# SIXTH, SEVENTH AND EIGHTH YEAR STUDENTS' KNOWLEDGE LEVELS ABOUT GREENHOUSE EFFECT, OZONE LAYER AND ACID RAIN

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**Abstract** – *The aim of this study is to investigate second stage primary school (6th, 7th and 8th year) students' knowledge levels about three important environmental topics, namely, the greenhouse effect, the ozone layer and acid rain. The study was carried out with 204 6th, 7th and 8th year students (11-14 year olds) in Turkey. A 25-item scale developed by Khalid (1999) was used as a data collection instrument. The instrument was adapted to the Turkish language and culture, was validated and its reliability co-efficiency was determined. The results of the study showed that 6th, 7th and 8th year students have a very low level of knowledge about the greenhouse effect, the ozone layer and acid rain. The results of this study can be used by experts of environmental education to focus on starting the teaching of environmental topics – like greenhouse effect, ozone layer and acid rain – thoroughly from the primary school to develop more environmentally sensitive citizens.*

## Introduction

Once, environmental problems only affected the locals, but with the passing of time, they now affect the whole world. In other words, the borders between countries cannot stop environmental problems; they therefore become global problems. The current dangerous situation of such problems and their extents can be seen in recent environmental incidents (see, for example, Demir, 1998; Bakac & Kumru, 2000; Goncaoglu et al., 2000).

Human beings are painfully experiencing these problems. For the sake of the future of nature and the human population in this world, it is important to prepare and conduct a proper environmental education to make individuals more conscious of the environmental problems that could lead to devastating results. The increase in fears, worries and sensitivities about the natural environment and its problems at international level gradually leads people to widely accept the idea that 'The best way of make people environmentally conscious is through

education'. This means that they accept that education plays an important role in finding solutions to these global problems and in inhibiting the start of new ones.

In order to protect natural resources like soil, water and forest, environmental education emphasises the protection and improvement of the environment as a whole, including the biosphere, biomes and ecosystems. In the course of time, apart from informing people, environmental education further included the aim of making individuals willing and skilful participants in environmental management (Peyton et al., 1995).

Some researchers claim that developing conscious behaviours towards environmental issues is directly related to positive attitudes of the individuals (Newhouse, 1990). While others insist on the environmental knowledge gained by the individuals, claiming that only through this knowledge could they be more environmentally conscious. Recently, constructivist environmental educators, on the other hand, proposed another way of looking at this issue. Conceptual understanding, according to them, is much more important than pure knowledge because since individuals construct their own knowledge, they could have misconceptions about such concepts which are barriers to understanding (Munson, 1994). Without understanding knowledge, they could neither behave with that knowledge nor develop a positive attitude.

The position we adopted in this study agrees with that of the constructivist environmentalists. We hold moreover that some environmental topics need some degree of knowledge base. This applies, for example, to acid rain and its negative effects on environment and health, the destruction in the ozone layer, and the damages caused by the greenhouse effect that could all be counted among the global problems. The point is that if individuals do not know what makes acid rain happen, what causes the greenhouse effect, what depletes the ozone layer, or what harms or damages are caused to humans, how could they develop a positive attitude and environmentally responsible behaviours or consciousness towards these issues? With this understanding, the aim of this study was to identify 6$^{th}$, 7$^{th}$ and 8$^{th}$ year students' knowledge levels about the three global problems of greenhouse effect, ozone layer and acid rain.

## Materials and method

*Participants*

This study was carried out with 6$^{th}$, 7$^{th}$ and 8$^{th}$ year students (i.e., those in the second stage of primary school) in central Ankara, the capital city of Turkey, during the 2004-2005 scholastic year. Table 1 presents the number of participants according to their school year or grade. As can be seen from this table, 45 grade

6 students, 78 grade 7 students and 81 grade 8 students participated in this study. Their age levels were between 11 and 14. The main reason for choosing students from these levels was that in the teaching sequence of Turkish science classes, topics related to the ozone layer, acid rain and the greenhouse effect are first introduced to students at these levels in the integrated science courses. To gain information from equal and homogenous groups, the data collection instrument was moreover applied to students from schools with similar socio-economical background.

*TABLE 1: Number of participants in the study according to their grade and age group*

| Grade Level | Age Group | Number of Participants |
|---|---|---|
| Grade 6 | 11-12 | 45 |
| Grade 7 | 12-13 | 78 |
| Grade 8 | 13-14 | 81 |

*The data collection instrument*

To determine students' knowledge levels about the greenhouse effect, the ozone layer and acid rain, a scale with 29 items developed by Khalid (1999) was used as the data collection instrument. After requesting permission from the developer of the scale, appropriate modifications were carried out in order to suit the aims and needs of the study. For example, the responses expected from the participants were redesigned as 'Yes', 'No' and 'Don't know'. The new version of the scale was first piloted with 65 second stage primary school students. It was determined from the pilot study that some items were not suitable. The 'unsuitable' items that could not be modified were removed from the scale, while those that could were changed in the light of recommendations by field experts. As a result, a scale with 25 items was finalised as the data collection instrument of this study.

The 25 items were divided into three probes – namely, the greenhouse effect (11 items), ozone layer (9 items), and acid rain (5 items). The items categorised under the three probes were also divided into two factors in each probe. Itemised lists of each group in the scale are presented in Table 2.

*TABLE 2: Classification of items by factor for each probe*

| **Probe** | **The Factors within each Probe** | **Distribution of items by Factor within each Probe** |
|---|---|---|
| Greenhouse effect | Factor 1: Possible events that may happen as a result of the greenhouse effect | 1, 2, 10 |
| | Factor 2: Possible events that may happen as a result of an increase of the greenhouse effect | 3, 4, 5, 6, 7, 8, 9, 11 |
| Ozone layer | Factor 1: Functions of ozone layer | 1, 2, 3, 9 |
| | Factor 2: Things damaging the ozone layer | 4, 5, 6, 7, 8 |
| Acid rain | Factor 1: Things causing acid rain | 1, 3, 5 |
| | Factor 2: Effects of acid rain | 2, 4 |

*Data analysis*

The data obtained through this study was analysed by using SPSS (version 11.0). In the data analysis, descriptive statistics (mean and standard deviation) and inferential statistics methods were used. The students' total mean scores, mean and standard deviation of each probe were calculated for each class level. The mean scores of each probe were calculated out of 100, the highest score that each student could have achieved.

High mean scores mean that students have sufficient knowledge about the probe. On the other hand, high standard deviation values mean that there is a wide gap between different students' knowledge level about the respective probe. The one-way ANOVA test was then conducted to determine whether there were significant differences among students from different class levels. The significant level was calculated in between 95% intervals of reliability.

## Results

*Probe 1: Students' knowledge levels about the greenhouse effect*

Table 3 presents the means and standard deviations of 6th, 7th and 8th year students on the greenhouse effect probe by total score, Factor 1 and Factor 2.

*Table 3: Means (M) and standard deviations (SD) of total and factor scores obtained by the student year groups for the greenhouse effect probe*

| **Knowledge of Greenhouse Effect** | Grade 6 *n* = 45 | | Grade 7 *n* = 78 | | Grade 8 *n* = 81 | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *S* |
| Total Score | 13.3 | 13.9 | 18.7 | 14.9 | 20.1 | 14.6 |
| Factor 1 | 16.3 | 24.2 | 19.2 | 26.6 | 17.7 | 22.4 |
| Factor 2 | 12.2 | 13.5 | 18.4 | 16.5 | 22.2 | 16.9 |

As can be seen from this table, the students' total mean scores for this probe ranged from 13.3 to 20.1. Similarly, the students' mean scores for Factor 1 (i.e., possible events that may happen as a result of the greenhouse effect) varied from 16.3 to 19.2. For Factor 2 (i.e., possible events may happen as a result of an increase of the greenhouse effect), their mean scores were between 12.2 and 22.2.

Table 3 reveals that the total mean score of 6th year students was lower than the total mean score of 7th year students, which was lower in turn than that of 8th year students. The same pattern can be observed for the mean scores of Factor 2. With regards to Factor 1, however, 7th year students had a higher mean score than 8th year students, who had in turn a higher mean score than 6th year students. Although there were some differences in the mean scores among students from different class levels, the low means reported in Table 3 (especially in view of the consideration that the highest score for this probe was 100) suggest that 6th, 7th and 8th year students invariably have an insufficient knowledge level about the greenhouse effect.

The results of the one-way ANOVA revealed that with regards to the total mean scores, there was a significant difference among the responses given to this probe by students in different year groups ($F(2, 201) = 4.122$, $p < .05$). Dunnette *C* test, which was then used to determine the pair-wise difference between means, indicated that the differences were in favour of 7th and 8th year students. With regards to Factor 1, no significant differences were found among the means of students from different class levels ($F(2, 201) = 0.214$, $p > .05$). On the other hand, for Factor 2, the means of different class levels were found to be significantly different ($F(2, 201) = 5.636$, $p < .05$).

*Probe 2: Students' knowledge levels about the ozone layer*

Table 4 presents the means and standard deviations of 6th, 7th and 8th year students on the ozone layer probe by total score, Factor 1 and Factor 2.

*TABLE 4: Means (M) and standard deviations (SD) of total and factor scores obtained by the student year groups for the ozone layer effect probe*

| **Knowledge of the Ozone Layer** | Grade 6 $n = 45$ | | Grade 7 $n = 78$ | | Grade 8 $n = 81$ | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *S* |
| Total Score | 19.7 | 17.1 | 26.8 | 13.5 | 25.1 | 17.0 |
| Factor 1 | 11.1 | 15.6 | 14.7 | 14.8 | 13.9 | 16.8 |
| Factor 2 | 26.7 | 21.7 | 36.4 | 19.3 | 34.1 | 22.7 |

As can be seen from the table, the means of the students' total score for this probe ranged from 19.7 to 26.8. For Factor 1 (i.e., functions of ozone layer), the mean scores varied from 11.1 to 14.7, and for Factor 2 (i.e., things damaging the ozone layer) the mean scores varied between 26.7 and 36.4.

Table 4 shows that the total and the two factor mean scores of 6th year students were lower than those of 7th and 8th year students. Interestingly enough, 7th year students had, for this probe, higher means than 8th year students for the total score and the two factors. Despite the differences among the means of different class levels, all the scores were very low (the highest score for this probe was again

100). In this scenario, the situation appears to be worse on Factor 1 (i.e., functions of ozone layer), whose highest mean score was only 14.7. As with probe 1, 6th, 7th and 8th year students were found to have an insufficient knowledge level about the ozone layer.

A one-way ANOVA was conducted to reveal whether or not there were significant mean differences among the responses given by the students in different year groups. The results indicated that with regards to the total score ($F(2, 201) = 2.917$, $p > .05$) and Factor 1 ($F(2, 201) = .779$, $p > .05$), there were no significant differences between the means scores of the three student groups. But, for Factor 2, the mean scores of students from different class levels were found to be significantly different ($F(2, 201) = 3.089$, $p < .05$). Further investigation determined that the difference was significant between the mean scores of 6th and 7th year students, and that it was in favour of 7th year students.

*Probe 3: Students' knowledge levels about acid rain*

Table 5 presents the means and standard deviations of 6th, 7th and 8th year students on the acid rain probe by total score, Factor 1 and Factor 2.

*TABLE 5: Means (M) and standard deviations (SD) of total and factor scores obtained by the student year groups for the acid rain probe*

| **Knowledge of Acid Rain** | Grade 6 $n = 45$ | | Grade 7 $n = 78$ | | Grade 8 $n = 81$ | |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *S* |
| Total Score | 26.2 | 30.1 | 26.9 | 22.1 | 24.4 | 27.6 |
| Factor 1 | 33.3 | 38.3 | 31.6 | 32.2 | 29.6 | 34.2 |
| Factor 2 | 15.6 | 23.4 | 19.9 | 27.1 | 16.7 | 26.2 |

A glance at Table 5 reveals that the means of the students' total scores for this probe ranged from 24.4 to 26.9. For Factor 1 (i.e., things causing acid rain), the students' means varied from 29.6 to 33.3, and for Factor 2 (i.e., effects of acid rain), the mean scores of the different student groups were between 15.6 and 19.9.

It emerges from Table 5 that although 8th year students were older and educationally more experienced, their mean scores for the total and Factor 1 of this

probe were lower than those of 6th and 7th year students. Again, 7th year students had higher total and Factor 2 mean scores than those of 6th and 8th year students. On the other hand, 6th year students had a higher mean score on Factor 1 than the older students. Although some individual students scored relatively high scores for this probe, the mean scores were again generally very low for all class levels. Like the other two probes, the results seen in Table 5 indicate that students' knowledge levels for this probe were again at an insufficient level.

The one-way ANOVA results indicated that there were no significant differences among the means of students from different grade levels with regards to the total score ($F(2, 201) = .186$, $p > .05$), Factor 1 ($F(2, 201) = .177$, $p > .05$) and Factor 2 ($F(2, 201) = .489$, $p > .05$).

## Discussion

Along the lines of the constructivist environmental educationalists, this study is based on the claim that the understanding of taught environmental concepts during formal education is crucial to train environmentally conscious and responsible individuals. However, it was also emphasised that without a basic knowledge level of some environmental concepts that cannot be constructed by the individuals themselves through their personal experiences with the physical world or with the social world in which they grown up, the educational target of training environmentally responsible individuals cannot be achieved. This study therefore tried to determine the basic knowledge level of Turkish 6th, 7th and 8th year students about three global environmental problems: the greenhouse effect, the ozone layer and acid rain. The previous part of this article presented the results of the students' responses to a 25-item scale developed by Khalid (1999) and modified by us. In this part of the article, after presenting a general overview of the present results, the results for each probe will be discussed separately before having a look at the wider picture.

### *General overview*

Considering the possible scores that could have been obtained, the results of this study show that the students' total and factors mean scores were very low (see Tables 3, 4 and 5). This indicates that the knowledge about these three important environmental probes of Turkish students in the second stage of primary school is low. On the other hand, the high standard deviations reported for each probe and within each grade group imply that students in the same class level had heterogeneous knowledge levels.

*The greenhouse effect*

With total mean scores between 13.3 and 20.1 over 100, the results presented in Table 3 indicated a marked knowledge deficiency about the greenhouse effect among 6th, 7th and 8th year students. This knowledge appeared to be weakest among 6th year students.

Other research results in the field seem to support our findings. For example, Boyes & Stanisstreet (1992) reported that high school and university students have a knowledge deficiency and make some mistakes about the greenhouse effect. Similarly, Groves & Pugh (1996) maintained that college students suffer from misconceptions about the greenhouse effect and global warming. According to another study, some students have various misconceptions about the greenhouse effect, the ozone layer depletion and acid rain (Boyes et al., 1995). In another study by Boyes et al. (1999), it was found that Greek second stage primary school students had wrong and low levels of knowledge about the greenhouse effect. On their part, Leighton & Bisanz (2003) reported in their study that some students not only did not have a satisfactory knowledge level, but also had some misconceptions about the greenhouse effect. In a more recent study, Pekel (2005) reported similar results for Turkish high school students and prospective science and biology teachers.

It can be surmised from the studies reported above that students across different school levels (indeed, from the primary to university) and cultures either have insufficient knowledge or have some misconceptions about the greenhouse effect.

*The ozone layer*

The very low mean scores seen in Table 4 show that students in the three grade levels lack a satisfactory level of basic knowledge about the depletion of the ozone layer. Some studies from Turkey and from some other countries reported similar findings. For example, a recent study in Turkey concluded that the knowledge levels of secondary school students (i.e., in the second stage of primary schools) were lower than expected (Pekel & Özay, 2005). In another recent study, Pekel (2005) claimed that high school students and prospective science and biology teachers had a general lack of knowledge about ozone layer depletion. Much along the same lines, Cordero (2001) reported that university students did not have a satisfactory knowledge level about the depletion of the ozone layer. In their totality, the present results and the results of the other studies seem to depict a situation characterised by students generally not having a satisfactory knowledge level about the ozone layer depletion and some students also having various misconceptions.

*Acid rain*

According to Table 5, 6th, 7th and 8th year students had low and similar levels of knowledge about acid rain. Although their scores on the acid rain probe were higher than their scores on the greenhouse effect and the ozone layer probes, the fact that their acid rain mean scores averaged approximately 25% still indicates an insufficient knowledge level. This is again in line with the results of other studies. Boyes & Stanisstreet (1997) reported from their study on 14-15 year old students ($n$ = 1637) that most of them did not have sufficient knowledge about acid rain. Again, Brodie et al. (1989) pointed out that the gasses which cause acid rain were thoroughly unknown by students. Similarly, Dove (1996) showed that students did not have basic information about acid rain. According to other studies, students seem to confuse the different major environmental problems. For example, Cordero (2000) and Fisher (1998) reported that Australian students confuse the greenhouse effect with ozone layer depletion.

*The wider picture*

The wider research picture is equally strong in projecting an environmental knowledge deficiency in students. A study conducted by Bahar (2002) in Turkey revealed that students at university graduation level did not have sufficient knowledge about the greenhouse effect and the ozone layer depletion. Moreover, Groves & Pugh (2002) reported that among the environmental problems noted in the prospective teachers who participated in their study were the various mistaken information they had about global warming and the greenhouse effect. In Lebanon, a study by Makki et al. (2003) on students attending the second stage level of primary school established that although these students' environmental knowledge was far from satisfactory, their attitude towards the environment was high. These results indicate that there is no direct relation between students' knowledge and actions. Indeed, it appears possible to have an insufficient knowledge level about the environment but still have a positive attitude towards it.

## Planning ahead

Research findings, the present included, suggest that not only do students (from primary to university level) have a low level of knowledge about the greenhouse effect, the ozone layer depletion and acid rain, but that they also suffer from various related misconceptions or mistakes. For instance, while some confuse the greenhouse effect with ozone layer depletion, some others have no

idea which gasses cause acid rain. The situation is such that even student teachers that are going to be responsible for the teaching of environmental topics have a general lack of knowledge about ozone layer depletion, and have various mistaken information about global warming, the greenhouse effect and some other environmental problems.

It is however hoped that experts of environmental education (who can be involved in a variety of activities, such as, curriculum development, textbook writing and teacher training) analyse carefully the results of existing studies, including the present one, before proceeding to plan and to implement courses that teach environmental topics. This would, it is thought, ensure an improvement in students' knowledge levels about environmental topics (particularly pertinent here are the greenhouse effect, the ozone layer and acid rain) across all levels of education and also develop more environmentally sensitive citizens. The following recommendations are meant as guidelines towards this end:

- Early childhood is an absolutely critical time for environmental education (Palmer, 1999). These formative years leave an impact on children's thinking and feelings about the environment that will endure the passage of time. Needs also to be said that, as Palmer (1999) pointed out, young people (including the very young) are capable of far more complex thinking about environmental issues than many may think. In view of this, environmental experts should rethink their environmental education programmes in order to introduce seemingly difficult topics, such as the greenhouse effect, the ozone layer and acid rain, to students from an early stage provided that the methodology used suits the students' age and educational level.

- Since knowledge deficiency about issues, such as the ones investigated here, seems to continue throughout the various educational levels, it makes good sense to also develop appropriate techniques that help the older students to improve their environmental knowledge level and understanding.

- In the teaching sequence, curriculum designers, teacher trainers and the teachers themselves should bear in mind that students in all educational levels have various misconceptions about environmental concepts (Palmer, 1999). Formal education does not (and perhaps cannot) make a real impact on the nurturing of people's innermost feelings about the environment. Therefore, an appropriate curriculum should be designed for younger students to learn and understand these environmental issues.

- Topics related to the greenhouse effect, the ozone layer and acid rain are not simple concepts. Indeed, they rather constitute a set of concepts, a sort of a

conceptual framework or clusters. To reflect on a complex, integrated and multidisciplinary conception of natural phenomena, a multidisciplinary teaching sequence is needed.

- One of the aims of environmental education is to give individuals more environmental knowledge in order to change their behaviour so that they become environmentally responsible persons (Hungerford & Volk, 1990). To realise such a complex set of frameworks however requires effective teaching methods. For instance, Thompson & Stoutemyer (1991) proposed in their study two strategies for dealing with the dilemma of water consumption. One strategy focused on giving information about the potentially harmful long-term effects and other provided information linked to the immediate economic aspects. The authors reported that the only type of information that resulted in behavioural change was that which focused on long-term effects. This puts forward the case of designing and promoting a teaching approach that highlights the long-term effects of the three environmental issues discussed in this paper.

- In an environmental education program, the aim should not be the 'giving of environmental knowledge'. Instead, students should be taught how to acquire knowledge and how to use it to find feasible solutions to problems.

- It is important to include global environmental problems – such as, the greenhouse effect, ozone layer depletion, and acid rain – in the content of new environmental education programmes.

- As teachers are responsible for the teaching of environmental topics, their environmental knowledge levels and understandings need to be checked. The point is that should teachers have knowledge deficiencies, misunderstandings, or misconceptions about the frameworks involved, they may directly affect their students (Groves & Pugh, 1999).

The above recommendations are indicative of how much still needs to be done in order to come up with a suitable environmental education programme. One result from this study that may play a particularly contributory role here is the following:

> *'Although their scores on the acid rain probe were higher than their scores on the greenhouse effect and the ozone layer probes, the fact that their acid rain mean scores averaged approximately 25% still indicates an insufficient knowledge level.'*

For it would be interesting to know why the students' scores about the acid rain probe, although still insufficient, were higher than those for the greenhouse effect and the ozone layer probes. But to answer this, we need extra information that may be obtained through qualitative research and analyses of textbooks and educational programmes. Since this study aimed to investigate second stage primary school students' knowledge levels about the three global environmental problems of the greenhouse effect, the ozone layer and acid rain, their misunderstandings or misconceptions and the reasons behind their knowledge deficiency were not investigated. But given that these well-documented realities present obstacles to teaching, it is clearly important to also study what lies behind students' knowledge deficiency at various educational levels and their misconceptions.

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## References


Bahar, M. (2000). *Üniversite Ögrencilerinin Çevre Egitimi Konularındaki Ön Bilgi Düzeyi, Kavram Yanılgıları.* V. Uluslararası Ekoloji Ve Çevre Sorunları Sempozyumunda Poster Çalıflması, TUBITAK, Ankara.

Bakac, M., & Kumru, M. N. (2000) The radioactivity investigation in water and soil of Menemen (Izmir) Basin and heavy metal pollution, *Ekoloji*, Vol. 9(35), pp. 26-30.

Boyes, E., & Stanisstreet, M. (1992) Students' perceptions of global warming, *International Journal of Environmental Studies*, Vol. 42(4), pp. 287-300.

Boyes, E., & Stanisstreet, M. (1997) Children's models of understanding of two major global environmental issues (ozone layer and greenhouse effect), *Research in Science and Technological Education*, Vol. 15(1), pp. 19-28.

Boyes, E., Stanisstreet, M., & Chambers, W. (1995) Trainee primary teachers' ideas about the ozone layer, *Environmental Education Research*, Vol. 1(2), pp. 133-145.

Boyes, E., Stanisstreet, M., & Papantoniou, V. S. (1999) The ideas of Greek high school students about the 'ozone layer', *Science Education*, Vol. 83(6), pp. 724-737.

Brodie, M., Chipman, E., & Marion, S. (1989) Student knowledge of scientific and natural resource concepts concerning acid deposition, *Journal of Environmental Education*, Vol. 20(2), pp. 32-42.

Cordero, E. (2000) Misconceptions in Australian students' understanding of ozone depletion. In R. T. Cross & P. T. Fensham (eds.) *Science and the Citizen*. Melbourne: Arena Publications.

Cordero, E. C. (2001) Misconceptions in Australian students' understanding of ozone depletion, *Melbourne Studies in Education*, Vol. 41, pp. 85-97.

Demir, R. (1998) Determination of heavy metals in water melon grown in the neighborhood of Tigris river, *Ekoloji*, Vol. 7(26), pp. 18-20.

Dove, J. (1996) Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain, *Environmental Education Research*, Vol. 2(1), pp. 89-100.

Fisher, B. (1998) Australian students' appreciation of the greenhouse effect and the ozone hole, *Australian Science Teachers Journal*, Vol. 44(3), pp. 46-55.

Goncaoglu, B. I., Erturk, F., & Ekdal, A. (2000) Comparison of thermal power plants with nuclear power plants according to environmental impact assessment, *Ekoloji*, Vol. 9(34), pp. 9-14.

Groves, F. H., & Pugh, A. F. (1996) *College Students' Misconception of Environmental Issues related to Global Warming*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Tuscaloosa, USA.

Groves F., & Pugh A. (1999) Elementary pre-service teacher perceptions of the greenhouse effect, *Journal of Science Education and Technology*, Vol. 8(1), pp. 75-81.

Groves, F. H., & Pugh, A. F. (2002) *College Environmental Science Misconception-Resolution of an Anomaly.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Chattanooga, USA.

Hungerford, H. R., & Volk, T. L. (1990) Changing learner behavior through environmental education, *Journal of Environmental Education*, Vol. 21(3), pp. 8-21.

Khalid, T. (1999) *The Study of Pre-Service Teachers' Alternative Conceptions regarding three Ecological Issues*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. Boston, Massachusetts.

Leighton, J. P., & Bisanz, G. L. (2003) Children's and adults' knowledge and models of reasoning about the ozone layer and its depletion, *International Journal of Science Education*, Vol. 25(1), pp. 117-139.

Makki, M. H., Abd-El-Khalick, F., & Boujaoude, S. (2003) Lebanese secondary school students' environmental knowledge and attitudes, *Environmental Education Research*, Vol. 9(1), pp. 21-33.

Munson, B. H. (1994) Ecological misconceptions, *Journal of Environmental Education*, Vol. 25(4), pp. 30-34.

Newhouse, N. (1990) Implications for attitude and behavior research for environmental conservation, *Journal of Environmental Education*, Vol. 22(1), pp. 26-32.

Palmer, J. A. (1999) Research matters: a call for the application of empirical evidence to the task of improving the quality and impact of environmental education, *Cambridge Journal of Education*, Vol. 29(3), pp. 379-396.

Pekel, F. O. (2005) High school students' and trainee science teachers' perceptions of ozone layer depletion, *Journal of Baltic Science Education,* Vol. 1(7), pp. 12-21.

Pekel, F. O., & Özay, E. (2005) Turkish high school students' perceptions of ozone layer depletion, *Applied Environmental Education and Communication*, Vol. 4(2), pp. 115-123.

Peyton, B,. Campa, H., Peyton, M. D., & Peyton, J. V. (1995) *Biological Diversity for Secondary Education* (Environmental Education Module) [On-line]. Available: http://unesdoc.unesco.org/images/0011/001113/111306eo.pdf

Thompson, S., & Stoutemyer, K. (1991) Water use as a common dilemma: the effects of education that focuses on long-term consequences and individual action, *Environment and Behavior*, Vol. 23(3), pp. 314-333.