongoing support, and (4) data validation and analysis.

# 2. Four steps of Plastic Pirates data verification

## 2.1 Planning and involvement of participants

Data quality considerations before the active involvement of the participants concerned mainly the development of research questions and accompanying adequate methods addressing the plastic pollution problem. Building on experiences made by Rech et al. [16], also investigating river litter with schoolchildren offered the advantage of avoiding errors and thus



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enhance data quality. The research questions were concise and omitted methods that other groups of researchers might have employed (e.g. investigating microplastics smaller than 1 mm) to streamline the sampling and not overburden participants with tedious tasks (e.g., sorting through a fine microplastic net loaded with organic material, [16]; Figure 1). Accompanying educational material (in the form of booklets) was important to engage the participants and offered them a wider perspective about the plastic pollution problem (the material was available free of charge https://www.plastic-pirates.eu/en/material/order). This material as well as the sampling methods were co-created between a team of scientists and schoolteachers. Involving members directly working with the targeted citizen science group at this stage was important to reflect on the appropriateness of employed methods. Coulson and Woods also emphasize the importance of co-created booklets to assist participants in monitoring environmental pollution in their surroundings [17]. For the Plastic Pirates a full co-creation approach involving school-children was not used because of time constraints and experiences of successful river and beach litter studies of the citizen science programs Científicos de la Basura (Litter Scientists, http://www.cientificosdelabasura.cl/en/) and Following the Pathways of Platic Litter [16, 18-19].

## 2.2 Motivation and training of the participants

The motivation and the goals of the participants are important aspects to consider planning a citizen science activity [20]. As a study by Land-Zastra et al. indicates, the level of engagement is strongly dependent on the individual motivation of the participants [21]. Contrary to most studies involving citizens, schoolchildren are usually not volunteers but compelled to participate by their teacher. To account for varying levels of enthusiasm, to motivate participants to get involved in tasks diverging from usual classroom assignments, and to address different personal capacities the field sampling offered a variety of activities (ranging from establishing transects to sorting through larger quantities of litter items, or inspecting potential litter sources and interviewing passersby, the latter being a more investigative approach; Figure 1). Regarding practical aspects, the project was developed to allow flexibility for already overtasked teachers trying to incorporate a citizen science project into a busy school curriculum: the only core activity was the field sampling (which could be conducted within a day) and other aspects were optional, e.g. working through exercises and experiments in the educational booklet and training before the sampling via a webinar offered by the project coordinators. The methods also allowed for some flexibility and could be employed at all kinds of rivers (large and small, urban and rural, with and without direct access to the river itself). Finding a balance between these practical considerations and ensuring high data quality were a main concern when developing the methods before the actual data collection phase (and are a main concern in other citizen science projects as well, see for example the review by Buytaert et al. for projects focusing on hydrology [22]).

## 2.3 Data collection and ongoing support

For the actual field sampling, a participating course split up into several groups of about six to eight schoolchildren, each addressing their own research question, such as quantifying the riverside litter, sampling the river for microplastics or looking for sources of the litter. This reduction of complexity reduces possible mistakes during the sampling [8, 23] and ensured that relevant data were obtained, even if one research question could not be



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addressed adequately (in one instance this happened due to very complex sampling instructions to assess accumulations of litter objects [24]). This was also recommended by Kosmala et al., particularly in cases where no training sessions with the participants were provided in advance [8].

For the quantification of riverside litter, three transects were established by the schoolchildren extending from the river shore up the riverbank. Sampling circles were located on each transect and only items within the circles were counted in order to record the level of pollution. Afterwards schoolchildren were asked to photograph their findings (so that they can be corroborated by the project coordinators). The instructions included a guide on how to take these pictures (placing the litter items on a uniformly-coloured background in such a way that items could be differentiated). For the investigation of microplastics a standardized net (mesh size of 1 mm) was used. Using standardized sampling instruments is a quality control measure commonly employed in citizen science projects, such as the Swiss Common Breeding Bird Survey which used a simplified territory mapping protocol [14; Figure 1]. The net was sent free of charge in a package including assembly instructions, and a post-paid return stamp, to make the use of the net and shipment of sample as convenient as possible. Overall, apart from the microplastic net, only easily obtainable materials were included in the sampling, such as buckets, gloves, sticks and ropes. After the sampling, collected data as well as photos were uploaded via a centralised website, usually by the teachers.

After a school class participated in the sampling, the coordinators at Kiel Science Factory revised whether all information and materials were available, i.e., data about the sampling itself (location and time), data about the litter findings, photos to corroborate the findings, and microplastic samples. Rapid communication and documentation of the conversations proved to be crucial to obtain missing data and clarify questions related to the respective data set, for example why annotated litter objects did not show up in photos. In total more than 11,000 emails were written and received over the project's lifetime, many of which were concerned with obtaining and verifying the materials submitted by the participants, which represented a significant workload for project coordinators. This experience was also shared by Bonter and Cooper from the FeederWatch project, who therefore used a semi-automated system to detect potentially erroneous observations at an early stage [6]. A further challenge during data revision was that we, as project coordinators, had no local knowledge about the sampling sites. Tools such as OpenStreetMap (https://www.openstreetmap.org) and Google Earth helped to double check certain parameters (such as the width of the investigated rivers at the sampling sites).

## 2.4 Data validation and analysis

Once all initial concerns had been resolved (or no further information was obtained) it was assessed whether a respective dataset could be considered for analysis following a decision making flowchart. This flowchart shows step by step under which circumstances data were accepted or rejected and was published together with the scientific findings. Further, examples of photographs detailing individual cases of datasets accepted or rejected and a list of how many datasets had to be rejected (including the reason why) have been added to the study [24; Figure 1]. The main reasons for rejecting a datapoint included missing samples and missing photographs to corroborate litter findings [24, 25] highlighting the need for efficient communication between all parties involved. Regarding microplastics, similar

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to a study by the Cientificos de la Basura [26] a thorough analysis took place in the lab of the project coordinators. For the Plastic Pirates samples this included the extraction of potential microplastic particles from the samples by visual inspection with a dissecting microscope and infrared spectroscopy-analysis for each plastic particle in order to confirm whether the particle consisted of plastic or not [25].

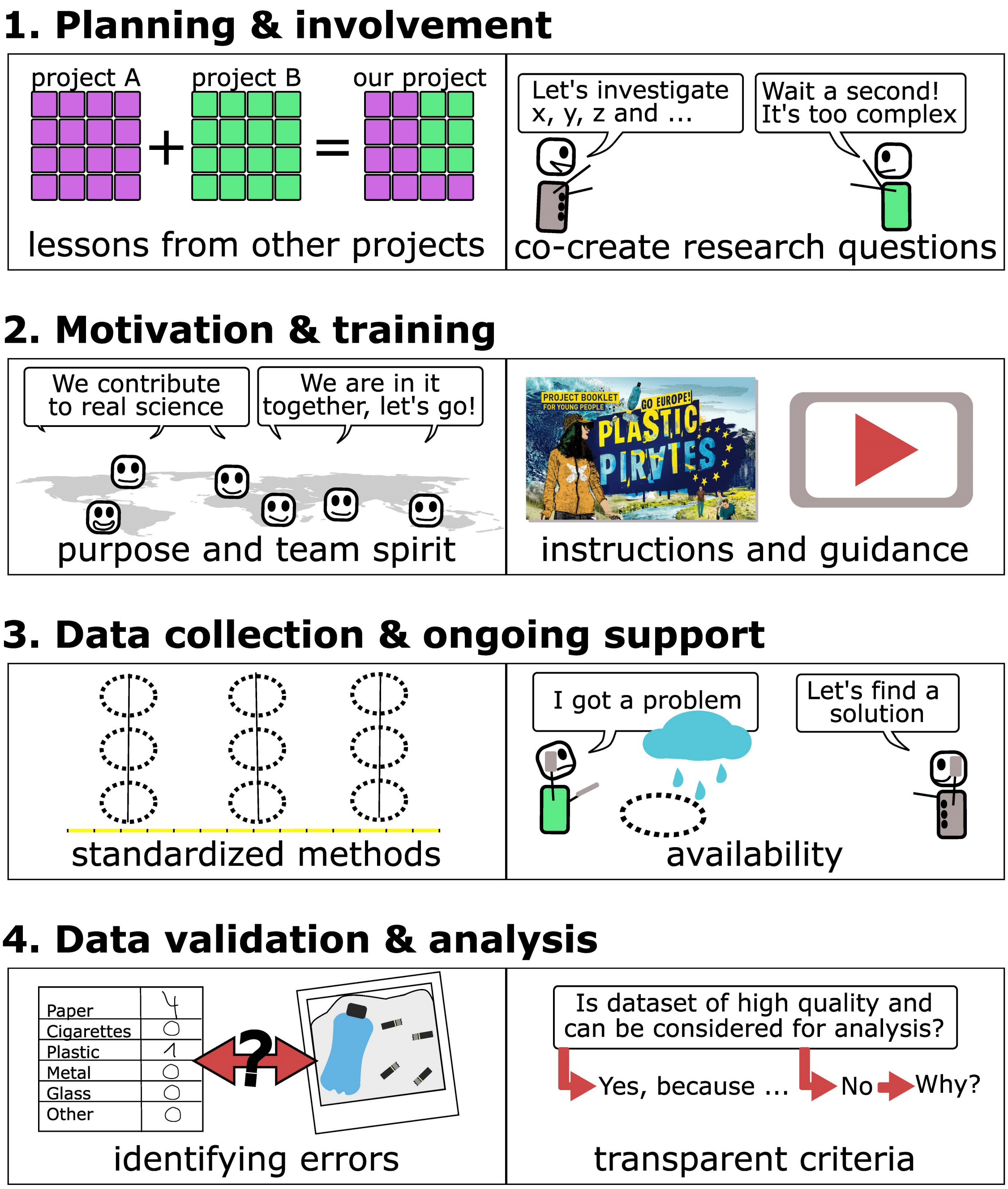


**Figure 1:** Mechanisms for high quality of citizen science data during different phases of a citizen science project, based on experiences from the Plastic Pirates.

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## 3. Conclusion

In summary, high quality of the citizen science data originating from the Plastic Pirates project could only be ensured through comprehensive strategies applied before, during and after data collection. Questions related to data verification ("Which methods were employed to ensure data quality in the field?", "How were data treated for analysis?", "How many datasets were considered for analysis", "Which problems caused the exclusion of datasets?") were an integral part of the Plastic Pirates throughout all project stages and key for the scientific success of the project. Developing functioning data quality assurance for citizen science projects is a long-term process involving multiple iterative steps where mistakes—when they happen—are continuously being corrected. We therefore call for active collaboration between existing and future citizen science projects, explicitly also sharing mishaps (see e.g. [16, 24]) in order to improve the data quality of citizen science studies and foster the acceptance of citizen science data within the scientific community.

**Acknowledgements**

We are grateful to all schoolchildren and teachers who participated in the Plastic Pirates, without their effort the project could not have been realized! Enthusiastic people from the Ecologic Institute, the German Aerospace Centre, the Cientificos de la Basura in Chile, and project partners from Slovenia and Portugal played an essential role for the success of the Plastic Pirates (https://www.plastic-pirates.eu/en/crew). Funding was supplied by the German Federal Ministry for Education and Research (BMBF).

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