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**RESEARCH REPORT**
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# WATER AND AIR POLLUTION: PRIMARY STUDENTS' CONCEPTIONS ABOUT "ITINERARIES" AND INTERACTIONS OF SUBSTANCES

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**ABSTRACT:** This work is part of a larger program aiming at the introduction of innovative ways of teaching and learning science in primary education. Seven primary schools, with eleven experimental classes (N = 229) and eight control classes (N = 170) participated. A written questionnaire was answered by the 11-12 years-old students of the experimental group before and after a nine-hour constructivistic teaching intervention. The same questionnaire was also answered at the beginning by the control group. Prior to the intervention, the majority of students considered the phenomenon of pollution a local event without conceiving its global dimension. They also believed that when air pollutants and waste go in the atmosphere or in water they cause only physical but not chemical phenomena. After the intervention, the students' answers improved substantially. Concerning air pollution, students came to realise that fumes and pollutants can come from (and spread) everywhere because the molecules of the pollutants get diffused in the atmosphere, are diluted and transferred everywhere. With respect to water pollution, students also realised that waste molecules are diffused or diluted into water and can be transferred everywhere. In addition, after the intervention students thought that not only physical but also chemical phenomena can take place in the air (acid rain) or in the water. On the contrary in the control group, students' initial ideas resisted teaching and did not improve to more scientific ones. [*Chem. Educ. Res. Pract. Eur.*: 2001, *2*, 31-41]

**KEY WORDS:** *water pollution; air pollution; diffusion; dilution; chemical interactions; primary students' conceptions.*

## INTRODUCTION AND AIM

Air pollution is one of the most important problems that affect our society. Nowadays the environmental issues and especially the pollution problems are subjects of everyday discussions all over the world. However little research is presently being carried out on the primary students' conceptions on aspects of pollution. In our view, it is really important for the promotion of environmental education and prospective teachers' scientific (environmental) literacy, to look into the way primary students conceive pollution.

The most common research subjects related to environmental issues are the greenhouse effect (Boys & Stanisstreet, 1993; Francis, Boys, Qualter, & Stanisstreet, 1993; Dove, 1996; Koulaidis & Christidou, 1999), the ozone layer depletion (Boys & Stanisstreet, 1993, 1994; Francis, Boys, Qualter, & Stanisstreet, 1993; Dove, 1996; Christidou & Koulaidis, 1996; Boyes, Stanisstreet, & Spiliotopoulou-Papantoniou, 1999) and acid rain (Brody, Chipman, & Scott, 1989; Dove, 1996). According to these research findings, the students have alternative ideas about basic environmental issues and consequently it is difficult for them to think and realise the causes of these phenomena and the ways that they can be solved. For example students usually believe that the ozone layer depletion has probably something to do with the greenhouse effect (Francis, Boys, Qualter, & Stanisstreet, 1993; Rye, Rubba, & Randal,

1997), that the use of unleaded petrol might help reduce the greenhouse effect (Francis et al. 1993), or that carbon dioxide destroys the ozone layer (Rye, Rubba, & Randal, 1997). Also, a lot of children raise the idea that carbon dioxide is something which 'should not be' in the air, because it is harmful for the human beings and the environment (Thornber, Stanisstreet, & Boyes, 1999).

Students generally conceive environmental pollution as something which goes into the atmosphere or air or as something which kills, destroys, damages, affecting people and animals and, moreover, they argue that the negative activity of air pollution to the plants is not an ecological problem (Brody, 1994).

Students usually believe that everything natural is not pollution, meaning that anything that comes out from the earth or exists in nature cannot cause pollution (e.g. the volcano fumes). On the contrary, they think that everything produced or related to human beings is harmful and causes pollution (Ali, 1991; Brody, 1991, 1994; Boys & Stanisstreet, 1994; Dove, 1996, Thornber, Stanisstreet, & Boyes, 1999). They also believe that biodegradable materials are not pollutants (Brody, 1991), that when an item disintegrates or breaks down it eventually disappears and no longer is a problem, and that solid waste in dumps is safe. When younger students were probed about where trash in the garbage went each week, they responded "to the dump". They seemed to think that this was the end of the problem (Brody, 1991).

Environmental issues and especially pollution problems are quite abstract. Given the fact that these issues are being taught partially in primary and secondary education, not only students but also prospective teachers have alternative ideas about them. For example, prospective teachers usually cannot distinguish the differences among the three most important environmental problems, i.e. the greenhouse effect, the ozone layer depletion and acid rain. Apart from these, they cannot explain the way CFCs appear in areas far away (e.g. Antarctica) from the places where they were produced (Dove, 1996).

From all these ideas that have already been laid out, it is clear that further investigations need to be done about students' ideas concerning these environmental issues; in addition, there is need for planning and organising appropriate teaching interventions in order to counter children's pre-conceptions. In the case of Greece, there is a lack of educational programs aiming at the development, application and evaluation of innovative educational approaches, working on the reconstruction of students' alternative conceptions. For example, we know little about students' ideas on the pollution resources and the chemical interactions that take place in the air and in the water and cause negative effects to human beings and the environment.

**Aim**

The aim of this work is to detect students' ideas before and after an innovative teaching intervention, and to find out:

a) in what degree Greek primary students can realise the international dimension of air/water pollution;
b) if they conceive the way in which pollution 'transfers' from one place to another;
c) if they think of possible chemical interactions that happen in the air or into water.

## METHOD

Seven primary schools participated in this program, comprising eleven experimental classes and eight control classes. In total, 229 students participated in the experimental classes, and 170 in the control classes. Nineteen teachers (11 of the experimental and 8 of the control classes) participated, all being volunteers. The development of the program was mainly based on the following steps:

- teachers' training in order to appreciate and adopt the constructivist view of learning and change their everyday teaching practices;
- design of new teaching sequences deriving from research data about students' conceptions and difficulties (new curriculum, new worksheets and teaching materials, new organisation of the class in small groups of four);
- teachers' training and familiarisation with the new teaching approach and materials;
- organisation of the teaching sequences according to the teachers' remarks and suggestions;
- detection of young students' initial conceptions about the selected science topics;
- realisation of the new teaching sequences (for a period of three months, for three hours per week);
- evaluation of the learning outcomes of the new teaching interventions.

One of the three selected science topics was 'water and air pollution'. During a pilot study on students' conceptions about water and air pollution, 14 students (11-12 years old) were interviewed. Their answers showed that they considered pollution as a rather local event. For instance, they said that acid rain is an event that always occurs in town, because of the presence of cars and industries, and never in the country or in small villages, where the air is very clean. The analysis of the interviews showed that students hardly represented diffusion or displacement of substances in the atmosphere and in water (seas, rivers, etc.), as well as possible changes or interactions of substances. Additionally, it is well known that in everyday life substances are often considered as inert objects and that the concept of formation of new substance(s) may not be achieved by most people (Solomonidou & Stavridou, 2000).

According to the data analysis of our pilot study and relevant literature in the field, we developed a new curriculum comprising nine new units about air pollution and six new units about water pollution. Our new curriculum was inspired by social constructivism and co-operative learning. Two written questionnaires (one about air pollution and another about water pollution) were administered and answered by the students of both the experimental and control classes. The aim of the questionnaires was to detect and elucidate young (aged 11-12) students' initial conceptions about:

a) the ways pollution is produced;
b) the possibility of displacement of different substances in the atmosphere or into water;
c) the possible conservation or interaction of substances in the atmosphere or in water.

The questionnaire comprised both multiple choice and open-ended questions. The students were also invited to make drawings in order to explain their ideas, and were encouraged to justify their answers.

The results derive from the elaboration of the students' answers to the two written questionnaires. To be more specific, 128 students of the experimental classes, who were taught about air pollution, filled in the first written questionnaire (pre-test and post-test).

Sixty-two of these students (37 boys, 25 girls) were attending, at that time, the 5th grade of primary school and 66 students (29 boys, 37 girls) were attending the 6th grade. The control group classes comprised 101 students. Fifty-nine among these students (31 boys, 28 girls) were attending the 5th grade (11 years old) and 42 students (22 boys, 20 girls) were attending the 6th grade (12 years old).

As far as water pollution is concerned, 84 students participating in the experimental classes were taught about water pollution and also completed the second (pre-test and post-test) written questionnaire. The 5th grade of primary school was attended by 55 students (27 boys, 28 girls), while the 6th grade by 29 students (14 boys, 15 girls). The control group classes comprised 59 students, with 39 students (25 boys, 14 girls) attending the 5th grade and 20 (10 boys, 10 girls) the 6th grade.

For the statistical analysis of students' answers, the SPSS statistical package was used. Students' answers deriving from both questionnaires on air pollution and on water pollution are described in further detail.

## RESULTS AND DISCUSSION

### Air pollution

*Question AP1*. The first question about air pollution was the following:

> "*If exhaust fumes and other harmful gases emitted from central heating and factory chimneys appear in a distant place, from which of the following places, do you think that they will finally reach Volos*?"

Students were asked to fill in a table by ticking an 'X' against the appropriate case and to justify their answers. The frequencies of the students' answers to this question at pre-testing are presented in Table 1.

**TABLE 1.** *Students' answers to the first question of the pre-test and the post-test about air pollution.*

| | It can come to Volos from ... | | It can come to Volos from ... | |
|---|---|---|---|---|
| | **Pre-test** | | **Post-test** | |
| | **N = 128** | **%** | **N = 126** | **%** |
| USA | 36 | 28.1 | 124 | 98.4 |
| England | 39 | 30.5 | 125 | 99.2 |
| Germany | 38 | 29.7 | 126 | 100.0 |
| Italy | 65 | 50.8 | 126 | 100.0 |
| Crete | 89 | 69.5 | 126 | 100.0 |
| Athens | 110 | 85.9 | 126 | 100.0 |
| Thessaloniki | 110 | 85.9 | 125 | 100.0 |
| Larissa | 125 | 97.7 | 125 | 100.0 |
| Almyros | 124 | 96.9 | 126 | 100.0 |
| Anchialos | 123 | 96.1 | 125 | 100.0 |
| Agria | 124 | 96.9 | 125 | 100.0 |

It follows that students believed that pollution was likely to reach Volos from nearby areas (e.g. 96.9% ticked Agria, a small village 5 kilometres away from Volos), whereas it is unlikely for distant sources of emissions (e.g. USA) to be transferred to their region (only 28.1% ticked USA).

The students' explanations (pre-testing) were the following: a) 66.4% of them firmly believed that harmful gases reach Volos only if they are produced in nearby areas, and they cannot possibly be detected in their town if they are produced in faraway places; b) 15.6% of the students thought that air pollutants may come to Volos from everywhere because they move in the air; c) 1.6% of them claimed that pollutants may come to Volos from everywhere because gases can move; d) 0.8% of the students believed that pollutants may come to Volos from any place on the earth, since there are factories and cars everywhere; e) 7.8% of them gave different answers; and f) 10.0% of the students could not provide an explanation.

The frequencies of the students' answers to the same question in the post-test questionnaire are also presented in Table 1. Students' answers in both pre- and post-testing showed that their initial views had changed, so that they seemed to believe that fumes and harmful gases can reach their town from everywhere (for instance 98.4% ticked USA).

The students' explanations (post-testing) are categorised as follows: a) harmful gases could come to Volos from everywhere because their molecules are easily carried in the air and tend to move on their own also (41.3% of the students); b) fumes and harmful gases can come to Volos from any place on the Earth because their molecules are easily carried in the air (40.5% of the students); c) air pollutants can come to Volos from everywhere because gas molecules tend to move on their own (14.3% of the students); and d) no explanation (4.0% of the students).

*Question AP2.* The second question about air pollution was:

> "*If automobile fumes, central heating fumes and fumes emitted from factory chimneys appear in Volos, to which of the following areas do you think they can go*? *Put an 'X' against the appropriate case and justify your answer*".

Table 2 presents the frequencies of the students' answers to this question both in pre- and post-testing. In the pre-test, students followed the same pattern as in the previous question, and seemed to believe that pollution could reach other nearby regions (e.g. 97.7% among them ticked Agria). On the contrary, students believed that it was unlikely that pollution would be transferred to more distant areas (e.g. only 25% ticked the USA).

Students' explanations in the pre-test were: a) fumes and harmful gases, in general, could reach only areas adjacent to Volos, not faraway areas (68.8% of the students); b) these air pollutants could go everywhere because they are easily be carried in the air (14.8%); c) these gases can go everywhere because they can move (1.6%); d) various answers (5.5%); and e) no explanation given (9.4%).

The frequencies of the students' answers to the same question in the post-test are also presented in Table 2. It is obvious from the students' answers that their initial ideas, as revealed also in the previous question, had substantially changed, so that they seemed to believe that automobile fumes and other harmful gases can go everywhere (99.2% ticked USA). The explanations given by the students to justify their ideas (post-test questionnaire) were the

**TABLE 2.** *Students' answers to the second question of the pre-test and the post-test about air pollution.*

| | From Volos it can go to ... | | From Volos it can go to... | |
|---|---|---|---|---|
| | **Pre-test** | | **Post-test** | |
| | **N = 128** | % | **N = 126** | % |
| USA | 32 | 25.0 | 125 | 99.2 |
| England | 33 | 25.8 | 126 | 100.0 |
| Germany | 35 | 27.3 | 126 | 100.0 |
| Italy | 58 | 45.3 | 126 | 100.0 |
| Crete | 95 | 74.2 | 126 | 100.0 |
| Athens | 107 | 83.6 | 126 | 100.0 |
| Thessaloniki | 107 | 83.6 | 126 | 100.0 |
| Larissa | 123 | 96.1 | 126 | 100.0 |
| Almyros | 125 | 97.7 | 126 | 100.0 |
| Anchialos | 126 | 98.4 | 126 | 100.0 |
| Agria | 125 | 97.7 | 126 | 100.0 |

following: a) air pollutants could reach not only areas adjacent to Volos but far away places as well, because their molecules are easily carried in the air and tend to move on their own (41.3%); b) fumes and harmful gases could reach not only areas adjacent to Volos but far away places as well, because their molecules are easily carried in the air (40.5%); c) pollutants, as well as gases, could reach not only areas adjacent to Volos, but also far away places because their molecules tend to move on their own (14.3%). Four per cent of the students gave no explanation.

*Question AP3*. The third question concerned the possibility of chemical interactions of the air pollutants into the atmosphere:

> "*The exhaust fumes and other harmful gases emitted from central heating and the factory chimneys when they go in the atmosphere, do you think that they change or not? If they change what changes do you think that happen to them*?"

The frequencies of the students' answers to the third question of the pre- and post-test are presented in Table 3.

Students' answers in the pre-test showed that almost half of them (48.4%) believed that air pollutants change, whereas the rest of them (48.4%) thought that they do not change.

Students' initial ideas about the pollutants' changes can be classified in two categories:

- type A changes: "*the air pollutants mix with the air or other gases in the atmosphere*" (14.1%),
- type B changes: "*the air pollutants are influenced and finally changed from other gases existing in the air, they become clouds and make a hole in the ozone layer, they become clouds and rain, they multiply, they disappear*" (17.1%).

We should note that the students referred only to physical changes in the atmosphere, while they did not mention the possibility of chemical changes.

**TABLE 3.** *Students' answers to the third question of the pre-test and the post-test about air pollution.*

| Students' answers | | Experimental classes | | | |
|---|---|---|---|---|---|
| | | Pre-test | | Post-test | |
| a/a | | N = 128 | % | N = 126 | % |
| 1 | Don't change | 62 | 48.4 | 17 | 13.5 |
| 2 | Change | 62 | 48.4 | 109 | 86.5 |
| 3 | No answer | 4 | 3.1 | 0 | 0.0 |

*If you think that the air pollutants change, what changes do you think that happen to them?*

| a/a | Students' answers | N = 62 | % | N = 109 | % |
|---|---|---|---|---|---|
| 1 | Change type A | 18 | 14.1 | 23 | 18.2 |
| 2 | Change type B | 22 | 17.1 | 4 | 3.1 |
| 3 | Change type C | 0 | 0.0 | 72 | 57.1 |
| 4 | I don't know | 2 | 1.5 | 0 | 0.0 |
| 5 | Other | 11 | 8.6 | 10 | 7.9 |
| 6 | No answer | 9 | 7.0 | 0 | 0.0 |

The frequencies of the students' answers to the same question in the post-test are also presented in Table 3. From the results it is clear that the students' ideas and answers had changed substantially after the teaching intervention. The majority of them (86.5%) seemed to believe that air pollutants do change in the atmosphere. The changes students referred to can now be classified in a new category, type C, according to which, the idea of a chemical interaction or change of air pollutants is present in the majority of the students' answers (57.1%). Especially these students thought that some air pollutants can combine with the water existing in the atmosphere and produce acids that drop on to the earth like acid rain.

**Water pollution**

Three similar questions where also given to the students who participated in the experimental classes and had been taught about water pollution.

*Question WP1*. The first question about water pollution was the following:

> "*If waste pouring out from sewers of towns and factories appear at a distant place, from which of the following places do you think they can finally reach Volos?" Put an "X" against the appropriate case of the following table and justify your answer.*

The frequencies of the students' answers to the first question of the pre-test questionnaire are presented in Table 4.

The above answers show that the students believed that pollution (waste) can possibly come from nearby areas (e.g. 95.2% ticked Agria). However, students thought that the more distant the
source of waste is (e.g. the USA) –in relation to the area they live in (Volos)- the less possible it is for pollution to be transferred from these areas to their own. The explanations given by the

**TABLE 4.** *Students' answers to the first question of the pre-test and the post-test about water pollution.*

| | It can come to Volos from ... | | It can come to Volos from ... | |
|---|---|---|---|---|
| | **Pre-test** | | **Post-test** | |
| | **N = 84** | **%** | **N = 85** | **%** |
| USA | 3 | 3.6 | 80 | 94.1 |
| England | 11 | 13.1 | 82 | 96.5 |
| Germany | 13 | 15.5 | 81 | 95.3 |
| Italy | 36 | 42.9 | 83 | 97.6 |
| Crete | 55 | 65.5 | 84 | 98.8 |
| Athens | 63 | 75.0 | 84 | 98.8 |
| Thessaloniki | 69 | 82.1 | 83 | 97.6 |
| Almyros | 81 | 96.4 | 84 | 98.8 |
| Anchialos | 81 | 96.4 | 83 | 97.6 |
| Agria | 80 | 95.2 | 84 | 98.8 |

students for the above statements (pre-testing) were the following: a) 73.8% of the students thought that waste arrive in Volos only from nearby areas but not from distant places; b) 6% of the students gave various answers; c) 20.2% gave no explanation.

The frequencies of the students' answers to the same question in the post-test are also presented in Table 4. As we can see, there has been an important change in their initial ideas and after the teaching sequences they seemed to believe that waste can come from everywhere (94.1% ticked USA). The justifications provided by the majority of the students (84.7%) can be summarized as follows: "*waste can come from any place because their molecules are diffused in water, diluted in it, and consequently carried away to all possible destination*" The rest (5.3%) of the students gave no explanation.

*Question WP2.* The second question about water pollution was*:*

> *"If waste coming out from the sewers of cities and factories appear in Volos, to which of the following areas do you think they can go*?" *Put an "X" to the appropriate case and justify your answer".*

The frequencies of the students' answers given for the second question of the pre-test questionnaire are shown in Table 5.

It seems that students believed that pollution (waste) can possibly go to nearby areas (e.g. 91.7% ticked Agria), but not to distant areas or countries (e.g. only 6% ticked USA). The majority of the students (73.8%) gave an explanation (pre-test questionnaire) which can be summarized in the following proposition: "*waste can only go to areas near Volos, but it cannot eventually reach distant areas*". A 4.8% gave various answers, whereas 21.4% gave no explanation.

The frequencies of the students' answers to the same question of post-test are also presented in Table 5. In the above answers an important change is detected, as now the vast majority of the students seemed to believe that waste can go everywhere (96.5% ticked USA). The explanations they gave in the post-test are summarized as follows: "*waste can go to any place because its molecules are diffused in water, diluted in it, and consequently carried away to all possible destinations*" (84.7% of the students), while 15.3% gave no explanation.

**TABLE 5.** *Students' answers to the second question of the pre-test and the post-test about water pollution.*

| | From Volos it can go to ... | | From Volos it can go to... | |
|---|---|---|---|---|
| | **Pre-test** | | **Post-test** | |
| | **N = 84** | **%** | **N = 85** | **%** |
| USA | 5 | 6.0 | 82 | 96.5 |
| England | 12 | 14.3 | 83 | 97.6 |
| Germany | 10 | 11.9 | 83 | 97.6 |
| Italy | 34 | 40.5 | 84 | 98.8 |
| Crete | 51 | 60.7 | 84 | 98.8 |
| Athens | 61 | 72.6 | 84 | 98.8 |
| Thessaloniki | 58 | 69.0 | 83 | 97.6 |
| Almyros | 79 | 94.0 | 84 | 98.8 |
| Anchialos | 79 | 94.0 | 83 | 97.6 |
| Agria | 77 | 91.7 | 84 | 98.8 |

*Question WP3.* The third question referred to possible chemical interactions of waste in water:

> "*Considering the waste coming out from the sewers of cities and factories that goes in (falls into) the water, do you think that it changes or not? If it changes, what changes do you think that happen to it*?"

Table 6 shows the frequencies of the students' answers given for the third question in the pre-test. According to those answers, 51.2% of the students believed that when waste falls into water, it changes, whereas 40.3% of them considered waste as inert materials (Solomonidou & Stavridou, 2000) that do not change, while a 8.3% gave no answer. As for the changes which take place in the first case, students believed that waste mixes up with other substances in water (27.9%), that waste becomes plankton (18.6%), or that it dilutes and disappears in water (20.9%) or that it "reaches" factories where it can be cleaned (4.7%). A 9.4% of the students gave various answers, whereas 18.6% gave no answer. From all these ideas it is quite clear that children referred only to physical changes and not to chemical ones.

The frequencies of the students' answers to the same question of the post-test questionnaire are also presented in Table 6.

These results show that the students' answers had substantially changed. After the teaching intervention the majority of the students (76.5%) seemed to believe that waste changes, and that chemical changes can take place (new product formation) (61.5%) as well. Some of them (15.4%) made the distinction between inert and non-inert materials, claiming that only non-inert materials (materials that split in water) change, while the inert ones (materials that do not split in water) do not change, or they thought that waste breaks into small pieces (13.8%). From all these answers it can be assumed that students conceived the idea of chemical change even if they could not really give specific explanations for these changes.

The study of the students' initial answers in the control and the experimental group showed that before the teaching intervention all the students of both groups had the same initial ideas. In the post-test questionnaire, the control group students continued to have the same ideas as before teaching, so it seems that traditional teaching had little influence on their alternative ideas which really did not change.

**TABLE 6.** *Students' answers to the third question of the pre-test and the post-test about water pollution.*

| Students' answers | | Experimental classes | | | |
|---|---|---|---|---|---|
| | | Pre-test | | Post-test | |
| a/a | | N = 84 | % | N = 85 | % |
| 1 | Don't change | 34 | 40.5 | 19 | 22.4 |
| 2 | Change | 43 | 51.2 | 65 | 76.5 |
| 3 | No answer | 7 | 8.3 | 1 | 1.2 |

*If you think that the waste changes, what changes do you think that happen to it?*

| a/a | Students' answers | N = 43 | % | N = 65 | % |
|---|---|---|---|---|---|
| 1 | Waste mix with other substances | 12 | 27.9 | 0 | 0 |
| 2 | Chemical changes | 0 | 0 | 40 | 61.5 |
| 3 | The non inert materials change and not the inert | 0 | 0 | 10 | 15.4 |
| 4 | Waste break into small pieces | 0 | 0 | 9 | 13.8 |
| 5 | Waste become plankton | 8 | 18.6 | 0 | 0 |
| 6 | Waste dilute and disappear | 9 | 20,9 | 0 | 0 |
| 7 | Waste "reach" to the factories and be cleaned | 2 | 4.7 | 0 | 0 |
| 8 | Other | 4 | 9.4 | 5 | 7.7 |
| 9 | No answer | 8 | 18.6 | 1 | 1.5 |

## CONCLUSIONS AND PROPOSITIONS

The results of this study showed that after the teaching intervention about air and water pollution the answers of the students in the experimental classes improved substantially. On the contrary, the students of the control group answered both in the pre- and the post-test questionnaire in a quite similar way. Before the innovative teaching intervention, all students did not realise the international dimension of air/water pollution, since they claimed that air pollutants or waste could go/come from/to their town only to/from nearby distances. Moreover, they did not understand the way air pollutants and waste move from one place to another. Before teaching, the students did not realise that air pollutants in the atmosphere and waste in water can change and that the changes that occur are not only physical, but chemical as well. The students also manifested a lack of representations about the particulate nature of matter.

The students' answers after the teaching intervention showed that the majority of them had developed a better understanding of the international dimension of pollution and the ways of pollution transfer. They also realised the way acid rain is produced and that air pollutants and waste are not inert materials but materials that can interact chemically with other substances when they get into the atmosphere or into water. Additionally, students had developed appropriate representations about the particulate nature of matter regarding water and air pollution.

The improvement of the experimental group students' ideas can be directly attributed to the following characteristics of the new learning environment:

a. the students' cooperation in small groups of 4-5 persons;
b. the expression of the students' ideas about the phenomena under study;
c. the intra- and inter-groups discussion and communication;
d. the students' active involvement in appropriate experimental activities.

The results deriving from the present study lead us to some directions concerning teaching and learning about environmental issues Teaching should help students understand the global dimension of pollution as well as the ways air and water pollutants transfer from one place to another. For this reason, the science curriculum should include science concepts relevant to the diffusion/dilution of pollutants in the atmosphere, the role of movement of the air masses, the distinction between physical and chemical phenomena, and the acid rain formation.

In our view, environmental education, combined with a change of attitudes towards the environment, should not be solely based on emotional factors, but be supported also by a good understanding of the basic mechanisms, which underlie the appearance of environmental problems. Our research data showed that these concepts are accessible by 10-12 year-old primary students.

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