Australian Journal of Environmental Education (2023), **39**, 522–535
doi:10.1017/aee.2023.14

CAMBRIDGE UNIVERSITY PRESS

ARTICLE

Students' attitudes towards the environment and marine litter in the context of a coastal water quality educational citizen science project

José Luís Araújo[1], Carla Morais[2] and João Carlos Paiva[2]

[1]Open Laboratory for Science Education, Research Centre on Didactics and Technology in the Education of Trainers (CIDTFF), Department of Education and Psychology, University of Aveiro, 3810-193 Aveiro, Portugal and [2]CIQUP, IMS, Science Education Unit, Department of Chemistry and Biochemistry, Faculty of Sciences, University of Porto, 4169-007 Porto, Portugal
Corresponding author: José Luís Araújo; Email: jlaraujo@ua.pt

(Received 18 October 2021; revised 26 May 2023; accepted 27 May 2023; first published online 04 July 2023)

Abstract

This research focus on the evaluation of the impact on students' attitudes towards the environment, fostered by their involvement in an educational citizen science project related to the monitoring of physicochemical properties and the detection of (micro)plastics in Portuguese coastal waters. We developed an attitude scale, comprising four dimensions (Collective, Personal, Recycling and Reuse and Microplastics), which was applied, as a pre-test and post-test, to 574 middle school students (aged 12–14): 442 in the experimental group and 132 in the control group. Initially, based on pre-test results, both groups revealed positive attitudes. In the experimental group, the post-test results revealed that significantly positive attitude changes were promoted in all dimensions, whereas, in the control group, this occurred only in the Personal dimension. The control group also exhibited significantly negative attitude changes in the collective dimension. Students' engagement in sustainability-related citizen science projects can enhance environmentally literate society.

Keywords: Attitudes towards the environment; Attitudes towards marine litter; Citizen science; Environmental awareness; Coastal water quality

Citizen science and environmental literacy

The participation of citizens in the process of scientific construction is not new, particularly in the field of sciences, where the collection of large amounts of samples and data plays an important role. Citizen science is more than an approach to scientific research where data is collected by citizens in favour of the scientific community. On the one hand, citizen science has made it possible to democratise science as it literally becomes open to the community, where citizens can be an active and integral part of the whole scientific process and, therefore, more inclusive (Hecker et al., 2018). On the other hand, citizen science can promote science education and science literacy, and in particular environmental education and literacy (e.g. Zeegers et al., 2012), through citizen engagement in science through socially relevant contexts such as marine pollution by microplastics (Paradinas et al., 2021; Setälä et al., 2022). With citizen science having great potential to involve the younger public in science, through appropriate pedagogical dynamics, a bridge can be established between the contents addressed in the scientific subjects and the socially

The authors state that this manuscript is an original work that has not been submitted to nor published anywhere else.

relevant contexts, such as sustainability-related contexts, in which these projects are inserted (e.g. Kelemen-Finan et al., 2018). Regarding the impact of citizen science on students' science and environmental literacy, particularly in its affective domain, the literature reveals the contributions of this involvement are vast, but difficult to assess and widely differentiated (Harlin et al., 2018). In this way, it is crucial to comprehend how citizens' engagement in citizen science projects fosters positive attitudes towards the environment, specifically regarding emergent environmental issues like marine pollution caused by (micro)plastics.

Attitudes towards the environment and marine litter

Recent decades have seen the emergence of new challenges and environmental problems, to which society must respond (Srbinovski & Stanisic, 2020). Thus, promoting the affective domain of environmental literacy is an important tool to counteract the consequences of human activity and industrial production on the environment, such as marine litter and, particularly, the microplastics therein. Therefore, environmental education emerges as "an approach, a philosophy, a tool, and a profession" (Monroe, Andrews, & Biedenweg, 2008) with the objective of understanding environmental problems, while raising environmentally literate citizens and addresses the environment and sustainable resources and promotes positive attitudes towards the environment (Biber et al., 2022). Environmental education "empowers the individual to make informed decisions and act responsibly while dealing with these issues and problems" (Faize & Akhtar, 2020, p. 2). In this regard, Korkmaz et al. (2018), mention that environmental education is important to promote the development of affective connections with nature, fostering the interest, pro-environment behaviours and attitudes of citizens; while also arguing that awareness of environmental issues is more effective when fostered up to adolescence. As such, it is essential that curricula also focus on environmental education, which should emphasise promoting environmental literacy in all its dimensions and, specifically, in the attitude domain.

Milfont and Duckitt (2010) define attitudes towards the environment as the assessment of the natural environment that individuals perform based on their perceptions, which are related to the level of affinity the individual has with the environment. Liu and Chen (2020) describe attitudes towards the environment in more detail, referring that they are a factor that directly influences an individual's environmental awareness, because if he or she exhibits positive attitudes towards a certain issue related to the environment, he or she is also more likely to adopt more favourable and responsible behaviours towards the environment.

Several initiatives have been carried out at a global level related to environmental literacy and particularly with the promotion of pro-environmental attitudes related to the marine litter problem. For example, Hartley et al. (2018) conducted the first large-scale European study aiming to explore the public's perceptions about marine litter. The authors concluded that the public recognise that marine litter is a global problem and show high levels of concern about this topic. Also, according to these authors, "participants who were older, female, had a higher educational level, accessibility to and experience of the coast and marine litter, reported greater concern, personal motivation, competence, social support, and who placed higher value on the coast, reported greater willingness to act" (p. 953). These factors are consistent with theories of environmental behaviour and empirical research into other environmental issues (Gifford, 2014). Hartley et al. (2018) also emphasise the need to actively engage citizens in approaches related to marine litter, as they found that the more litter people saw on beaches and coastal regions, the greater were their concern about this topic and the more predisposed they were to act.

In Portugal, some work has been published on the characterisation of marine litter, especially microplastics found in coastal regions (e.g. Prata et al., 2020). There are also some citizen science projects to promote pro-environmental attitudes and behaviours about this subject (e.g. the initiatives of the Portuguese Association of Marine Litter (2022) or the Coastwatch projects

(2022)), which actively involve primary and/or secondary school students. However, the impact of project participation on students' attitudes, behaviours or values is still poorly explored. As such, it is important to develop projects that promote environmental education among young people and which focus on assessing the impact of these approaches not only on the cognitive domain (e.g. Araújo et al., 2021), but also on the affective domain as it was intended to be done with the development of PVC – *Perceiving the Value of Chemistry behind water and microplastics*, an educational citizen science project as described below in more detail.

The PVC citizen science project

The environmental problem addressed in the PVC project was selected due to three main reasons: i) meet the objectives of the United Nations Decade of Ocean Science for Sustainable Development (United Nations, 2022), ii) the contamination of coastal waters by (micro)plastics, which are increasingly current and relevant issues for society and scientific community (e.g., Mercogliano et al., 2020) and iii) Portugal is a country with a large coastal area and strong historical ties to the sea. Thus, emerged the idea of developing a citizen science project, with a strong educational component, which aimed to monitor the quality of coastal waters and marine litter in the Northern Coast of Portugal, also intended to promote positive attitudes and awareness towards the environmental issues explored. Thus, the PVC project actively involved students in four main phases that took place in the classroom, in the chemistry laboratory, in field visits and in extra-classroom moments: 1) *online tasks* such as guided searches, video visualisation, interpretation and creation of posters and infographics to raise awareness of marine litter, especially the presence of (micro)plastics in coastal waters and its consequences aimed to highlight the relevance of chemistry and its preventive role in combating these environmental scourges. This stage took place during the autumn and winter months so that stage 2) *sampling of coastal waters and beach plastics*, could take place in suitable weather conditions so that students could safely collect the coastal waters. The stages 2) and 3) *conducting a physicochemical analysis of the water and identifying (micro)plastics* aimed to promote the learning of Chemistry curriculum contents underlying the project; and the stage 4) focussed on *project dissemination* to mobilise acquired knowledge and to develop communication skills (Araújo et al., 2022).

Therefore, this study intended to gather students' attitudes towards the environment and marine litter before their involvement in the PVC project and the following null (H_0) and alternative (H_1) hypotheses were pointed out:

H_0: Students participation in the PVC project does not promote positive changes in their attitudes towards environment.

H_1: Students participation in PVC project contributes significantly to positive changes in their attitudes towards the environment.

Methods

Participants

The PVC project took place during 2018/2019 school year and included 574 students, from 26 Chemistry classes, attending middle school (aged 12–14 in Portuguese schools – 7th, 8th and 9th grades). The classes involved in the PVC project were from four schools in the Northern Coastal Region of Portugal and were taught by nine teachers who revealed interest and willingness to collaborate in this research. Considering the number of classes taught by each teacher, they randomly choose six of their classes (132 students, 65 boys and 67 girls) to be part of the control group (CG) and 20 classes (442 students, 208 boys and 234 girls) to be part of the experimental group (EG). Both groups, according to students' school year, receive the same chemistry instruction. As the environment-related contents explored in the PVC project were transversal to the 7th, 8th and 9th grades, all students were engaged in similar educational and awareness activities. In each school class, students from EG worked on the project for seven months, in small groups comprising two to five members. The implementation of the various phases of the PVC project was actively conducted by the teachers involved, who collaborated in this research by monitoring their students' participation in the project and helping to apply the data collection instruments, in close collaboration with the researchers.

All participation in the study was voluntary. The parents or legal guardians of the students signed an informed consent form, which described students' participation in the research and the activities in which they would be involved and ensured the anonymity and confidentiality of personal data complying with national data protection legislation.

Procedures

Attitudes towards the environment and marine litter scale design

The field of behavioural sciences and psychology has been contributing to the area of the environmental studies by developing a considerable number of scales that intend to access public environmental concerns and attitudes. Some of the most relevant and used scales are the scale for the measurement of ecological attitudes and knowledge (Maloney et al., 1975), the scale for environmental concern (Weigel & Weigel, 1978), the New Environmental Paradigm (NEP) scale (Dunlap & van Liere, 1978), the Two Major Environmental Values (2-MEV) scale (Bogner & Wiseman, 1999), the Environmental Attitudes Inventory (Milfont & Duckitt, 2010) or the Revised Environmental Identity Scale (Clayton et al., 2021). Also, it is worth mentioning that some of the authors of this article had previously conducted other research studies using these scales, which makes them more familiar with their psychometric properties (Morais et al., 2022). However, none of those scales focussed on the most crucial aspects explored in the PVC project: the contamination of marine environments by plastics and microplastics. As such, we felt the need to develop a new attitude scale, inspired by other examples from the literature, which would be appropriate for the research objectives and the age range of participating students.

Teixeira (2018) developed an attitudinal scale to know the attitudes of university students about the environmental theme of marine litter in a broader sense. So, to better address our research goals, the Attitudes towards the Environment and Marine Litter (ATEML) Scale was developed comprising 18 statements, 13 of which are retrieved and adapted from the scale developed by Teixeira (2018) and five of our own authorship (as shown below in Table 1). Items selected from Teixeira's scale related to environmental sustainability and to marine litter and the items of our own authorship were about students' pro-environmental behaviours and their perspectives about microplastics which were the main topics addressed within PVC project. For content validation purposes, the attitude scale was first answered, by two students of each school year of the middle school, in a total of six students, who were not involved in the CG or EG groups. This procedure was adopted to guarantee that all statements presented were intelligible and understandable. Subsequently, the scale was submitted for analysis by two teachers specialised in Science Education.

The final version of the ATEML Scale includes 18 statements, for students to express their level of agreement using a 7-point *Likert* scale (1 = Strongly disagree; 2 = Disagree; 3 = Partially disagree; 4 = Neither agree nor disagree; 5 = Partially agree; 6 = Agree; 7 = Strongly agree). Moreover, students also answered a set of questions that aimed to collect sociodemographic

Table 1. Principal component analysis with Varimax rotation of the ATEML Scale

Items	Factor			
	1	2	3	4
1. I think it is the responsibility of human beings to preserve the marine environment for future generations.[a]	.76			
2. I consider the issue of marine litter to be relevant for today's society.[a]	.71			
3. I am concerned with the problems marine litter can cause for species.[a]	.74			
4. If I by chance drop litter on the beach, I pick it up and place it in the appropriate bin.[b]	.66			
5. It disturbs me to know that sea water might be globally polluted with small and unnoticeable plastic particles.[a]	.66			
6. I am worried the growing tendency of plastic production and increasing human population will worsen the problem of marine litter.[a]	.62			
7. I am worried to find out that I might be a consumer of foods that may have plastics from marine litter.[a]	.62			
8. I try to consume products that are less harmful to the environment.[a]		.75		
9. It worries me that food from the marine environment might contain microplastics.[a]		.66		
10. I try to replace single-use containers with reusable containers.[b]		.62		
11. I tend to pay attention to the amount of plastic I consume and/or waste on a daily basis.[a]		.61		
12. I try to inform myself on the measures I can take to reduce my contribution to environmental pollution.[a]		.55		
13. I am willing to join initiatives for marine litter collection on beaches.[a]		.56		
14. I separate the waste in my house.[a]			.82	
15. I try to reuse and/or recycle the plastic I use on a daily basis.[a]			.62	
16. Whenever I go shopping I try to reuse the plastic bags.[b]			.54	
17. Knowing about the presence of microplastics in hygiene and beauty products would prevent me from buying them.[a]				.84
18. I believe the presence of microplastics in personal hygiene products should be forbidden or avoided.[b]				.75

Items adapted from Teixeira (2018)[a] and self-authorship items[b].

information, such as gender and grade. The attitude scale was anonymised and coded so that students' responses could be compared between the different moments of application.

An exploratory factor analysis was conducted to define the factors present in the attitude scale. Thus, students' responses to the scale, when applied as a pre-test, were subjected to a principal component analysis (PCA) with Varimax rotation, from which emerged four factors that explain 60.5% of the variance (above the desired minimum of 60%) (Tabachnik & Fidell, 2006). The Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO) indicated the adequacy of the sample was marvellous (KMO = .94) (Kaiser, 1974). The Bartlett's Test of Sphericity was statistically significant (χ^2 (153) = 7211.03, $p < .001$), allowing us to conclude that the variables are sufficiently correlated to conduct a PCA. Table 1 displays the items of the correlation matrix with saturation values above 0.50 (Field, 2009), organised by factor.

Subsequently, we proceeded with the interpretation of results emerging from the PCA and defined the dimensions underlying each factor:

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

Table 2. Descriptive analysis of the dimensions of the ATEML Scale: Pre-test

Dimension	N	Mean	Standard Deviation
1. Collective	574	5.97	.92
2. Personal	574	5.14	1.05
3. Recycling and reuse	574	5.42	1.29
4. Microplastics	574	5.11	1.35

The values above refer to the measurement scale of 1 to 7.

1. *Collective* – dimension related to society's awareness towards environmental problems, particularly global behaviours adopted by humans in order to preserve the environment (items 1–7);
2. *Personal* – dimension related to individual behaviours and concerns regarding this issue (items 8–13);
3. *Recycling and reuse* – dimension related to personal behaviour in a more specific domain, such as recycling and plastic reuse (items 14–16);
4. *Microplastics* – dimension related to awareness of the presence of microplastics in the environment (items 17 and 18).

Data collection

The attitude scale was answered by the participating students, as a pre-test, at the beginning of the 2018/2019 school year, from September to October 2018. After the completion of the PVC project, between May and June 2019, the same scale was also answered by all participating students, as a post-test. The collection of this data was monitored by the teachers during one of their classes.

Results

The internal consistency of the ATEML Scale was also analysed (using the *IBM SPSS Statistics* software (version 25)). The reliability analysis (Cronbach's alpha) reveals good internal consistency values for dimensions *1. Collective* (0.875) and *2. Personal* (0.803). Dimensions *3. Recycling and reuse* (0.635) and *4. Microplastics* (0.651) show moderate values regarding the internal consistency of the scale. The value of Cronbach's Alpha is above 0.60 for all dimensions, thus the scale has moderate reliability. Nonetheless, the dimensions of this attitude scale exhibit acceptable internal consistency (Briggs & Cheek, 1986).

The results show that, overall, before their participation in the PVC project, students presented very positive attitudes towards the four dimensions under analysis, with their answers to the attitude scale, applied as a pre-test, revealing a mean value above 5 on the measurement scale (Table 2).

To better understand how the PVC project contributed to changes in students' attitudes, the results of the pre-test application of this scale were compared with the results obtained in the post-test, for both groups.

Comparison of results between the experimental group and the control group

Given the existence of small differences in the means of all dimensions of the scale, in the pre-test, for each group (see Tables 3 and 5) we can consider that the attitudes of CG and EG were equivalent. In Table 3 presents the mean values for EG students' responses, and respective standard deviations, in both moments of application of the ATEML Scale. These results were subjected to a paired samples *t*-test, as presented in Table 4, which revealed that the mean value

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

Table 3. Presentation of the mean values for the dimensions of the ATEML Scale, as pre-test and post-test in the EG

Dimension		N	Mean	Standard deviation
1. Collective	Pre-test	442	6.03	.87
	Post-test	442	6.22	.82
2. Personal	Pre-test	442	5.25	.94
	Post-test	442	5.68	.94
3. Recycling and reuse	Pre-test	442	5.53	1.22
	Post-test	442	5.69	1.09
4. Microplastics	Pre-test	442	5.18	1.33
	Post-test	442	5.40	1.27

Table 4. Comparison between the dimensions of the ATEML Scale, as pre-test and post-test, in the EG

			95% CI			
(Post-test − Pre-test)	Difference of mean	Standard deviation	LB	UB	t	p
1. Collective	.184	.801	.098	.270	4.207	<.001
2. Personal	.434	.964	.331	.538	8.263	<.001
3. Recycling and reuse	.163	1.025	.053	.273	2.911	.004
4. Microplastics	.217	1.536	.052	.382	2.593	.010

CI– 95% Confidence interval (Field, 2009) LB–Lower bound UB–Upper bound.

Table 5. Presentation of the mean values for the dimensions of the ATEML Scale, as pre-test and post-test, in the CG

Dimension		N	Mean	Standard deviation
1. Collective	Pre-test	132	5.82	.96
	Post-test	132	5.54	1.23
2. Personal	Pre-test	132	4.81	1.23
	Post-test	132	5.12	1.31
3. Recycling and reuse	Pre-test	132	5.06	1.47
	Post-test	132	5.06	1.38
4. Microplastics	Pre-test	132	5.01	1.39
	Post-test	132	5.08	1.36

significantly increases from pre- to post-test, for all dimensions. Since the attitude changes observed in EG are statistically significant for all the analysed dimensions (p value <.05), unlike the changes observed in the CG (Table 6) the null hypothesis was rejected.

The same procedures were used to compare the attitudes of students in the CG. Thus, Table 5 presents the mean values for students' responses and respective standard deviations, in both moments of application. Similarly, the paired samples t-test (Table 6) allows us to conclude that, in the CG, only dimensions *1. Collective* and *2. Personal* revealed significant changes from pre- to post-test. In dimension, *1. Collective,* the students from the CG expressed less positive attitudes in

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

Table 6. Comparison between the dimensions of the ATEML Scale, as pre-test and post-test, in the CG

(Post-test – Pre-test)	Difference of mean	Standard deviation	95% CI LB	95% CI UB	t	p
1. Collective	−.284	1.143	−.502	−.065	−2.577	.011
2. Personal	.312	1.181	.086	.539	2.737	.007
3. Recycling and reuse	−.005	1.500	−.292	.283	−.032	.974
4. Microplastics	.065	1.675	−.256	.387	.404	.687

CI–95% Confidence Interval (Field, 2009) LB–Lower bound UB–Upper bound.

Table 7. Descriptive analysis of the students' responses (CG and EG) to the ATEML Scale: pre-test and post-test

	Pre-test				Post-test			
	CG		EG		CG		EG	
Items	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1.	6.39	.99	6.33	1.06	5.74	1.44	6.49	.90
2.	5.79	1.25	5.79	1.37	5.68	1.36	6.05	1.23
3.	6.10	1.05	6.21	1.04	5.63	1.36	6.34	.96
4.	5.84	1.49	6.06	1.33	5.57	1.47	6.26	1.13
5.	5.78	1.33	5.99	1.18	5.56	1.44	6.19	1.14
6.	5.60	1.43	5.95	1.19	5.52	1.43	6.12	1.10
7.	5.42	1.54	5.78	1.35	5.28	1.51	6.10	1.12
8.	4.82	1.71	5.29	1.50	5.13	1.68	5.58	1.31
9.	5.42	1.80	5.88	1.28	5.60	1.55	6.08	1.16
10.	4.54	1.73	4.70	1.74	4.96	1.61	5.63	1.27
11.	4.53	1.62	4.85	1.56	5.08	1.54	5.45	1.33
12.	4.92	1.60	5.28	1.38	5.20	1.47	5.71	1.22
13.	4.77	1.84	5.37	1.61	4.71	1.66	5.61	1.45
14.	4.47	2.17	5.13	2.01	4.87	1.93	5.44	1.84
15.	5.06	1.69	5.59	1.37	5.03	1.69	5.77	1.19
16.	5.67	1.61	5.85	1.39	5.25	1.50	5.83	1.40
17.	4.36	1.72	4.71	1.69	4.80	1.61	4.90	1.63
18.	5.60	1.52	5.58	1.42	5.37	1.50	5.89	1.31

the post-test than in the pre-test, as opposed to what was observed in dimension *2. Personal*. On the other hand, no statistically significant differences were found for the results of dimension *3. Recycling and reuse* and *4. Microplastics*.

A more detailed analysis of students' responses to the attitude scale showed that, regarding the results of the pre-test (and of the post-test), all items of this scale presented, for both groups, mean values above the intermediate point (4) of the scale (Table 7).

Specifically, for the CG, items 17, 14, 11 and 10 are those with the lowest mean values. In the case of the EG, items 10, 17 and 11 present the lowest results. On the other hand, the response means are higher for items 1, in both groups. Furthermore, similar to the pre-test results, the

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

Table 8. Comparison of variations in the dimensions of the ATEML, from pre-test to post-test, between the CG and EG

Dimension		N	Difference of mean	Standard deviation	F	p
1. Collective	CG	132	−.284	1.14	22.231	<.001
	EG	442	.184	.80		
2. Personal	CG	132	.313	1.18	1.160	.282
	EG	442	.434	.96		
3. Recycling and reuse	CG	132	−.005	1.50	1.698	.193
	EG	442	.163	1.03		
4. Microplastics	CG	132	.065	1.68	.759	.384
	EG	442	.217	1.54		

results of the attitude scale applied as a post-test reveal that the values for each item are above the intermediate point of the measurement scale. In this case, for the CG, we positively emphasise items 3, 2 and 1. Conversely, for the EG, it is items 4, 3 and 1 that obtain the most positive attitudes from students. On the other hand, items 13 and 17 are those which exhibit a lower mean value for the CG. However, for the EG, item 17 is the only one with a mean value below 5 points on the measurement scale. Overall, there is a tendency for the results of EG students in the post-test to be considerably higher than those of students from the CG.

Therefore, to examine the significance of the differences between groups, observed in the variations from pre- to post-test, the results of this attitude scale were submitted to an ANOVA analysis. As such, Table 8 systematises the results of Tables 4 and 6, and the results of the statistical test conducted. From the analysis of Table 8, it is possible to conclude that significant variations only occur between groups for dimension 1. *Collective,* where the changes in attitudes, from pre- to post-test, are positive for the EG and negative for the CG. The same tendency was also found for dimension *3. Recycling and reuse*, although, in this case, the differences were not statistically significant. Dimensions *2. Personal* and *4. Microplastics* also showed no statistically significant differences in the attitude changes of both groups. Nevertheless, the changes observed in the EG were always more positive than those observed in the CG.

Since the literature reveals that gender can be a differentiating variable for students' attitudes towards the environment (Hartley et al., 2018; Srbinovski, 2019), we considered relevant to examine whether these differences in attitudes between boys and girls were also present in this research.

Effect of gender on the variation from pre-test to post-test, for the CG and EG

Table 9 shows the variation in attitudes occurring from pre- to post-test, in the EG and CG, for boys and girls. It is possible to observe that, for CG, the variation in dimension *1. Collective* is negative for both boys and girls. However, it is the boys who exhibit a more negative change in attitudes for this dimension. On the other hand, in the EG, the same dimension revealed positive attitude changes for both boys and girls, with girls revealing a more positive change than boys.

Regarding dimension *2. Personal*, both groups exhibited positive attitude changes from pre- to post-test. In the CG, the mean value of boys' responses increased more than that of girls. Conversely, in the EG, girls presented more positive changes between the two moments of data collection. For dimension *3. Recycling and reuse*, girls revealed more positive attitude changes than boys. For this dimension, in the CG, girls exhibited more positive attitudes in the post-test, whereas boys revealed a negative attitude change. In the EG, both boys and girls exhibited more

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

Table 9. Relationship between the variations in the dimensions of the ATEML Scale, from pre-test to post-teste, and gender

		Experimental group			Control group		
Dimension	Gender	N	Difference of mean	Standard deviation	N	Difference of mean	Standard deviation
1. Collective	Male	214	.068	.92	67	−.396	1.11
	Female	228	.275	.68	65	−.171	1.18
2. Personal	Male	214	.364	1.03	67	.346	1.13
	Female	228	.490	.91	65	.280	1.24
3. Recycling and reuse	Male	214	.132	1.04	67	−.025	1.50
	Female	228	.187	1.01	65	.015	1.51
4. Microplastics	Male	214	.159	1.64	67	−.076	1.79
	Female	228	.263	1.45	65	.204	1.56

positive attitudes in the post-test, with girls presenting more positive attitudes than boys. For the final dimension of this scale, *4. Microplastics*, in the CG, the mean value of boys' attitudes decreased, from pre- to post-test, as opposed to what occurred for girls. In the EG, the changes in attitudes for boys and girls were positive, with girls revealing more positive attitude changes for this dimension, when compared to boys.

To determine whether the attitude changes of students in each group differ according to gender, an ANOVA analysis was conducted. The results of this statistical test (*1. Collective*: $F_{1,442} = 0.009$, $p = .923$; *2. Personal*: $F_{1,452} = 0.720$, $p = .397$; *3. Recycling and reuse*: $F_{1,442} = 0.003$, $p = .955$; *4. Microplastics*: $F_{1,452} = 0.250$, $p = .618$) indicate the pattern of interactions for the attitude changes between groups does not differ according to gender.

Discussion

As issues related to the environment have sparked the interest of society in general, there is a growing concern, from citizens, regarding the potential consequences of environmental issues for their daily lives (European Commission, 2014). Thus, citizens often exhibit positive attitudes towards the environment (Korkmaz et al., 2017; Srbinovski, 2019). Indeed, as reported in the literature (e.g, Hartley et al., 2018; Lucrezi & Digun-Aweto, 2020; Teixeira, 2018), the public tends to be aware of environmental problems, such as marine litter, and recognise the need for measures to solve or minimise these problems. However, these ideas do not translate, as would be expected, into behaviours and actions. For this reason, promoting positive attitudes towards the environment should be an important focus of environmental education, since adolescence is the developmental stage where this promotion is most effective in order for behavioural changes to take place (Korkmaz et al., 2017). As such, we considered it important to examine the impact of participation in the PVC project on the attitudes of middle school students.

From the results we concluded that, as indicated in the literature (e.g, Hartley et al., 2018; Srbinovski, 2019), in the pre-test, students from both groups exhibited clearly positive attitudes towards the four dimensions emerging from the scale. Of these, we highlight dimension *1. Collective* as the one for which students presented the most positive attitudes and, conversely, dimension *2. Personal* as the one for which students exhibited the least positive attitudes. Dimension *4. Microplastics* presents very low mean values when compared to the remaining dimensions of the scale, possibly because this topic was unfamiliar to many of the students. An overall analysis of these results also suggests the attitudes of the EG students in the pre-test were slightly more positive than those of the CG. This difference may be explained by the fact that,

https://doi.org/10.1017/aee.2023.14 Published online by Cambridge University Press

when answering the attitude scale, the PVC project was presented to EG students, with great emphasis being given to the environmental context explored, which may have immediately awakened the sensitivity of these students to issues related to ocean pollution by microplastics.

From the analysis of students' responses to the post-test, we found that, for the CG, large attitude changes were observed in dimensions *1. Collective*, where students exhibited significantly less positive attitudes. Conversely, for dimension *2. Personal*, the attitudes were significantly more positive, which may suggest greater concern with personal actions in favour of the environment. Although these students were not directly involved in the intervention program, the awareness-raising activities developed in schools, within the scope of the PVC project, focussed on what everyone could do or which habits or behaviours each of us could change to mitigate the marine litter. So, this could be a reason that may have positively influenced dimension *2. Personal* for these students. Nonetheless, it also can be argued these findings result from the involvement of these students in other projects or from environmental awareness campaigns in the media. However, dimension *2. Personal*, for which students exhibited the most positive attitudes, comprise items clearly focussed on the context explored by the PVC project. Additionally, the informal observations and conversations with students reported by teachers may help to support these results. For the same reason, as expected, dimension *4. Microplastics* slightly increased, with this increase also possibly being a consequence of the awareness raised within the schools. It is worthwhile to point out that other formal and informal sustainability-related dissemination activities that often occur in schools and daily life contexts could bias the pre-and post-test results. Moreover, even though we did not promote intentional contact between CG and the PVC project, the project dissemination activities were organised for the whole school community, which means that CG students could have been reached in some way. However, the post-test results of the EG reveal a significant positive change in attitudes, for all dimensions, which suggests the effectiveness of the project in promoting personal behaviours and actions towards marine litter and microplastics pollution. Lucrezi and Digun-Aweto (2020) suggest the involvement of individuals in pro-environmental initiatives promotes more positive attitudes and behaviours, which may justify the results found for the EG students.

As reported in the literature (e.g. Hartley et al., 2018; Lucrezi & Digun-Aweto, 2020), gender could be a fact that influences attitudes towards environment. So, in terms of the differences in attitude changes between boys and girls, we found, from pre- to post-test, that the attitude changes in girls from both groups are, overall, greater than the attitude changes observed in boys, as pointed out in the referred literature. We also found that boys in the CG expressed less positive attitudes in the post-test, whereas boys in the EG exhibited more positive attitudes, which suggests the positive impact of the PVC project on boys' awareness and attitudes. Although, overall, girls in the CG had more positive attitudes in the post-test, we also observed that the attitude changes of girls in the EG were considerably more positive, corroborating the idea that the PVC project had a positive impact on students' attitude changes.

The PVC project contributed to promote more positive attitudes in the EG towards these environmental problems, also revealing good indicators of the contribution of the project towards behavioural changes in the participating students, but whose true impact can only be measured in a more longitudinal study (Araújo et al., 2023).

According to European Commission (2014), a large proportion of European citizens reveal that, after the media, conversations with family members and other close people, as well as participation in events, are the most important sources of information regarding the environment. Moreover, conversations and shared activities with family members are seen as important sources of information and awareness-making regarding other socio-scientific issues (Paiva et al., 2017). Thus, given the PVC project's scientific dissemination component, we also highlight its contribution to promoting environmental awareness in this community.

Conclusion

Students' involvement in educational citizen science projects, particularly if contextualised with current and relevant environmental situations, as was the case of the PVC project, promote the affective dimension of environmental literacy. Despite study limitations, its findings gave us good indicators of the positive impact of this project on students' attitude changes regarding the environment and the marine litter. So, this educational experience, profiles a positive way to raise students' awareness of the marine litter problem, promoting opportunities to enhance an environmental literate society by linking and relating the environmental education to other areas such as chemistry education and its fundamental contents (Araújo et al., 2015, 2021, 2022; Morais et al., 2021).

Acknowledgements. The authors gratefully acknowledge the teachers and students who took part in this project and greatly contributed to its success.

Financial support. This work is financially supported by National Funds through FCT – Fundação para a Ciência e a Tecnologia, I.P. under the projects UIDB/00081/2020 (CIQUP), LA/P/0056/2020 and UIDB/00194/2020 (CIDTFF).

Competing interests. None.

Ethical standards. Nothing to note.

References

Araújo, J., Morais, C., & Paiva, J. (2023). Citizen science in promoting chemical-environmental awareness of students in the context of marine pollution by (micro)plastics. *Revista Electrónica Educare*, *27*(1), 1–21. DOI: 10.15359/ree.27-1.15845.

Araújo, J.L., Morais, C., & Paiva, J.C. (2015). Poetry and alkali metal: Building bridges to study the atomic radius and the ionization energy. *Chemistry Education Research and Practice*, *16*(4), 893–900. DOI: 10.1039/C5RP00115C.

Araújo, J.L., Morais, C., & Paiva, J.C. (2021). Students' attitudes towards science: The contribution of a citizen science project for monitoring coastal water quality and (micro)plastics. *Journal of Baltic Science Education*, *20*(6), 881–893. DOI: 10.33225/jbse/21.20.881.

Araújo, J.L., Morais, C., & Paiva, J.C. (2022). Student participation in a coastal water quality citizen science project and its contribution to the conceptual and procedural learning of chemistry. *Chemistry Education Research and Practice*, *23*(1), 100–112. DOI: 10.1039/d1rp00190f.

Biber, K., Cankorur, H., Güler, R., & Demir, E. (2022). Investigation of environmental awareness and attitudes of children attending nature centred private kindergartens and public kindergartens. *Australian Journal of Environmental Education*, *39*(1), 1–13. DOI: 10.1017/aee.2022.1.

Bogner, F.X., & Wiseman, M. (1999). Toward measuring adolescent environmental perception. *European Psychologist*, *4*(3), 139–151. DOI: 10.1027/1016-9040.4.3.139.

Briggs, S.R., & Cheek, J.M. (1986). The role of factor analysis in the development and evaluation of personality scales. *Journal of Personality*, *54*(1), 106–148. DOI: 10.1111/j.1467-6494.1986.tb00391.x.

Clayton, S., Czellar, S., Nartova-Bochaver, S., Skibins, J.C., Salazar, G., Tseng, Y-C., . . . , & Monge-Rodriguez, F.S. (2021). Cross-cultural validation of a revised environmental identity scale. *Sustainability*, *13*(4), 2387. DOI: 10.3390/su13042387.

Coastwatch. (2022). Coastwatch - Portugal, Available at https://coastwatchnacional.wixsite.com/coastwatch-portugal.

Dunlap, R.E., & Van Liere, K.D. (1978). The 'new environmental paradigm': A proposed measuring instrument and preliminary results. *Journal of Environmental Education*, *9*(4), 10–19. DOI: 10.1080/00958964.1978.10801875.

European Commission (2014). *Special Eurobarometer 416 "Attitudes of European citizens towards the environment"*. Brussels.

Faize, F.A., & Akhtar, M. (2020). Addressing environmental knowledge and environmental attitude in undergraduate students through scientific argumentation. *Journal of Cleaner Production*, *252*, 119928. DOI: 10.1016/j.jclepro.2019.119928.

Field, A. (2009). *Discovering statistics using SPSS (3a ed.)*. London: SAGE Publications.

Gifford, R. (2014). Environmental psychology matters. *Annual Review of Psychology*, *65*(1), 541–579. DOI: 10.1146/annurev-psych-010213-115048.

Harlin, J., Kloetzer, L., Patton, D., Leonhard, C., & **Students** 2018). Turning students into citizen scientists. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel & A. Bonn (Eds.), *Citizen science: Innovation in open science, society and policy*. London: UCL Press.

Hartley, B.L., Pahl, S., Veiga, J., Vlachogianni, T., Vasconcelos, L., Maes, T., & Thompson, R.C. (2018). Exploring public views on marine litter in Europe: Perceived causes, consequences and pathways to change. *Marine Pollution Bulletin*, *133*, 945–955. DOI: 10.1016/j.marpolbul.2018.05.061.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., & Bonn, A. (2018). Innovation in open science, society and policy – setting the agenda for citizen science. In S. Hecker, M. Haklay, A. Bowser, Z. Makuch, J. Vogel & A. Bonn (Eds.), *Citizen science: Innovation in open science, society and policy*. London: UCL Press.

Kaiser (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31–36. DOI: 10.1007/BF02291575.

Kelemen-Finan, J., Scheuch, M., & Winter, S. (2018). Contributions from citizen science to science education: An examination of a biodiversity citizen science project with schools in central Europe. *International Journal of Science Education*, *40*(17), 2078–2098. DOI: 10.1080/09500693.2018.1520405.

Korkmaz, M., Fakir, H., & Alkan, H. (2018). Effects of nature training projects on environmental perception and attitudes. *Applied Ecology and Environmental Research*, *16*(1), 359–369. DOI: 10.15666/aeer/1601_359369.

Liu, W., & Chen, J. (2020). Modified Two Major Environmental Values scale for measuring Chinese children's environmental attitudes. *Environmental Education Research*, *26*(1), 130–147. DOI: 10.1080/13504622.2019.1697431.

Lucrezi, S., & Digun-Aweto, O. (2020). "Who wants to join?" Visitors' willingness to participate in beach litter clean-ups in Nigeria. *Marine Pollution Bulletin*, *155*, 111167. DOI: 10.1016/j.marpolbul.2020.111167.

Maloney, M.P., Ward, M.P., & Braucht, G.N. (1975). Psychology in action: A revised scale for the measurement of ecological attitudes and knowledge. *American Psychologist*, *30*(7), 787–790. DOI: 10.1037/h0084394.

Mercogliano, R., Anastasio, A., Avio, C.G., Regoli, F., Colavita, G., & Santonicola, S. (2020). Occurrence of microplastics in commercial seafood under the perspective of the human food chain. A review. *Journal of Agricultural and Food Chemistry*, *68*(19), 5296–5301. DOI: 10.1021/acs.jafc.0c01209.

Milfont, T.L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology*, *30*(1), 80–94. DOI: 10.1016/j.jenvp.2009.09.001.

Monroe, M.C., Andrews, E., & Biedenweg, K. (2008). A framework for environmental education strategies. *Applied Environmental Education & Communication*, *6*(3-4), 205–846 216. DOI: 10.1080/15330150801944416.

Morais, C., Ferreira, A.J., & Araújo, J.L. (2021). Qualitative polymer analysis lab through inquiry-based. *Educación Química*, *32*(1), 85. DOI: 10.22201/fq.18708404e.2021.1.75770.

Morais, C., Moreira, L., Teixeira, A., & Aguiar, T. (2022). No waves from surface knowledge: Diving into the social representations of the deep sea. *International Journal of Science Education, Part B*, *12*(1), 22–41. DOI: 10.1080/21548455.2021.2017507.

Paiva, J.C., Morais, C., & Moreira, L. (2017). Activities with parents on the computer: An ecological framework. *Education Technology & Society*, *20*(2), 1–14.

Paradinas, L.M., James, N.A., Quinn, B., Dale, A., & Narayanaswamy, B.E. (2021). A new collection tool-kit to sample microplastics from the marine environment (sediment, seawater, and biota) using citizen science. *Frontiers in Marine Science*, *8*, 657709. DOI: 10.3389/fmars.2021.657709.

Portuguese Association of Marine Litter. (2021). Por um mar sem lixo [For a sea without litter], Available at https://www.aplixomarinho.org/.

Prata, J.C., Costa, J.P., Lopes, I., Duarte, A.C., & Rocha-Santos, T. (2020). Environmental status of (micro)plastics contamination in Portugal. *Ecotoxicology and Environmental Safety*, *200*, 110753. DOI: 10.1016/j.ecoenv.2020.110753.

Setälä, O., Tirroniemi, J., & Lehtiniemi, M. (2022). Testing citizen science as a tool for monitoring surface water microplastics. *Environmental Monitoring and Assessment*, *194*(12), 851. DOI: 10.1007/s10661-022-10487-w.

Srbinovski, M.S. (2019). Environmental attitudes of Macedonian school students in the period 1995-2016. *Teaching Innovations*, *32*(4), 81–96. DOI: 10.5937/inovacije1904081S.

Srbinovski, M.S., & Stanišić, J. (2020). Environmental worldviews of Serbian and Macedonian school students. *Australian Journal of Environmental Education*, *36*(1), 20–43. DOI: 10.1017/aee.2020.1.

Tabachnik, B.G., & Fidell, L.S. (2006). *Using multivariate statistics*. 5th edition, Boston, MA: Pearson Education.

Teixeira, A. (2018). *Marine litter: Social representations and persuasion in science communication through infographics*. Porto: Dissertação de Mestrado, Universidade do Porto.

United Nations. (2022). United nations decade of ocean science for sustainable development, Available at https://www.oceandecade.org/.

Weigel, R., & Weigel, J. (1978). Environmental concern: The development of a measure. *Environment and Behavior*, *10*(1), 3–15. DOI: 10.1177/0013916578101001.

Zeegers, Y., Paige, K., Lloyd, D., & Roetman, P. (2012). 'Operation Magpie': Inspiring teachers' professional learning through environmental science. *Australian Journal of Environmental Education*, *28*(1), 27–41. DOI: 10.1017/aee.2012.4.

José Luís Araújo is an Assistant Professor in the Department of Education and Psychology at the University of Aveiro. He is also an integrated member of Research Group 2 – Science, Technology, and Innovation, and LEduC – Open Laboratory for Science Education at the Research Center on Didactics and Technology in the Education of Trainers (CIDTFF). His research focuses on chemistry and physics teaching and outreach, and on public engagement in scientific research, particularly through citizen science approaches.

Carla Morais is an Assistant Professor and member of the Science Education Unit at the Faculty of Science of the University of Porto. She is also a member of the Centre for Research in Chemistry at the University of Porto (CIQUP – RG5: Education, Science Communication and Society). Her areas of interest include professional development and pedagogic practices for Physics and Chemistry teachers; dissemination models and processes for scientific knowledge and the involvement and participation of citizens in Science; technological and digital ecologies in Science Education and Communication.

João Carlos Paiva is an Associate Professor in the Chemistry Department (Education), of the Faculty of Sciences of the University of Porto – PORTUGAL. He is the coordinator of the Education, Science Communication and Society area in the Centre for Research in Chemistry of the University of Porto (CIQUP). He has a particular interest in research on the subject of science-education-religion.

Cite this article: Araújo, J.L., Morais, C., & Paiva, J.C. (2023). Students' attitudes towards the environment and marine litter in the context of a coastal water quality educational citizen science project. *Australian Journal of Environmental Education* **39**, 522–535. https://doi.org/10.1017/aee.2023.14