New Perspectives in Science Education
International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION

Impact of an Educational Proposal on the Knowledge about Plastics and their Contamination in Grade-8 Students.

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Abstract

Plastic pollution is found in marine and terrestrial ecosystems. Plastics can enter the food chain, accumulating in aquatic species' organs or humans [1]. People's attitude towards nature represents the driving force behind the commitment to ecological behaviour [2]. Therefore, it is necessary to raise environmental awareness at school. For this purpose, a study was carried out with 40 Spanish grade-8 (13-14 years) students from a high school in Malaga (Spain) belonging to two class groups. First, the students answered a survey on their knowledge of plastics. Secondly, a design and implementation of a teaching-learning sequence on critical thinking and plastics was carried out [3]. The teaching-learning sequence consisted of murals and presentations on the types of plastics, an inquiry into different plastics [4], a role play about the ban of single-use plastics, and an audio story. Finally, they did the same survey as post-test. Productions were categorised as adequate and inadequate responses. The behaviour of the two groups was similar as the Chi-square test showed no statistically significant differences between the two groups. However, McNemar's test showed significant differences in some items, namely on microplastics, recycling and pollution, in all cases in favour of the post-test, indicating the effectiveness of the teaching-learning sequence.

Keywords: *Plastic, secondary education, pollution*

1. Introduction

Plastics have helped to improve our health or sanitation. However, plastics are causing major environmental problems. For this reason, these materials present a complex situation in society [5]. The production of plastics has increased in the last decades. Much of this is single-use packaging that is not recycled or non-biodegradable [1]. They can be found from the atmosphere to the terrestrial and marine environments. The plastics are trapped and concentrated by circulating ocean currents (gyres) and then forming extensive areas of plastic debris [6].

Plastics can enter the food chain, which may accumulate in aquatic species' organs or humans, producing consequences for the environment and our health. In addition, different authors indicate problems such as DNA damage, inflammatory responses or reproductive effects [1].

People's attitude towards nature represents the driving force behind the commitment to ecological behaviour [2]. This commitment must start at school. A way to treat this question in the classroom is through socio-scientific problems since they pose real situations in which science and technology are important in society. Some examples of socio-scientific problems are mixtures of alcoholic beverages [7] or pollution resulting from the degradation of plastics in ecosystems [8]. López-Fernández, González-García and Franco-Mariscal [3] finding the importance of including this type of activity in the chemistry classroom. It is necessary to raise environmental awareness at school for students to learn to question, discuss aspects of chemistry, or make decisions, all of which may affect them [5].

2. Methodology

This study was carried out with 44 Spanish grade-8 (13-14 years) students from a high school in Malaga (Spain). The students were enrolled in a chemistry programme and belonged to two different class groups (N=23, group A and N=21, group B).

First, the students answered a survey on their knowledge of plastics (pre-test) which consisted of 19 items about plastics and pollution. Twelve items were multiple-choice questions, and seven were open-ended questions.

Secondly, a teaching-learning sequence about plastics and critical thinking was designed and implemented [3]. During the teaching-learning sequence, the students made murals and presentations

on types of plastics, an inquiry into different plastics [4], role-playing about the ban of single-use plastics [5], and an audio story (Figure 1).

After the teaching-learning sequence, the students answered the same survey as post-test.

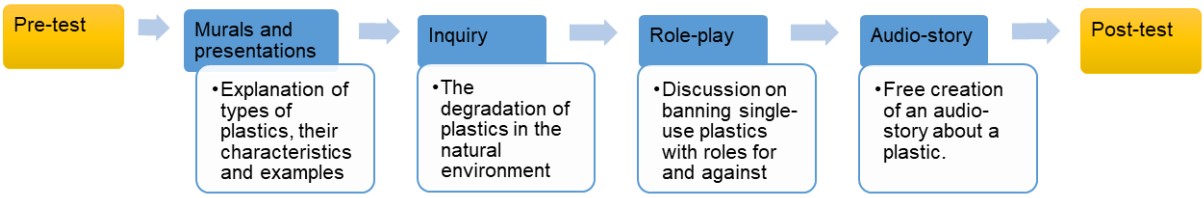

Figure 1: Teaching- learning sequence on plastics and critical thinking

This study focuses on 10 multiple-choice items with closed-ended answers to the survey (table 1). Adequate answers are shown with an asterisk in table 1.

Table 1: Survey items and answers options used for pre-test and post-test.

Items	Answers		
	A	B	C
1. Where do you think the plastic comes from?	Plastic is extracted directly from nature	It is derived from petroleum*	It is produced by living animals and plants
2. Do you think all plastics are the same?	No, there are different types*	Yes, they are all the same	I do not know
3. Can all plastics be reused and recycled?	Yes, but not everybody recycles it	Yes, that is why all plastics are recycled	No, some do, some do not*
4. Can all plastics be used to make water bottles?	No, because some are difficult to extract	No, because some can be toxic*	Yes, because plastics are moldable
5. Plastic pollution is due to...	only because of the large number of plastics	to their low degradability, along with other factors*	to their low usefulness
6. What are single-use plastics?	Plastics that people use once and then throw away	The plastics that can only be used once*	All of them, since we should not reuse them.
7. How are microplastics formed?	From oil for use in very small things.	The environment creates very small fragments from larger plastic*	In recycling plants, as a previous step to make plastic.
8. The degradation of plastic...	It is very slow, and its characteristics hardly change over time*	It is slow; in a few weeks, it is degraded.	It degrades very quickly, in a few hours.
9. Plastic pollution affects the environment...	Only to the oceans	Only to living beings	To the entire planet Earth*
10. Plastics found in the sea may be...	Short time, because they degrade easily	Only at the surface	Up to thousands of meters deep*

The objective is to determine whether the students' knowledge of plastics and pollution changed after implementing a teaching-learning sequence about plastics and critical thinking was carried out [3]. Responses were grouped into adequate and inadequate answers in order to facilitate analysis.

The chi-square test was carried out to test for statistically significant differences between the pre-test of groups A and B on the one hand and between the post-test of both groups on the other hand. The McNemar test was used to analyse differences in adequate responses between pre-test and post-test for each group and the total of students.

3. Results

Table 2 shows the frequency of responses for pre- and post-test in each group and the total of students and the Chi-square test.

Table 2: Chi-squared test results for pre-test and post-test

Item	Pre-test								Post-test								Total Increase Adequate Responses
	Adequate Responses			Inadequate Responses			Chi-square test		Adequate Responses			Inadequate Responses			Chi-square test		
	A	B	Total	A	B	Total	χ^2	p-value	A	B	Total	A	B	Total	χ^2	p-value	
1	22	21	43	1	0	1	0.93	NS	23	21	44	0	0	0	0.00	NS	1
2	20	14	34	3	7	10	2.57	NS	23	20	43	0	1	1	1.12	NS	9
3	3	3	5	20	19	39	0.01	NS	17	16	33	6	5	11	0.03	NS	27
4	17	11	28	6	10	16	2.20	NS	18	17	35	5	4	9	0.05	NS	7
5	20	11	31	3	10	13	6.30	0.02	19	18	37	4	3	7	0.08	NS	6
6	15	11	27	8	9	17	0.75	NS	15	11	26	8	10	18	0.75	NS	0
7	5	7	13	18	13	31	0.74	NS	15	17	32	8	4	12	1.37	NS	20
8	22	17	39	1	4	5	2.36	NS	18	21	39	5	0	5	5.15	NS	0
9	23	20	43	0	1	1	1.12	NS	23	21	44	0	0	0	0.00	NS	1
10	17	16	33	6	5	11	0.03	NS	19	21	40	4	0	4	4.02	NS	7

NS: No significant differences

The Chi-square test showed no significant differences between the groups A and B in the two moments, except for item 5 *Plastic pollution is due to...* in the pre-test ($\chi^2 = 2.20$; $p = 0.02 < 0.05$) favouring group A. This indicates that both groups of students behaved similarly in the pre- and post-test.

In the pre-test, the items with the highest number of adequate answers were related to the origin of the plastics (item 1), their contamination (item 9) and their degradation (item 8). These same items remain in the majority in the post-test, together with the chemical composition of plastics (item 2) and the time plastics remain in the sea (item 10).

The questions with the best increase in adequate answers were *Can all plastics be reused and recycled?* (item 3) and *How are microplastics formed?* (item 7). For these items, it is very remarkable that the number of students who answered inadequately in pre-test and after the teaching-learning sequence responded adequately in post-test (24 for item 3, and 19 for item 7).

On the other hand, items (1, 8 and 9) have not improved the results due to the high frequency of students giving adequate answers in the pre-test. We have to consider that the students were enrolled in a chemistry subject and knew of some issues related to plastics. Moreover, there are no questions where the results worsen noticeably.

The McNemar test showed significant differences between some items (table 3) to compare the adequate responses between pre-test and post-test in each group and the total number of students.

Table 3: McNemar test results for the comparison of the adequate responses

Item	Group A				Group B				Total			
	Pre-test	Post-test	McNemar test		Pre-test	Post-test	McNemar test		Pre-test	Post-test	McNemar test	
			χ^2	p-value			χ^2	p-value			χ^2	p-value
1	22	23	0.00	NS	21	21	-	-	43	44	0.00	NS
2	20	23	1.33	NS	14	20	3.13	NS	34	43	5.82	0.02
3	3	17	9.39	0.00	3	16	0.60	0.00	6	33	20.49	0.00
4	17	18	0.00	NS	11	17	3.13	NS	28	35	3.27	NS
5	20	19	0.00	NS	11	18	5.14	0.02	31	37	3.13	NS
6	15	15	0.00	NS	11	11	0.00	NS	26	26	0.00	NS
7	5	15	6.75	0.01	7	17	5.79	0.02	12	32	13.89	0.00
8	22	18	1.50	NS	17	21	2.25	NS	39	39	0.00	NS
9	23	23	-	-	20	21	0.00	NS	43	44	0.00	NS
10	17	19	0.25	NS	16	21	3.20	NS	33	40	4.00	0.046

NS: No significant differences

Significant differences were detected for adequate responses in group A for items 3 (*Can all plastics be reused and recycled?*; χ^2 = 9.39, p = 0.00) and 7 (*How are microplastics formed?*, χ^2 = 6.75; p= 0.01). Differences were found in group B for the same items (item 3: χ^2 = 0.60, p= 0.00; item 7: χ^2 = 5.79, p= 0.02). In addition, significant differences were detected for item 5 (*Plastic pollution is due to...*, χ^2 = 5.14, p= 0.02).

Differences were also found for the same items for the total of students (item 3: χ^2 = 20.49, p= 0.00; item 7; χ^2 = 13.89, p= 0.00). Moreover, we found significant differences for item 2 (*Do you think all plastics are the same?;* χ^2 = 5.82, p= 0.02) and item 10 (*Plastics found in the sea may be...*, χ^2 = 4.00, p= 0.046). The differences for all cases were in favour of the post-test.

Generally speaking, we can state that the teaching-learning sequence was responsible for the results of the post-test results was better than pre-test results, and students demonstrated an improvement in their attitudes.

4. Conclusions

In conclusion, the results show that, after the teaching-learning sequence on plastics and critical thinking, students improved their knowledge about plastics and pollution. Although participants were studying a chemistry subject and they knew of plastics and materials, the main progress in this topic was related to microplastics (item 7), recycling (item 3), pollution (items 5 and 10), and types of plastic (item 2). The tasks that could have had the most significant influence on this progress were the production of murals about types of plastics, their characteristics and recyclability, and inquiry about the degradation of plastics, formation of microplastics and consequences for the environment. In addition, an improvement in their attitudes was also perceived by the teacher.

Once again, we semphasise the importance of including this type of activity in the chemistry classroom to improve students' knowledge, argumentation skills and decision making because they are future citizen. Therefore, it is important that they know and become aware of decisive aspects such as plastics and their contamination to ensure a sustainable future without compromising the opportunities of future generations [5].

Our aim in future studies is to implement this teaching-learning sequence in other groups of students to generalise results and draw conclusions.

5. Acknowledgements

This work is part of the R&D project, reference PID2019-105765GA-I00, entitled "Citizens with critical thinking: A challenge for teachers in science education", financed by the Spanish Government in the 2019 call.

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