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LET THEM PARTICIPATE! SCHOOL STUDENTS AS CITIZEN SCIENTISTS AND AGENTS OF CHANGE

TIM KIESSLING[1*], SINJA DITTMANN[2], JANTO SCHÖNBERG[2], JULIE PANTEL[3]

[1]*Opaki - Participation in Research through Design, Professor-Anschütz-Str. 72, 24118 Kiel, Germany*

[2]*Kiel Science Factory, Leibniz Institute for Science and Mathematics Education (IPN) and Kiel University (CAU), Am Botanischen Garten 16i, 24118 Kiel, Germany*
Sinja Dittman: dittmann@leibniz-ipn.de
Janto Schönberg: schoenberg@leibniz-ipn.de

[3]*julie_pantel@gmx.de*

ABSTRACT

Through citizen science initiatives, school students have contributed substantially to scientific knowledge. Often, their contribution is limited to the collection of data and other processes of the research cycle such as developing a research question or disseminating research outputs that are not part of a citizen science initiative. In this article we present the involvement of school students in the citizen science program, Plastic Pirates, investigating plastic pollution of the environment. We project two collaboration opportunities beyond data collection and purely academic work: fitting citizen science initiatives to policy-making processes and engaging with local stakeholders and decision makers. This would ensure that school students as citizen scientists do not only create data and knowledge but experience self-efficacy and step into negotiation spaces, where they are able to act on and engage with the investigated topic at hand.

Keywords: school students, citizen science, self-efficacy, participation in research, decision-making processes

INTRODUCTION

There is much evidence that school students can do science – apart from conducting experiments with a predetermined outcome in the

* Author to whom correspondence should be addressed: timkiessling@mailbox.org

classroom. Notable examples are large-scale studies involving school students as data contributors (e.g. Miller *et al.* 2024 for an example from astronomy or Varaden *et al.* 2021 for air pollution monitoring) or studies in which school students came up with a research question and were actually writing and publishing scientific articles (e.g. Blackawton *et al.* 2010, Nicosia *et al.* 2014). Many of such studies are labelled as 'citizen science', meaning that people without a formal scientific education participate in research initiatives led by accredited scientists (see Eitzel *et al.* 2017 for a critical discussion of this term). But it should be emphasized that many school student-led initiatives exist, which have a clear research focus, yet do not fall under the label of 'academic research' (consider, for example, science competitions, hackathons or the makerspace movement).

THE PLASTIC PIRATES CITIZEN SCIENCE PROGRAM

The citizen science program we (the authors TK, SD, JS) coordinate has involved more than 25,000 school students over the past decade in Germany (Dittmann *et al.* 2023). The initiative, called 'Plastic Pirates' (plastic-pirates.eu/) includes school students in the research of plastic pollution in aquatic environments. The Plastic Pirates initiative is based on the citizen science program Científicos de la Basura ('Litter Scientists'), active since 2007 in Latin America (Thiel *et al.* 2023), and has since been extended to other European countries (Uogintė et al. 2024) and to Nova Scotia in Canada as a pilot project (Kiessling *et al.* 2025).

So far, the school students investigated more than 1500 sampling sites in Germany, classified thousands of litter items and identified potential litter sources (Dittmann *et al.* 2024; Fig 1). The research data they collected also allowed us to evaluate a European policy instrument to curb plastic pollution (Kiessling *et al.* 2023), highlighting the potential to address novel challenges through citizen science. While many of the school students' research findings have been published, a provocative follow-up question would be: Do the school students actually care about academic research articles? While the value of their research contribution is obvious to us and fellow scientists, research outputs are commonly presented in a format that remains out of grasp for the school students and their teachers.

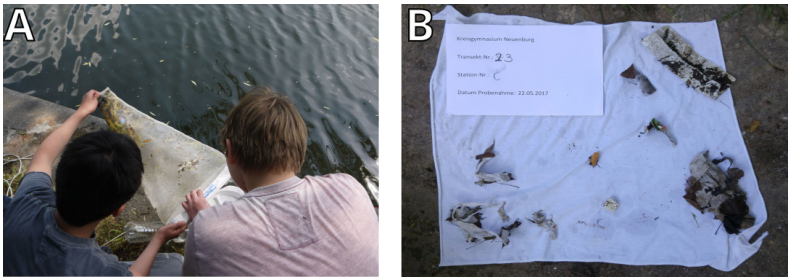


Fig 1 **(A) School students handle a sampling net, used to capture small plastic particles (microplastics). Photo by Bertha-von-Suttner Gymnasium Berlin. (B) A photograph used by Plastic Pirates researchers for data quality review, comparing litter items in the photo with those annotated on data sheets submitted by school students or teachers. Photo by Kreisgymnasium Neuenburg.**

FROM KNOWLEDGE CONTRIBUTION TO CO-PRODUCING CHANGE

We undertook some efforts to make research resulting from the contributions by the school students more accessible to them, for example in the form of short videos (youtube.com/watch?v=tM4J07gzxhw, in German) or social media updates showing ongoing research processes. Yet, the Plastic Pirates can be seen as a largely 'contributory' citizen science initiative (Senabre Hidalgo *et al.* 2021), meaning that school students are mainly involved in large-scale data collection and rarely participate in further phases of the research cycle (such as data analysis or knowledge dissemination). Similarly, though the related educational material (plastic-pirates.eu/de/material/download) offers additional exercises and instructions for project-based work to address the topic of plastic pollution after participation in the citizen science program, it is up to the teachers, and available space in an oftentimes busy school environment, to implement these further steps. Further, a study (Kruse *et al.* 2020) related to the predecessor project of the Plastic Pirates investigated changes in self-efficacy of the participating school students, meaning an individual's belief to act out of their own capacity to address a relevant goal or problem (in this case plastic pollution): It showed that school students did not increase their perception of self-efficacy after participating in the citizen science program (Kruse *et al.* 2020). We suspect two possible causes; the ubiquitous and global scale of plastic pollution might be overwhelming, or school students did not relate their research contribution to advancing on solving

plastic pollution. Either way, there is a need to discover pathways to relate the participation of school students in citizen science to real-world changes. In our opinion, this might happen through opening up collaboration opportunities at (i) a supranational level relating to legislation by the European Union, and (ii) a local level involving relevant stakeholders and decision makers.

ENABLING CHANGE THROUGH ENGAGING WITH PLASTIC POLLUTION LEGISLATION

In a recently published article we suggested how data originating from the Plastic Pirates program could inform the Water Framework Directive of the European Union (Schönberg *et al.* 2025). The Water Framework Directive has the goal to achieve healthy aquatic environments but does not yet consider plastics as a relevant source of pollution (e.g. Black *et al.* 2019). The already existing Plastic Pirates data in Germany and other European countries could be used as a baseline to inform this directive regarding the integration of plastic pollution (Fig 2A, B). Further, in the future, citizen scientists could collect valuable data, complementary to the directive, for example by identifying pollution hotspots (Kiessling *et al.* 2021, Schönberg *et al.* 2025, Fig 2C). This approach, to systematically consider citizen science research outputs for the formulation, evaluation and improvement of this and similar directives would give citizens an engagement opportunity with high-level pieces of European policy-making (Oturai *et al.* 2023). It would also fulfil a self-imposed obligation of many such directives to involve citizens in meaningful ways (e.g. 'The success of this [Water Framework] Directive relies on close cooperation and coherent action at Community, Member State, and local level, as well as on information, consultation and involvement of the public […]', EU Directive 2000/60). The road to interlock citizen science and policy-making can be long and stony, as a case study about the uptake of publicly collected plastic pollution data in official reporting of the Sustainable Development Goals in Ghana showed (Fraisl *et al.* 2023). But the need for this is urgent: more than half of citizens believe that their voice does not count in the European Union and only 15% find it feasible to participate in European Union policy-making (Hierlemann *et al.* 2022). Key questions concern how to harmonise data sources with legislative requirements and how responsibilities can be shared

among diverse stakeholders, including citizens and, hopefully, school students (Schönberg *et al.* 2025).

ENABLING CHANGE THROUGH ENGAGEMENT OF LOCAL STAKEHOLDERS AND DECISION-MAKERS

Moving beyond data collection also means increasing the data literacy of school student, their capacity to draw data-based conclusions and to invite them to disseminate their knowledge (compare to Phillips *et al.* 2021 on building 'social capital'). Subsequently, school students could act as 'agents of change' to enter previously closed negotiation spaces in order to engage more effectively on the issue at hand. As an example, school students in Rendsburg (in northern Germany) who had participated in a waste audit of their school yard presented their findings on posters (Fig 3). The school principal attended the

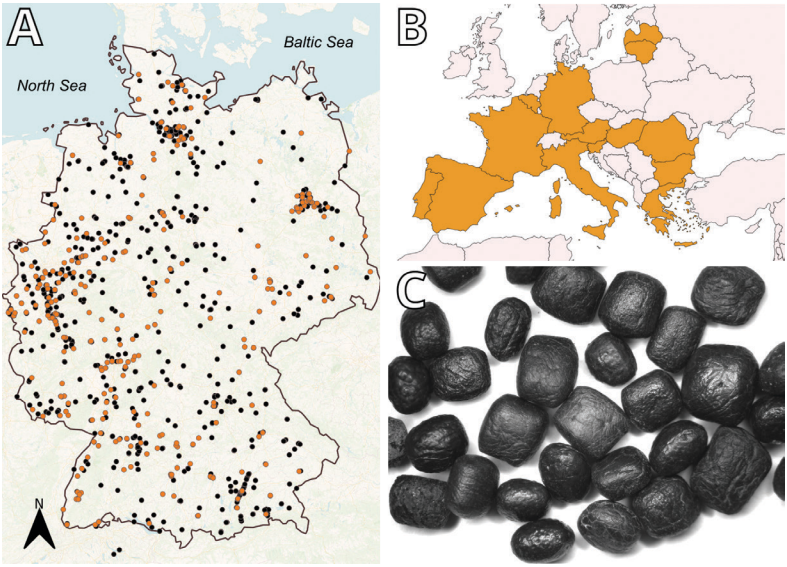


Fig 2 **(A) About one third of Plastic Pirates sampling sites in Germany (yellow dots) are already located within 1 km of a Water Framework Directive monitoring station. Fig from Schönberg *et al.* 2025, Creative Commons license CC BY 4.0. (B) European countries (in orange) participating in the Plastic Pirates program, showing the potential for large-scale data collection. (C) Microplastic particles from a river hotspot discovered by school students from Sekundarschule Schkopau. Photo by Magdalena Gatta-Rosemary/Kieler Forschungswerkstatt, Creative Commons license CC BY 4.0, first published by Kiessling *et al.* 2021.**



Fig 3 **(A) Litter collected in the schoolyard during a waste audit at the school Helene-Lange-Gymnasium Rendsburg. (B) Poster by school students presenting outcomes of the waste audit, focusing on single-use plastics. Photos by Tim Kiessling, Creative Commons license CC BY 4.0.**

poster presentation and related the research outcomes to the mayor of Rendsburg, who subsequently invited the young citizen scientists to a meeting to discuss potential solutions to the unhealthy consumption of packaged food products at their school (Flender *et al.*, in preparation). This civic engagement does not purely have an activist point of view, but is based on research data. The extensive occupation with a research topic also ensures a deeper understanding of the issue at hand. As another, larger-scale example, the schoolchildren of the Latin American Científicos de la Basura ('Litter Scientists'), have implemented 'environmental actions' related to plastic pollution after being involved in a citizen science study (cientificosdelabasura.ucn.cl/acciones-ambientales/). We assume that there might be other potential impact avenues, for example using municipality-backed sustainability initiatives as a leverage for increased and sustained engagement (such as the Zero Waste City certification in Europe, zerowasteeurope.eu/certification/) or harnessing the potential of favourable press and media attention (more than 2,000 media articles were published about the Plastic Pirates initiative and the research work by the school students, Dittmann *et al.* 2023). Key questions revolve around the identification of local decision makers (e.g. school principals, local politicians), and how to systematically establish collaborations and how to measure impacts.

OUTLOOK: POTENTIAL IMPACT OF TRANSFORMATIVE CITIZEN SCIENCE

Strong legislation as well as effective local action is needed to provide solutions to the ever-growing plastic pollution crisis, especially in the light of failing United Nations negotiations and powerful industry actors sabotaging solutions (Ralston and Taggart 2025). The citizen science approach, democratizing access to knowledge production, can act as a door opener for this and other societal problems, with the subsequent outlook of citizen scientists stepping into negotiation spaces. Currently, there often remains a disjunction between citizen research actors collecting data and the data itself, which is interpreted and used by academic researchers. In this article we suggested to keep involving citizen scientists beyond the phase of data collection, so that they can become agents of change. We argue that this would be especially beneficial for school students who work and learn in a performance-oriented school environment and have rare chances to meaningfully transform their environment due to a lack of financial means and political representation. Implementing school-based citizen science initiatives and adding civic engagement components could present a unique opportunity to increase their self-efficacy and become engaged and confident societal actors. We adults and academic researchers need to ensure that school students can step forward, take up space and be at the center as the initiators and leaders of change.

Acknowledgments We are indebted to thousands of school students and teachers who have made the Plastic Pirates what they are today. We apologize that we have not yet found adequate acknowledgment mechanisms beyond anonymous statements such as this one. We further want to point out that even this call for courage to open up spaces for school students remains (for now) yet another academic article, with limited relevance to the living realities of our young co-researchers.

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FURTHER INFORMATION

This article is based on a previously published blog article, titled "Can Schoolchildren Contribute to Research and Policy-making Through Citizen Science?", eiui.ca/can-schoolchildren-contribute-to-research-and-policy-making-through-citizen-science/

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