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STUDENTS' ATTITUDES TOWARDS SCIENCE: THE CONTRIBUTION OF A CITIZEN SCIENCE PROJECT FOR MONITORING COASTAL WATER QUALITY AND (MICRO)PLASTICS

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Abstract. *The promotion of positive attitudes towards science is an important goal of science education. This research aimed to identify students' attitudes towards science and whether their participation within a citizen science project has contributed to positive attitudinal changes. So, an attitudinal scale was developed, validated, and applied (as a pre and post-test) to 574 students aged between 12 and 14 years old. Positive attitudes towards science were recorded from the outset among children of both groups. Students' participation within the experimental group enhanced relevant positive attitudinal changes at the level of the critical analysis dimension, related to the perception of skills development such as questioning or critical thinking. Furthermore, positive attitudinal changes were achieved within the affinity dimension, related to perceived self-efficacy and appreciation of science and science classes. Positive attitudinal changes towards science among students indicate that citizen science contributes to enhance affective and attitudinal domains of their scientific literacy.*

Keywords: *attitudes towards science scale, attitudinal changes, citizen science, science education, water quality monitoring*

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Introduction

Scientific literacy may be defined as 'the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen' (OECD, 2016, p. 28). 'A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific inquiry, and interpret data and evidence scientifically' (Oliver & Adkins, 2020, p. 2). Cavas et al., (2013) stated that 'scientific literacy is the collective abilities and skills to function as a responsible citizen in scientifically and technologically dominated society' (p. 384). For the same authors, scientific literacy definition considers not only the knowledge and understanding of science but also attitudes, values, and reasoning related to science and technology and their impact on society. Bybee and McCrae (2011) also referred that 'the orientation of PISA (Programme for International Student Assessment) includes both knowledge and attitudes as these contribute to students' competencies that are central to scientific literacy' (p. 8). To use science as an effective tool for decision-making, Cudaback (2008) pointed out that it is crucial to have positive attitudes about science. According to the National Research Council (1996), 'science literacy begins with attitudes and values established in the earliest years' (p. 18). These attitudes and values towards science will determine their future scientific literacy development (Xanthoudak, 2012). Thus, scientific literacy corresponds to a set of competences that are 'influenced both by knowledge of and about science, and by attitudes towards science' (OECD, 2016, p. 17). Science education occupies a central role in the promotion of scientific literacy, in general (Du & Wong, 2019; Millar & Osborne, 1998; NRC; 2012; OECD, 2016, 2019; Pereira et al., 2020; Tang & Zhang, 2020) and its attitudinal dimension, in particular (Oliver & Adkins, 2020; Osborne et al., 2003; Snow & Dibner, 2015; Tee & Subramaniam, 2018;). However, most studies regarding scientific literacy assessment of young people still focus on determining 'some degree of complex knowledge of one or more specific science field/disciplines and most measures do not include assessment of attitudes towards science' (Fives et al., 2014, p. 551) although recent programmes on

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young people's scientific literacy assessment already include, a more systematic approach, of attitudes towards science as one assessed domain of scientific literacy (Altun & Kalkan, 2019; OECD, 2016; Siarova et al., 2019).

Attitudes Towards Science

The attitude concept is one of the fundamental concepts in social psychology and educational sciences (Dalgety et al., 2003). Despite the wide range of definitions that have emerged for this concept as a result of the research developed in this area over the last few decades 'all of them agree that an attitude is the tendency to think, feel, or act positively or negatively towards objects in our environment' (Salta & Tzougraki, 2004, p. 535). More specifically, as suggested by Lu et al. (2016), attitude may be defined as a characteristic of human beings expressing 'the feelings, beliefs, and values held about an object, which in terms of science may include enthusiasm about science, perceptions of school science, and contributions of science to society or of scientists themselves' (p. 2177). Cavas et. al (2013) referred that the cognitive component of an individual's attitudes towards science consists of the individual knowledge (understanding of basic scientific concepts and processes of science) and beliefs (that result in making evaluative judgments such as favourable or unfavourable, good or bad, desirable or undesirable, towards science). Moreover, the emotional component of attitudes towards science refers to science-related feelings (pleasing or displeasing, liked or disliked). There is also a behavioural component of attitudes towards science, associated with what individuals do or not do, their support to scientific endeavours, or their interests in pursuing a scientific career.

Science educators agree that the promotion of positive attitudes towards science is an important goal of science education (Tee & Subramaniam, 2018; Tee et al., 2020; Wang & Berlin, 2010) and 'high-level achievement on science education and positive attitudes towards science constitutes a crucial challenge for formal education' (Vilia et al., 2017, p. 1). In this regard, several studies reveal that students' attitudes towards science are considered positive, and there is a positive association between students' attitudes and their performance in science subjects (Brown et al., 2015; Heng & Karpudewan, 2015; Kubiatko et al., 2017; Musengimana et al., 2021; Sjøberg & Schreiner, 2010). However, according to the results of the TIMSS programme (2021), students aged 13-14 years (grade 8) presented more negative attitudes compared to younger students (10 years, grade 4). Similarly, several authors (Smith et al., 2020; Tee et al., 2020; Wang & Berlin, 2010; Wan & Lee, 2017) have pointed a decline in students' attitudes towards science that occurs more significantly towards the end of primary school. These findings suggest, thus, that during middle school – Key Stage 3 (KS3) aged 12–14 in Portuguese schools, initiatives that promote more positive attitudes towards science should be implemented to reverse this trend (Araújo & Taveira, 2009; Oliveira et al. 2017). The PVC educational citizen science project was developed to promote positive attitudes towards science among the students involved.

The PVC Citizen Science Project

Citizen science is an approach that promotes citizens' involvement in different stages of the scientific production process, for example, by conducting experiments or observations, collecting, analysing, and discussing data, and disseminating research findings (Bastos et al., 2019; Bonney et al., 2015; Cavalier, 2016). According to Tulloch et al. (2013), citizen science has great potential to foster knowledge and attitudes, and skills development. It is considered rather relevant for formal education since citizen science enables to bridge the gap between scientific content and the relevant and socially meaningful contexts in which citizen science projects are embedded (Ferreira et al., 2012; Harlin et al., 2018; Lukyanenko et al., 2020; Wiggins & Crowston, 2011; Wiggins et al., 2018).

Recently, an effort has been observed by the scientific community to develop citizen science projects with a strengthening educational component, evidencing an increasing involvement of schools and school's community, as described by Follett and Strezov (2015) in their systematic review of citizen science projects. Regarding the impact of engaging students in citizen science projects, the literature finds that their involvement is extensiveyet difficult to assess and widely differentiated (Harlin et al., 2018). Notably, publications resulting from these projects' assessments do not highlight their potential in terms of students' attitudes (i. e. Savage & Jude, 2014; Scheuch et al., 2018; Sullivan et al., 2014; et al., Wilken, 2018). The citizen science project PVC – *Perceiving the Value of Chemistry (behind water and microplastics)* emerged within this context. The project consisted in monitoring coastal waters and marine litter quality in the North Coastal region of Portugal, thus explaining the role of Chemistry in society and its contribution to mitigate environmental issues. Considering the guidelines of the United Nations Agenda 2030 for Sustainable Development (United Nations, 2021a) and the United Nations Decade of Ocean Science for

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Sustainable Development (United Nations, 2021b), as well as the social and scientific relevance of the subject (Li et al., 2020; Mercogliano et al., 2020; Uddin et al., 2020; Wang et al., 2019; Wang et al., 2020; Zhang & Chen, 2020), it was considered consistent that marine litter and coastal water quality context, specifically water contamination by plastics and microplastics, would be explored within the PVC project (Araújo et al., 2020a). The PVC project actively engaged students in four main stages:

> *1) online tasks such as guided searches, video visualization, interpretation, and creation of posters and infographics to raise awareness to marine litter, especially to the presence of (micro)plastics in coastal waters and its consequences; simultaneously, it was intended to highlight the importance of chemistry and its preventive role in combating these environmental scourges; 2) sampling of coastal waters and beach plastics; 3) performance of waters' physicochemical analysis and (micro) plastics' identification to promote the learning of chemistry curricular contents underlying the project; and 4) project dissemination to mobilize acquired knowledge and to develop communication skills (Araújo et al., 2020b, p. 1063).*

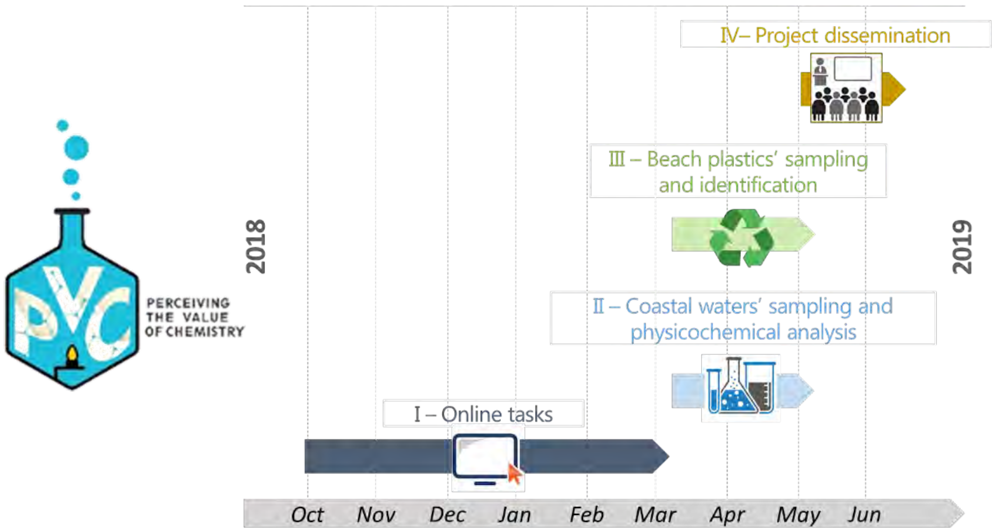
Thus, since the potential of educational citizen science projects regarding students' attitudes towards science is not systematically exploited in literature, this research aimed to identify attitudes towards science that students presented before their involvement within the PVC citizen science project and whether their participation in this project contributed to promote positive changes in their attitudes.

Research Methodology

The different tasks of the PVC project in which students were engaged were implemented at different moments across the school year 2018/2019, as Figure 1 shows.

Attending to the aim of this paper, i.e., to know the attitudes towards science of middle school students as well as how their participation in the educational citizen science project promoted attitudinal changes of the participating students, a quasi-experimental methodological design was conducted through the development, validation, and application of an attitudinal scale applied to control and experimental class groups which were randomly assigned. Data on students' attitudes were collected through the application of a questionnaire as a pre- and a post-test. The pre-test was applied at the beginning of the school year before the students' involvement in the PVC project tasks. Then, after completing students' participation in the project, the post- test was applied. The questionnaire average response time was approximately 10 minutes.

Figure 1
Phases and Chronogram of the PVC Project Implementation (Araújo et al., 2021).



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Participants

The PVC project involved 574 students from 26 chemistry classes of three school levels of the middle school –Key Stage 3 (KS3) aged 12–14 in Portuguese schools - 7th, 8th and 9th grades. From this sample, 442 students (208 boys and 234 girls) were part of the experimental group (EG), and 132 (65 boys and 67 girls) were part of the control group (CG). Students had an average age of 12, 13, and 14 years, respectively. The 26 chemistry classes were involved within the PVC project because they were taught by nine teachers who willingly accepted the invitation to collaborate in this research by monitoring their students' participation in the PVC project and being responsible for assisting data collection instruments application.

All parties involved participated in this research voluntarily. Students, teachers, and parents signed an informed consent regarding their participation in the study, which described the activities in which they would be involved, provided consent for their participation in the research, and ensured that all personal data would be treated anonymously and confidentially.

Procedures

Attitudes Towards Science Scale Design

Following an intensive literature review focused on the tools to assess students' attitudes towards science, a scale of attitudes towards science was developed, including some items present in the tools developed by Schreiner and Sjøberg (2004), Glynn and Koballa (2006) and Abd-El-Khalick et al. (2015), and others authorship (as Table 1 shows), that could be applied and validated for the participants age range within the PVC project (Portuguese students attending middle school –Key Stage 3 (KS3) aged 12–14 years old) and which, simultaneously, was consistent with the objectives proposed for this project. Items from the literature (in English) were subject to a translation into Portuguese and, subsequently, to a back-translation, again into English, to ensure that the meaning was preserved despite the translation. The phrasing of the items was assessed for readability, ambiguity, and abstraction (Angleitner et al., 1986).

For content validation purposes, the attitudes towards science scale was first answered, by a student of each school year of the middle school –Key Stage 3 (KS3) aged 12–14, to guarantee that all statements presented were intelligible and understandable. The attitudes scale was analysed by two teachers specialized in Science Education.

The attitudes towards science questionnaire consists of 16 statements in which students expressed their level of agreement with each statement using a 7-point Likert-type scale (1 = Strongly disagree; 2 = Disagree; 3 = Partly disagree; 4 = Neither agree nor disagree; 5 = Partially agree; 6 = Agree; 7 = Strongly agree). Additionally, students were asked a set of questions aimed at collecting socio-demographic information such as gender, school year, and school attended. The attitudes questionnaire was anonymised and encoded to allow student answers to be compared across different moments of this instrument application.

Data Collection

A printed version of the questionnaire was answered by students participating in the PVC project, as a pre-test, before the PVC project implementation, at the beginning of the 2018/2019 school year (from September to October 2018). After the PVC project conclusion at the end of that same school year (from May to June 2019), a printed version of the same questionnaire was also answered, by all participating students, as a post-test. The collection of these data was conducted during a Chemistry class, and teachers of each class were in charge of it.

Data Analysis

Data collected through attitudes towards science questionnaire application were submitted to descriptive statistics procedures (means and standard deviation) and inferential statistical procedures such as factorial analysis, and reliability analysis (Cronbach's alpha) conducted by the IBM SPSS Statistics software (Version 25).

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Research Results

An exploratory factor analysis was conducted in order to determine factors analysis present in the attitudes questionnaire. Thus, students' answers to attitudes towards science questionnaire, applied as a pre-test, were submitted to a principal component analysis (PCA) with a Varimax rotation from which three factors extracted that would explain 63.4% of variance (higher than the desirable minimum of 60%) (Costello & Osborne, 2005; Tabachnik & Fidell, 2006). The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) test was marvellous (KMO = .94) (Kaiser, 1974), and the Bartlett's Test of Sphericity was statistically significant ($\chi2$ (120) = 8328.98 $p < .001$), allowing to conclude that the variables are sufficiently correlated among themselves to conduct a PCA. Table 1 presents the items of the correlation matrix with saturation values greater than 0.50 (Field et al., 2012) organized by factor.

Following this, results emerging from the principal components analysis were interpreted, defining the dimensions underlying each of the factors:

(1) *Future* - dimension related to future trajectories choices related to science and technology and family influence on those choices (items 1-5);
(2) *Critical analysis* - dimension related to the perception of skills development such as questioning, curiosity, and critical thinking (items 6-10);
(3) *Affinity* - dimension related to the perception of self-efficacy and science appreciation as well as science lessons (items 11-16).

Table 1
Principal Component Analysis with Varimax Rotation of Attitudes Towards Science Scale

Items	Factor		
	1	2	**3**
1. [a]I would like to have a science-related job.	.81		
2. [a]My family supports me to follow a science-related job.	.80		
3. [a]I will carry on studying science when I finish school.	.73		
4. [b]I think that learning science can help my professional career.	.70		
5. [a]My family supports my interest in science.	.67		
6. [d]Science lessons make me wonder about the world around us.		.80	
7. [c] Science lessons have increased my curiosity about things we cannot fully explain yet.		.78	
8. [d] Science lessons motivate me to explore the causes of everyday events.		.72	
9. [d]Science lessons have taught me to critically analyse results achieved within laboratory activities.		.63	
10. [d]Science lessons help me to develop my critical thinking.		.51	
11. [a] Science is easy for me.			.77
12. [a]I am quite confident that I am able to understand science			.72
13. [b]I try hard enough to learn science.			.63
14. [b]I enjoy learning science.			.62
15. [c]I prefer science to other subjects.			.57
16. [a]If I was given a choice, I would take more science lessons at school.			.54

Note: Adapted items from: [a]Abd-El-Khalick et al. (2015), [b]Glynn e Koballa (2006) e [c]Schreiner e Sjøberg (2004) and items of authorship[d].

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Additionally, it was conducted an internal consistency analysis. The reliability analysis (Cronbach's alpha) reveals good values for the internal consistency regarding the following dimensions *1. Future* (0.869), *2. Critical analysis* (0.821) e *3. Affinity* (0.862). Cronbach's alpha value is higher than 0.80 for all dimensions, thus the scale's reliability is high. The item-total correlations are always positive and with minimum values higher than 0.5 for all situations. Yet, there is an adequate internal consistency of the dimensions of this attitudinal scale (Briggs & Cheek, 1986).

Within a global perspective, PCA results reveal that before students participate in the PVC project, they present more positive attitudes towards dimension *2. Critical* analysis, followed by dimension *3. Affinity* and, with lower values, regarding dimension *1. Future*. However, all dimensions have a mean value higher regarding the intermediary point (4) of the measurement scale (Table 2).

Table 2
Descriptive Analysis of Attitudes Towards Science Scale Dimensions: Pre-test

Dimensions	*N*	*M*	*SD*
1. Future	574	4.21	1.50
2. Critical analysis	574	5.08	1.10
3. Affinity	574	4.64	1.13

Note: The reported values refer to the measurement scale from 1 to 7.

To further understand how the PVC project contributed to students' attitudinal changes, questionnaire application results as a pre-test was compared with the results achieved in post-test for both groups.

Results Comparison Between Experimental Group and Control Group

Considering small mean differences were found in each dimension of the scale for each of the groups (see Tables 3 and 5), it may be considered that the CG and EG were equivalent in terms of their attitudes towards science. Thus, in order to compare students' attitudes integrating the EG from the pre-test to the post-test, for each dimension, Table 3 presents the mean values students answers and the respective standard deviation in both scale application moments. Consequently, pre-test and post-test EG results were subjected to a t-test for paired samples, as Table 4 shows, whereby it is concluded that the mean value of dimension 2. *critical analysis* significantly increases from pre-test to post-test (pre-test: $M = 5.17$, $SD = 1.06$; post-test: $M = 5.28$, $SD = 1.03$; $t_{441} = 1.969$, $p = .048$), while dimensions *1. Future* (pre-test: $M = 4.30$, $SD = 1.47$; post-test: $M = 4.41$, $SD = 1.47$; $t_{441} = 1.855$, $p = .065$) e *3. Affinity* (pre-test: $M = 4.66$, $SD = 1.10$; post-test: $M = 4.74$, $SD = 1.16$; $t_{441} = 1.573$, $p = .117$), despite higher mean scores in the post-test, there is no significantly variance between these two moments of the application.

Table 3
Mean Values Presentation of Attitudes Towards Science Scale Dimensions, as Pre-test and Post-test in the EG

Dimension		*N*	*M*	*SD*
1. Future	Pre-test	442	4.30	1.47
	Post-test	442	4.41	1.47
2. Critical analysis	Pre-test	442	5.17	1.06
	Post-test	442	5.28	1.03
3. Affinity	Pre-test	442	4.66	1.10
	Post-test	442	4.74	1.16

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Table 4
Compared Attitudes Towards Science Scale Dimensions, as Pre-test and Post-test in the EG

(Post-test – Pre-test)	*ΔM*	*SD*	*CI 95%*		*t*	*p*
			LL	UL		
1. Future	.114	1.126	-.007	.234	1.855	.065
2. Critical analysis	.105	1.092	-.012	.222	1.969	.048
3. Affinity	.082	.951	-.020	.183	1.573	.117

Note: CI– Confidence interval 95% (Field, 2009) LL–Lower limit UL–Upper limit

Similar procedures were applied to compare CG students' attitudes from the pre-test to the post-test, for each of the scale dimensions. Yet, Table 5 presents the mean values of these students answers and the respective standard deviation in these two scale application moments. Likewise, the t-test application for paired samples (Table 6), we conclude that the dimension 2. *Critical analysis* mean of CG has decreased significantly (t_{131} = -3.425, p < .001) from pre-test (M = 4.87, SD = 1.13) for post-test (M = 4.49, SD = 1.24) and dimension 1. *Future* (pre-test: M = 4.12, SD = 1.59; post-test: M = 4.26, SD = 1.53; t_{131} = 1.235, p = .219) and dimension *3. Affinity* (pre-test: M = 4.59, SD = 1.19; post-test: M = 4.52, SD = 1.17; t_{131} = -.801, p = .425) were not significantly different between these two data collection moments.

Table 5
Mean Values Presentation of Attitudes Towards Science Scale Dimensions, as Pre-test and Post-test in the CG

Dimension		*N*	*M*	*SD*
1. Future	Pre-test	132	4.12	1.59
	Post-test	132	4.26	1.53
2. Critical analysis	Pre-test	132	4.87	1.13
	Post-test	132	4.49	1.24
3. Affinity	Pre-test	132	4.59	1.19
	Post-test	132	4.52	1.17

Table 6
Compared Attitudes Towards Science Scale Dimensions as Pre-test and Post-test in the CG

(Post-test – Pre-test)	*ΔM*	*SD*	*CI 95%*		*t*	*p*
			LL	UL		
1. Future	.137	1.159	-.083	.357	1.235	.219
2. Critical analysis	-.381	1.162	-.602	-.161	-3.425	<.001
3. Affinity	-.074	.959	-.256	.109	-.801	.425

Note: CI– Confidence interval 95% (Field, 2009) LL–Lower limit UL–Upper limit

Furthermore, to determine whether differences among the groups identified within variations between the pre-test and the post-test were significant, the results of attitudes towards science scale were subjected to an ANOVA analysis. Hence, Table 7 systematises the results of Tables 4 and 6, as well as the results of the statistical test conducted. From the analysis of Table 7, it is possible to conclude that the variation within dimension 1. *Future* is higher for the CG (ΔM = .137, SD = 1.16) compared to the EG (ΔM = .114, SD = 1.13), yet differences are not significant ($F_{1,442}$ = .035, p = .852). Whereas the variation from pre-test to post-test regarding dimension *2. Critical analysis* is higher for the EG (ΔM = .105, SD = 1.09) compared to the CG (ΔM = -.381, SD =1.16), differences are sig-

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nificant ($F_{1,442}$ = 15.833, p < .001). Finally, regarding dimension 3 variation *Affinity* is higher for the EG (ΔM = .082, SD = .95) compared to the CG (ΔM = -.074, SD = .96), increasing in addition in EG and decreasing in CG, however, no significant differences were found ($F_{1,442}$ = 2.179, p = .141). Accordingly, we observed that, from the pre-test to the post-test, the mean of dimension 1. *Future* increased for both groups, with this variation being slightly higher in the CG. Regarding to dimension 2. *Critical analysis* and 3. *Affinity*, a mean increase was observed of these dimensions from the pre-test to the post-test within the EG while the CG there was a decrease.

Table 7

Compared Variation Among Attitudes Towards Science Scale Dimensions, as Pre-test and Post-test in the CG and EG

Dimension		*N*	***ΔM***	*SD*	*F*	*p*
1. Future	CG	132	.137	1.16	.035	.852
	EG	442	.114	1.13		
2. Critical analysis	CG	132	-.381	1.16	15.833	<.001
	EG	442	.105	1.09		
3. Affinity	CG	132	-.074	.96	2.179	.141
	EG	442	.082	.95		

Gender Effect on Pre-Test and Post-Test Variance for CG and EG

Considering gender variable effect on attitudes changes that were observed from pre-test to post-test (Table 8), it is noted that for CG students the change in dimension *1. Future* is positive for boys (ΔM = .309, SD = 1.15) and negative for girls (ΔM = -.032, SD = 1.16) while within EG, boys revealed higher positive attitudes changes (ΔM = .135, SD = 1.26) comparing to girls (ΔM = .097, DP = 1.01). Regarding dimension 2. *Critical analysis*, within CG the mean answers have decreased less among boys compared to girls (males: ΔM = -.313, SD = 1.05; females: ΔM = -.448, SD = 1.27). Furthermore, it is observed in this dimension, within EG, girls reveal more positive changes (females: ΔM = .180, SD = 1.06; males: ΔM = .011, SD = 1.13). Concerning the last dimension of this scale *3. Affinity*, it is observed within CG that boys' attitudes decreased less from pre-test to post-test, compared to girls' attitudes (males: ΔM = -.040, SD = .90; females: ΔM = -.107, SD = 1.02). By contrast, within EG, girls exhibit further positive attitudes compared to boys (males: ΔM = .059, SD = 1.00; females: ΔM = .099, SD = .91).

Table 8

Relation Among Variation Attitudes Towards Science Scale Dimensions, as Pre-test and Post-test, and Gender

Dimension	Gender	Experimental group			Control Group		
		N	***ΔM***	*SD*	*N*	***ΔM***	*SD*
1. Future	Male	214	.135	1.26	67	.309	1.15
	Female	228	.097	1.01	65	-.032	1.16
2. Critical analysis	Male	214	.011	1.13	67	-.313	1.05
	Female	228	.180	1.06	65	-.448	1.27
3. Affinity	Male	214	.059	1.00	67	-.040	.90
	Female	228	.099	.91	55	-.107	1.02

Thus, given the attitudes variance identified for gender in each group, an ANOVA analysis was conducted to determine whether students' attitudes changes within groups differ according to gender. Considering statistical test results (*1. Future*: $F_{1,442}$ = 1.468, p = .226; *2. Critical analysis:* $F_{1,442}$ = 1.548, p = .214; *3. Affinity:* $F_{1,442}$ = .256, p = .613) it is observed that gender is not a distinctive variable within student's attitudes changes regarding the three dimensions analysed among attitudes towards science scale.

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Discussion

Although students frequently present positive attitudes towards science (Cudaback, 2008, Sjøberg & Schreiner, 2010; Tee & Subramaniam, 2018; Wang & Berlin, 2010), literature (NRC, 1996; TIMSS, 2021; Wang & Berlin, 2010; Xanthoudak, 2012;) also reveals that students from the late years of middle school –Key Stage 3 (KS3) aged between 13 and 14 years (grade 8) present more negative attitudes when compared to younger students (10 years, grade 4). As citizen science projects, such as the PVC project, explore current and relevant subjects for the community and promote active students' involvement in science, these projects have the potential to promote more positive attitudes towards science in students (Bonney et al., 2009; Hecker et al., 2018; Strasser et al., 2019). Accordingly, it has been considered relevant to assess the PVC project contribution to fostering positive attitudes towards science among 12 to 14 years old students attending middle school –Key Stage 3 (KS3), through the attitudes towards science scale development and application as a pre-test and post-test questionnaire. Results reveal that EG and CG students presented positive attitudes towards the three scale dimensions before the PVC project implementation:: *1. Future*, *2. Critical analysis* e *3. Affinity*. For both groups, the dimension 2. *Critical analysis* achieved the highest mean, whereas the dimension *1. Future* presented the lower mean. Moreover, results from the post-test also indicate that, for both groups, the mean of the three dimensions remained positive.

Regarding the differences identified, it is possible to conclude that within EG, there were positive changes concerning students' attitudes towards the three dimensions. This change is significantly positive only regarding dimension *2. Critical analysis*. Within CG as dimensions *2.* and *3. Affinity* revealed further negative results in post-test and the mean of dimension *1. Future* has slightly increased. Just for the dimension *2. Critical analysis* significant changes in students' attitudes were found from pre-test to post-test. These findings indicate a positive attitudinal change of the activities developed throughout the PVC project. For example, stage 1 online tasks of the project and science dissemination events led by the students in stage 4 of the project, have been valuable in fostering students' affinity with science, but also in developing skills such as curiosity, once these events were more creative and awareness-raising nature on issues related to ocean sustainability, namely marine litter, and the role of science in combating this problem. On the other hand, stages 2 and 3 with its focus on laboratory work were important for the development of essential scientific skills such as questioning and critical thinking. These stages, as occurred more in a formal teaching context, have also been of value in developing children's interest in science lessons. Additionally, as in both groups there was a positive and similar trend regarding dimension 1. *Future*, it is possible to infer that there was no predominant influence of the PVC project regarding an intent to follow future science-related trajectories. Moreover, when comparing both groups' findings, it is also implied that the PVC project positively impacted *Affinity* within EG students towards science and scientific subjects (as presented, for example, items '14. I enjoy learning science' and '16. If I were given a choice, I would take more science lessons at school' from dimension 2. *Affinity* and the development of scientific attitudes such as questioning, curiosity and critical thinking (as illustrated, for example, by items '6. Science lessons make me wonder about the world around us' and '7. Science lessons have increased my curiosity about things we cannot fully explain yet' or '10. Science lessons help me to develop my critical thinking').

Regarding gender influence on attitudes towards science, several authors (Fulmer et al., 2019; Hacieminoglu, 2016; Sjøberg & Schreiner, 2010 et al.) note that this is a differentiating variable. According to Sjøberg and Schreiner (2010), 'there is a growing gender difference, with girls, being more negative (or sceptical, ambivalent) [towards science] than boys' (p. 7), this is considered one of the underlying factors, that account for example, 'the low proportion of girls who choose studies and occupations in SMT [Science-Mathematics-Technology]' (p. 30). Based on our analysis we observed that, in both groups, boys are who effectively present more favourable changes regarding attitudes about the dimension *1. Future* (as illustrated, for example, by items '1. I would like to have a science-related job' and '4. I think that learning science can help my professional career'). Within CG it is observed that the other two scale dimensions, boys and girls presented less positive attitudes from the pre-test to post-test, noting a decrease in the mean of the boys' answers lower than the girls' for these two dimensions, in line with the conclusions of Sjøberg e Schreiner (2010).

Although, within EG, it was noted that, from the pre-test to the post-test, there were positive students' attitudes changes from both genders. Thus, and considering EG students' attitudes towards dimensions *2. Critical analysis* and *3. Affinity* that is considered more positive in post-test compared with pre-test (as opposed to the CG) it is concluded that the PVC project contributes to promote greater affinity and raises scientific attitudes scientific attitudes in male and female students. And, unlike literature statement (Sjøberg & Schreiner, 2010), within these

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dimensions, female students' change attitudes revealed more positive, suggesting that girls' affective dimension towards science may be more enhanced by student-centred pedagogical experiences, as observed within the PVC project. However, although no significant changes were observed of girls' attitudes compared to boys, findings indicate that kids 'involvement within the PVC citizen science project promotes a more positive attitude towards science among children in general and girls in particular.

Conclusions

This research allowed to observe that both student group attitudes towards science were positive at the beginning of the school year and, in the post-test, there was a positive change of EG students regarding all analysed dimensions, with significant changes regarding dimension 2. *Critical analysis*. On the other hand, CG students also revealed higher positive attitudes towards dimension 1. *Future*, yet, in the post-test, their attitudes towards dimension 2. *Critical analysis* and 3. *Affinity* revealed more negative attitudes than those presented in the pre-test.

A more detailed analysis regarding attitudes towards science questionnaire results concludes that the attitude changes among groups were not differentiated according to participants' gender although indicators emerged from the findings' analysis indicate that, for the CG, boys presented more favourable (or less unfavourable) attitudes changes than girls. In both groups, as suggested by literature, it could be verified that boys are the ones who present the highest positive changes in attitudes towards dimension 1. *Future*, thus expressing higher expectations of pursuing professional careers in scientific and technological areas. Regarding the EG, as opposed to what was observed in CG, girls' attitudes changes were more positive in dimensions *2. Critical analysis* and 3. *Affinity,* which suggests that the participation experience within the citizen science PVC education project promoted higher positive attitudes towards science in both genders, yet opposes the trend reported in literature that girls present less positive attitudes.

Summarising, students' involvement in educational citizen science projects, particularly if held in contexts of current and relevant events for participants as the PVC project promotes positive changes in attitudes towards science. Thus, developing the affective dimension of scientific literacy often neglected in science teaching practices, although, along with the cognitive dimension, essential for students to become scientifically literate.

By developing and implementing the PVC project, it was intended to assess its impact within affective dimension level regarding scientific literacy of students involved in this educational experience. As follows, beyond findings regarding students' attitudes towards science presented here in the short term, it was also intended to present findings regarding students' attitudes/attitudes students' changes, specifically, towards Chemistry subject, in which this project was implemented, and the context addressed of environmental issues and marine litter.

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Declaration of Interest

Authors declare no competing interest.

References

Abd-El-Khalick, F., Summers, R., Said, Z., Wang, S., & Culbertson, M. (2015). Development and large-scale validation of an instrument to assess arabic-speaking students' attitudes towards science. *International Journal of Science Education, 37*(16), 2637-2663. https://doi.org/10.1080/09500693.2015.1098789

Altun, A., & Kalkan, O. K. (2019). Cross-national study on students and school factors affecting science literacy. *Educational Studies*, *47*(4), 403-421. https://doi.org/10.1080/03055698.2019.1702511

Angleitner, A., John, O. P., & Löhr, F-J. (1986). It's what you ask and how you ask it: An itemmetric analysis of personality questionnaires. In: A. Angleitner, & J. S. Wiggins (Eds), *Personality assessment via questionnaires*. Springer.

Araújo, A. M., & do Céu Taveira, M. (2009). Study of career development in children from a developmental-contextual perspective. *European Journal of Education and Psychology, 2*(1), 49-67. https://doi.org/10.30552/ejep.v2i1.19

https://doi.org/10.33225/jbse/21.20.881

Araújo, J. L., Morais, C., & Paiva, J. C. (2020a). Developing and implementing a low-cost, portable pedagogical *kit* to foster students' water quality awareness and engagement by sampling coastal waters and analyzing physicochemical properties. *Journal of Chemical Education, 97*(10), 3697–3701. https://doi.org/10.1021/acs.jchemed.0c00333

Araújo, J. L., Morais, C., & Paiva, J. C. (2020b). PVC project: Teaching Chemistry through marine litter context. In L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *ICERI2020 Proceedings – 13th Annual International Conference of Education, Research and Innovation* (pp. 1063-1072). Seville: International Association of Technology, Education and Development (IATED).

Araújo, J. L., Morais, C., & Paiva, J. C. (2021). 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.* Advance Article. http://dx.doi.org/10.1039/D1RP00190F

Bastos, A., Simeone, M., & Wilkinson, C. (2019). The potential opportunities and limitations of Public Engagement in Science and Technology. *INTERIN, 24*, 173-186. https://doi.org/10.35168/1980-5276.UTP.interin.2019.Vol24.N2.pp173-186

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., & Wilderman, C. C. (2009). *Public participation in scientific research: Defining the field and assessing its potential for informal science education. A CAISE inquiry group report.* Center for Advancement of Informal Science Education (CAISE).

Bonney, R., Phillips, T. B., Ballard, H. L., & Enck, J. W. (2015). Can citizen science enhance public understanding of science? *Public Understanding of Science, 25*(1), 2-16. https://doi.org/10.1177/0963662515607406

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. https://doi.org/10.1111/j.1467-6494.1986.tb00391.x

Brown, S. J., White, S., Sharma, B., Wakeling, L., Naiker, M., Chandra, S., Gopalan, R., & Bilimoria, V. (2015). Attitude to the study of chemistry and its relationship with achievement in an introductory undergraduate course. *Journal of the Scholarship of Teaching and Learning, 15*(2), 33-41. https://doi.org/10.14434/josotl.v15i2.13283

Bybee, R., & McCrae, B. (2011). Scientific literacy and student attitudes: Perspectives from PISA 2006 science. *International Journal of Science Education, 33*(1), 7-26. https://doi.org/10.1080/09500693.2010.518644

Cavalier, D. (2016). Preface. In D. Cavalier, & E. B. Kennedy (Eds.), *The rightful place of science: Citizen science*. Consortium for Science, Policy & Outcomes.

Cavas, P. H., Ozdem, Y., Cavas, B., Cakiroglu, J., & Ertepinar, H. (2013). Turkish pre-service elementary science teachers' scientific literacy level and attitudes towards science. *Science Education International, 24*(4), 383-401. https://files.eric.ed.gov/fulltext/EJ1022326.pdf

Costello, A., & Osborne, J. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. Practical Assessment. *Research & Evaluation, 10*(7), 1-9. https://doi.org/10.7275/jyj1-4868

Cudaback, C. (2008). Commentary: Ocean literacy – There's more to it than content. *Oceanography 21*(4), 10-11. https://doi.org/10.5670/oceanog.2008.21

Dalgety, J., Coll, R. K., & Jones, A. (2003). Development of Chemistry attitudes and experiences questionnaire (CAEQ). *Journal of Research in Science Teaching, 40*(7), 649–668. https://doi.org/10.1002/tea.10103

Du, X., & Wong, B. (2019). Science career aspiration and science capital in China and UK: A comparative study using PISA data. *International Journal of Science Education, 41*(15), 2136-2155. https://doi.org/10.1080/09500693.2019.1662135

Ferreira, M. A., Soares, L., & Andrade, F. (2012). Educating citizens about their coastal environments: Beach profiling in the Coastwatch project. *Journal of Coastal Conservation, 16*(4), 567-574.

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

Field, A. P., Miles, J., & Field, Z. (2012). *Discovering statistics using R*. SAGE Publications.

Fives, H., Huebner, W., Birnbaum, A. S., & Nicolich, M. (2014). Developing a measure of scientific literacy for middle school students. *Science Education, 98*(4), 549-580. https://doi.org/10.1002/sce.21115

Follett, R., & Strezov, V. (2015). An analysis of citizen science based research: Usage and publication patterns. *PLOS ONE, 10*(11), Article e0143687. https://doi.org/10.1371/journal.pone.0143687

Fulmer, G.W., Ma, H., & Liang, L.L. (2019). Middle school student attitudes towards science, and their relationships with instructional practices: A survey of Chinese students' preferred versus actual instruction. *Asia-Pacific Science Education 5*(9), 1-21. https://doi.org/10.1186/s41029-019-0037-8

Glynn, S. M., & Koballa, T. R., (2006). Motivation to learn college science. In J. J. Mintzes & W. H. Leonard (Eds.), *Handbook of college science teaching*. National Science Teachers Association Press.

Hacieminoglu, E. (2016). Elementary school students' attitude towards science and related variables. *International Journal of Environmental and Science Education, 11*(2), 35-52. https://doi.org/10.12973/ijese.2016.288a

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*. UCL Press.

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*. UCL Press.

Heng, C. K., & Karpudewan, M. (2015). The interaction effects of gender and grade level on secondary school students' attitude towards learning chemistry. *Eurasia Journal of Mathematics, Science & Technology Education*, *11*(4), 889-898. https://doi.org/10.12973/eurasia.2015.1446a

Kaiser (1974). An index of factorial simplicity. *Psychometrika, 39*, 31-36.

Kubiatko, M., Balatova, K., Fancovicova, J., & Prokop, P. (2017). Pupils' attitudes towards Chemistry in two types of Czech schools. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(6), 2539-2552. https://doi.org/10.12973/eurasia.2017.01239a

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Li, C., Busquets, R., & Campos, L. C. (2020). Assessment of microplastics in freshwater systems: A review. *Science of the Total Environment, 707*, 135578. https://doi.org/10.1016/j.scitotenv.2019.135578

Lu, Y-Y, Chen, H-T., Hong, Z-R., & Yore, L. D. (2016). Students' awareness of science teachers' leadership, attitudes towards science, and positive thinking. *International Journal of Science Education, 38*(13), 2174-2196. https://doi.org/10.1080/09500693.2016.1230792

Lukyanenko, R., Wiggins, A., & Rosser, H. K. (2020). Citizen science: An information quality research frontier. *Information Systems Frontiers, 22*, 961-983. https://doi.org/10.1007/s10796-019-09915-z

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. https://doi.org/10.1021/acs.jafc.0c01209

Millar, R., & Osborne, J. (1998). *Beyond 2000: science education for the future, a report with ten recommendations*. King's College London, School of Education.

Musengimana, J., Kampire, E., & Ntawiha, P. (2021). Factors affecting secondary schools students' attitudes towards learning chemistry: A review of literature. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(1), Article em1931. https://doi.org/10.29333/ejmste/9379

NRC, National Research Council (1996). *National Science Education Standards.* National Academy Press.

NRC, National Research Council (2012) *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press.

OECD (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*. PISA, OECD Publishing.

OECD (2019). *PISA 2018 Assessment and Analytical Framework*. PISA, OECD Publishing.

Oliveira, I. M., Taveira, M. C., & Porfeli, E. J. (2017). Career preparedness and school achievement of portuguese children: Longitudinal trend articulations. *Frontiers in Psychology*, *8*(618), 17-29. https://doi.org/10.3389/fpsyg.2017.00618

Oliver, M. C., & Adkins, M. J. (2020). "Hot-headed" students? Scientific literacy, perceptions and awareness of climate change in 15-year olds across 54 countries. *Energy Research & Social Science, 70*, 101641. https://doi.org/10.1016/j.erss.2020.101641

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079. https://doi.org/10.1080/0950069032000032199

Pereira, S., Rodrigues, M. J., & Vieira, R. M. (2020). Scientific literacy in the early years – practical work as a teaching and learning strategy. *Early Child Development and Care, 190*(1), 64-78. https://doi.org/10.1080/03004430.2019.1653553

Salta, K., & Tzougraki, C. (2004). Attitudes towards chemistry among 11th grade students in high schools in Greece. *Science Education, 88*(4), 535-547. https://doi.org/10.1002/sce.10134

Savage, A. F., & Jude, B. A. (2014). Starting small: using microbiology to foster scientific literacy. *Trends in Microbiology, 22*(7), 365-367. https://doi.org/10.1016/j.tim.2014.04.005

Scheuch, M., Panhuber, T., Winter, S., Kelemen-Finan, J., Bardy-Durchhalter, M., & Kapelari, S. (2018). Butterflies & wild bees: biology teachers' PCK development through citizen science. *Journal of Biological Education, 52*(1), 79-88. https://doi.org/10.1080/00219266.2017.1405530

Schreiner, C., & Sjøberg, S. (2004). *Sowing the seeds of ROSE : background, rationale, questionnaire development and data collection for ROSE (The Relevance of Science Education): A comparative study of students views of science and science education*. Unipub AS.

Siarova, H., Sternadel, D., & Szőnyi, E. (2019). *Research for CULT Committee – Science and Scientific Literacy as an Educational Challenge*, *European Parliament.* Policy Department for Structural and Cohesion Policies.

Sjøberg, S., & Schreiner, C. (2010). *The ROSE project: An overview and key findings*. Oslo University.

Smith, T. J., Walker, D. A., Chen, H-T., & Hong, Z-R. (2020). Students' sense of school belonging and attitude towards science: A cross-cultural examination. *International Journal of Science and Mathematics Education, 18*, 855-867. https://doi.org/10.1007/s10763-019-10002-7

Snow, C., & Dibner, K. (2016). *Science literacy: Concepts, contexts, and consequences.* The National Academies Press.

Strasser, B., Baudry, J., Mahr, D., Sanchez, G., & Tancoigne, E. (2018). "Citizen science"? Rethinking science and public participation. *Science & Technology Studies*, *32*(2), 52-76. https://doi.org/10.23987/sts.60425

Sullivan, B. L., Aycrigg, J. L., Barry, J. H., Bonney, R. E., Bruns, N., Cooper, C. B., Damoulas, T., Dhondt, A. A., Dietterich, T., Farnsworth, A., Fink, D., Fitzpatrick, J. W., Fredericks, T., Gerbracht, J., Gomes, C., Hochachka, W. M., Iliff, M. J., Lagoze, C., La Sorte, . . . Kelling, S. (2014). The eBird enterprise: An integrated approach to development and application of citizen science. *Biological Conservation, 169*, 31-40. https://doi.org/10.1016/j.biocon.2013.11.003

Tabachnik, B. G., & Fidell, L. S. (2006). *Using Multivariate Statistics,* (5th ed.). Pearson Education.

Tang, X., & Zhang, D. (2020). How informal science learning experience influences students' science performance: A cross-cultural study based on PISA 2015. *International Journal of Science Education, 42*(4), 598-616. https://doi.org/10.1080/09500693.2020.1719290

Tee, O. P., & Subramaniam, R. (2018). Comparative study of middle school students' attitudes towards science: Rasch analysis of entire TIMSS 2011 attitudinal data for England, Singapore and the U.S.A. as well as psychometric properties of attitudes scale. *International Journal of Science Education, 40*(3), 268-290. https://doi.org/10.1080/09500693.2017.1413717

Tee, O. P., Cheng, M. M. W., & Wong, A. S. L. (2020). Gender differences in attitude towards science: Methodology for prioritising contributing factors. *International Journal of Science Education, 42*(1), 89-112. https://doi.org/10.1080/09500693.2019.1701217

TIMSS (2021). *TIMSS: Trends In International Mathematics And Science Study*. Available at https://timssandpirls.bc.edu/timss-landing.html

Tulloch, A. I. T., Possingham, H. P., Joseph, L. N., Szabo, J., & Martin, T. G. (2013). Realising the full potential of citizen science monitoring programs. *Biological Conservation, 165*, 128-138. https://doi.org/10.1016/j.biocon.2013.05.025

Uddin, S., Fowler, S. W., & Saeed, T. (2020). Microplastic particles in the Persian/Arabian Gulf – A review on sampling and identification. *Marine Pollution Bulletin, 154,* 1111002. https://doi.org/10.1016/j.marpolbul.2020.111100

https://doi.org/10.33225/jbse/21.20.881

United Nations (2021a). *Sustainable Development Goals*. Available at https://sdgs.un.org/goals/goal14

United Nations (2021b). *United Nations Decade of Ocean Science for Sustainable Development*. Available at https://www.oceandecade.org/

Vilia, P. N., Candeias, A. A., Neto, A.S., Franco, M.S., & Melo, M. (2017). Academic achievement in Physics-Chemistry: The predictive effect of attitudes and reasoning abilities. *Frontiers in Psychology, 8*(1064), 81-89. https://doi.org/10.3389/fpsyg.2017.01064

Wan, Z. H., & Lee, J. C. K. (2017). Hong Kong secondary school students' attitudes towards science: A study of structural models and gender differences. *International Journal of Science Education, 39*(5), 507-527. https://doi.org/10.1080/09500693.2017.1292015

Wang, T-L., & Berlin, D. (2010). Construction and validation of an instrument to measure taiwanese elementary students' attitudes towards their science class. *International Journal of Science Education*, *32*(18), 2413-2428. https://doi.org/10.1080/09500690903431561

Wang, W., Gao, H., Jin, S., Li, R., & Na, G. (2019). The ecotoxicological effects of microplastics on aquatic food *Web*, from primary producer to human: A review. *Ecotoxicology and Environmental Safety, 173*, 110-110-117. https://doi.org/10.1016/j.ecoenv.2019.01.113

Wang, W., Ge, J., & Yu, X. (2020). Bioavailability and toxicity of microplastics to fish species: A review. *Ecotoxicology and Environmental Safety, 189*, 1099132. https://doi.org/10.1016/j.ecoenv.2019.109913

Wiggins, A., & Crowston, K. (2011). *From conservation to crowdsourcing: A typology of citizen science*. Paper presented at the 44th Hawaii International Conference on System Sciences.

Wiggins, A., Bonney, R., LeBuhn, G., Parrish, J. K., & Weltzin, J. F. (2018). A science products inventory for citizen-science planning and evaluation. *BioScience, 68*(6), 436-444. https://doi.org/10.1093/biosci/biy028

Wilken, U. (2018). Lakes, labs and learning: How an environmental DNA citizen science project makes sense for high school students, researchers and environmental managers. *K-12 STEM Education, 4*(4), 391-399.

Xanthoudak, M. (2012). *Quality science education: Where do we stand? Guidelines for practice from a European experience*. Milan: LLP Programme European Union / Museo Nazionale della Scienza e della Technologia Leonardo da Vinci.

Zhang, Z., & Chen, Yb. (2020). Effects of microplastics on wastewater and sewage sludge treatment and their removal: A review. *Chemical Engineering Journal, 382,* 122955. https://doi.org/10.1016/j.cej.2019.122955

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