ARPHA Proceedings

Proceedings ECSA-ÖCSK-2024, 0141-0145
doi: 10.3897/ap.e126817

Change – The transformative power of citizen science

Changing knowledge and attitudes through citizen science at schools

Natalia Pirani Ghilardi-Lopes* (a), Gustavo Bellini Monteiro (a), Jussara Almeida Bezerra (a), Janaína Dutra Gonzalez (a)

(a) Center for Natural and Human Sciences, Federal University of ABC (UFABC), São Bernardo do Campo, Brazil

Abstract

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

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

Published by NHM, BOKU and ECSA and peer-reviewed under responsibility of ECSA-ÖCSK-2024 (Change – The transformative power of citizen science)

* Corresponding author. E-mail address: natalia.lopes@ufabc.edu.br

Introduction

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

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

Objective

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

Methodology

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

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

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

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

Results and discussion

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

“Investigating the Biodiversity in School Gardens”

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

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

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

"Phenology of Trees"

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

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

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

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

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

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

"From Waste to Sustainability"

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

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

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

Conclusion

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

Acknowledgements

To all young citizen scientists and the schools. To the Postgraduate Program in Teaching and History of Science and Mathematics at UFABC. To CAPES, FAPESP (2022/06862-3; 2023/12674-8; 2023/12619-7) and CNPq (406137/2023-4).

The authors have declared that no competing interests exist.

References

Bonney R, Phillips TB, Ballard HL, Enck JW (2016) Can citizen science enhance public understanding of science? Public understanding of science 25(1): 2–16.

Fuccillo KK, Crimmins TM, de Rivera CE, Elder TS (2015) Assessing accuracy in citizen science-based plant phenology monitoring. International Journal of Biometeorology 59(7): 917–926. https://doi.org/10.1007/s00484-014-0892-7.

Jelly S (2001) The right question at the right time. In: Harlen, W. Primary Science Taking the Plunge: how to teach primary science more effectively. Heinemann Educational, Oxford, 116pp.

OECD (2022) Summary: PISA 2022 results. Available at: https://www.oecd.org/publication/pisa-2022-results/. Accessed on May 04, 2024.

Parris KM, Lentini PE, Hartel J, Soanes K (2023) The value of question-first citizen science in urban ecology and conservation. Conservation Science and Practice 5: e12917. https://doi.org/10.1111/csp2.12917

Phillips T, Porticella N, Constas M, Bonney R (2018) A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science. Citizen Science: Theory and Practice 3(2): 3. https://doi.org/10.5334/cstp.126.

Purvis B, Mao Y, Robinson D (2019) Three pillars of sustainability: in search of conceptual origins. Sustain Sci 14: 681–695. https://doi.org/10.1007/s11625-018-0627-5

Shirk JL, Ballard HL, Wilderman CC, Phillips T, Wiggins A, Jordan R, McCallie E, Minarchek M, Lewenstein BV, Krasny ME, Bonney R (2012) Public Participation in Scientific Research: a Framework for Deliberate Design. Ecology and Society 17(2): 29. http://www.jstor.org/stable/26269051

Wandersee JH, Schussler EE (1999) Preventing plant blindness. The American biology teacher 61(2): 82–86. https://doi.org/10.2307/4450624

Wyles K, Ghilardi-Lopes NP (2023) Citizen science as a pro-environmental behaviour and a catalyst for further behaviour change. In: Gatersleben, B. & Murtagh, N. Handbook on Pro-Environmental Behaviour Change. Edward Elgar Publishing, UK, 321–334.