Trainee science teachers' ideas about environmental problems caused by vehicle emissions

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Contents

Abstract

The purpose of this study was to determine students' knowledge level and misconceptions about cars and environment. The sample group of this study consists of randomly selected students from Science Education Department of Gazi Education Faculty in Turkey. The measure is applied to total of 298 students where 174 of them are female and 124 are male. According to the results the majority of the students correctly realized that car emissions contribute to the greenhouse effect and acid rain; however they have some well-known misconceptions about the mechanism by which this occurs. A quarter of the students who saw cars as a source of global warming accept that this might happen via chlorofluorocarbons (CFCs). The major misconception, held by more than two-fifth of the students who realized that cars increase global warming, is that heat from car exhaust causes

greenhouse effect. Half erroneously thought that carbon monoxide (CO) from car exhaust causes acid rain. A fifth of the students erroneously held the idea that cars contribute to acid rain by emitting CFCs. Most of the students erroneously thought that car exhausts damage the ozone layer. The dominant idea appeared to be that carbon monoxide from car exhaust is responsible for ozone layer damage. This study offers a useful warning to science educators about some of the learning problems.

Keywords: Environmental education; misconceptions; vehicle emissions; trainee teachers.

Introduction

Despite of the fact that cars have a positive impact on growth as an integral component of our society, they have unpleasant effects on the local and global environment, health and social life.

As the main source of the air pollution, motor vehicles emit large quantities of gases and particles such as carbon monoxide, nitrogen oxides, sulphur dioxide, hydrocarbons and toxic substances including fine particles and lead (Colvile et al., 2000; OECD, 2002; Siddique, 2004). Motor vehicles are the cause of environmental problems such as acid rain and global warming (Littledyke, 2004; Siddique, 2004; Fuqi et al., 2005; Ghose et al., 2005; Elshout, 2006; Sushko et al., 2007) and contribute to the human health problems such as respiratory symptoms, asthma attacks, lung cancer, reduction in lung function, cardiovascular diseases, heart diseases, visual impairment, reduction in learning ability, leukemia, lymphoma, bronchitis, etc. (Brauer et al., 2002; Fisher et al., 2002; Oftedal et al., 2003; Crosignani et al., 2004; Reynolds et al., 2004; Lanki et al., 2006). Moreover motor vehicles have been partly responsible for social problems that effect daily life such as accidents, noise pollution, congestion, etc.

The vehicle population is growing rapidly. Therefore, cars have an increasing impact on the future environment. Since today's young people will be leading tomorrow's society, they must be well aware of the environmental problems (Hilman et al., 1996; Boyes and Stanisstreet, 1998b).

The nature and predominance of today's children's ideas, including their misconceptions, are important because today's young people, who are tomorrow's scientists or policymakers, will be affected by these problems and will need to

provide solutions to the environmental problems which will arise from our current actions (Boyes and Stanisstreet, 1997; Bradley et al., 1999). Moreover, many of today's young people will soon be individuals who make personal decisions about vehicle usage, and these decisions will carry environmental implications (Hillman et al., 1996).

Children are the masters of the future (Boyes and Stanisstreet, 1998b), so the students of today are the key factor in solving future environmental problems. Having correct knowledge about environmental issues will provide solutions for environmental problems. Effective environmental education for young people should be a fundamental and integral part of societies' education systems (Bradley et al., 1999). Furthermore, environmental education, which is an essential component in the dynamics of environmental protection (OECD, 2002), should bring changes in one's attitudes, values, beliefs and actions (Boyes and Stanisstreet, 1998b). The three major components of environmental literacy are attitude, environmental behaviors and environmental knowledge, which are being expressed in the frame of a deeper and profound understanding of the air pollution topic.

The focus of this study is to examine trainee science teachers' who will educate children about the environmental effects of cars. We studied today's young people's understanding of the links between cars and environmental problems. In addition, this study evaluates the role of gender regarding to the knowledge of students about cars and the environment in Turkey. This study is important because it explores young people's environmental knowledge and ideas in a developing country like Turkey, where environmental issues are not considered a main subject due to economical, social and cultural factors; and is interesting and valuable for the future of the world. Ideas about environmental issues are related to the cultural situation. From this aspect, Turkey has interesting and unique characteristics. The differences about environmental issues between the East and West can be reflected by Turkish students who are the next generation of car owners and drivers.

The literature review showed that there is no research concerning students' knowledge or ideas about cars and the environment in Turkey. So this study is unique in terms of revealing the knowledge of Turkish students. There is a strong need to analyze students' knowledge level and misconceptions in developing countries such as Turkey. In this regard, this study focuses on the following questions: (1) What are the misconceptions of Turkish students about the effect of

cars on environmental issues? (2) What is the effect of gender on students' knowledge? (3) What are the information sources that students use to gain knowledge about the environmental effects of cars? (4) What do the findings of this study suggest for improving environmental education?

Method

1 Sample

The sample group for this study consists of randomly selected 1st, 2nd, 3rd and 4th grade students from the Science Education Department of the Gazi Education Faculty in Turkey. The students were voluntarily involved. There were a total of 298 students in the sample with 174 females and 124 males.

2 Data Collection Tools

In this study, in order to identify university students' knowledge levels and misconceptions about traffic based environmental problems, we used a questionnaire which is basically prepared by Hilman et al. (1996) and Boyes & Stanisstreet (1997). The measurement tool consists of 35 items that are used to determine the knowledge of the students about "traffic-based environmental problems." The items of the measure are evaluated by Likert-type grades (true, false, no idea). In the data gathering phase, the "true" answers were graded by a score of "1," and "false" and "no idea" answers are given a score of "0." The maximum available score of the measure is "35."

The template questionnaire was applied to 150 students who weren't in the sample group. By using the data gathered from this set of students, the questions that were not understood clearly were reorganized. The questionnaire was examined by the experts in the field and the last version was formed. The validity and reliability tests of the questionnaire were conducted. Cronbach's alpha coefficient was used as the indicator of reliability, and the reliability coefficient was determined to be 0.875.

3 Data Analysis

The frequency (f) and percent of frequency (%) of the respondents was obtained and the knowledge level and misconception of the students were identified.

Due to the subject areas, the classification of the items in the measure are as follows:

1. The relationship between car exhaust and the global environmental problems.

2. Gasses that are produced by cars' exhaust.

3. The effect of the gasses and heat on environmental problems.

In order to determine whether the overall score differs by gender, independent groups of t-tests were carried out. The data were analyzed using SPSS (SPSS 13.0 for Windows, SPSS, Inc., Chicago, IL, USA).

Results and discussion

The results about gender differences are shown in Table 1.

Table 1. *T-test results of the overall score of the students by gender*

Gender	n	$\bar{x}$	S	df	t	p
Male	124	12.66	3.77	147	1.958	0.052
Female	174	11.47	3.57			

As shown in Table 1, overall scores of undergraduate students do not have a statistically meaningful difference according to gender ($t_{(147)}$=1.958, p>0.05). Due to these results, male and female undergraduate students have a similar level of knowledge about traffic based environmental problems.

The students answers about the relationship of car exhaust gasses with environmental problems are summarized in Table 2, where f is the frequency.

Table 2. *The questions about the effects of car exhaust on environmental problems*

EXPRESSIONS	True		False		No idea	
	f	%	f	%	f	%
Vehicle exhaust increases global warming (making the greenhouse effect worse)	286	96.0	2	0.7	10	3.4
Vehicle exhaust causes more acid rain	246	82.6	3	0.2	50	16.8
Vehicle exhaust damages the ozone layer	268	89.9	14	4.7	16	5.4

The majority of the students correctly realized that car emissions contribute to the greenhouse effect (96%) and to acid rain (83%). However, the majority of the students (90%) erroneously thought that vehicles also endanger the ozone layer. In a similar study that was performed among trainee teachers, two thirds of the students erroneously thought that cars damage the ozone layer (Hillman et al., 1996).

Previous studies in different countries have shown that although students correctly linked vehicle emissions with greenhouse effect and acid rain, they also incorrectly associated cars with ozone layer depletion. This misconception was common for students of different grade levels, ages and genders (Boyes and Stanisstreet, 1993; Boyes and Stanisstreet, 1994; Boyes et al., 1995; Leeson et al., 1996, 1997; Batterham et al., 1996; Dove, 1996; Hillman, et al., 1996; Boyes and Stanisstreet, 1997; Dimitriou, 2001, 2002, 2003; Khalid, 2001; Daskolia et al., 2006).

Motor vehicles are the most predominant source of carbon monoxide (Fisher et al., 2002) and three-forths (75%) of the students realized that car exhaust emissions include carbon monoxide, which is an odorless gas formed as a result of incomplete combustion of carbon containing fuels, including petrol and diesel (Fisher et al., 2002). It is interesting that only two-fifths (40%) of the students understood that cars emit carbon dioxide. Cars were considered a source of nitrogen oxide by relatively fewer (17%) students, but in fact motor vehicles are usually the major source of nitrogen oxides (Fisher et al., 2002). More than a third (34%) thought that car exhausts contain sulphur dioxide. In reality, although cars do emit some sulphur dioxide, exhaust emissions are responsible for only a small proportion of the

atmospheric load of sulphur dioxide (Hillman et al., 1996; Boyes and Stanisstreet, 1997). In fact, car exhaust does contain water vapor, however only a quarter of students agreed with this idea. 44% of the students evaluated acid vapor as a component of vehicle exhaust emissions. As might be expected, most of the students (84%) realized that car exhaust produces heat. On the other hand, about a third (31%) of the students erroneously thought that cars emit chlorofluorocarbon gases (CFCs). Many of the students (56%) responded in the "do not know" category here; and less than a seventh (13%) strongly rejected this idea.

Most of the students (80%) understood that carbon monoxide makes the greenhouse effect worse. 69% of them knew that carbon dioxide contributes to global warming. Only, 38% of the students realized that nitrogen oxide is responsible for global warming. More than half (52%) erroneously thought that sulphur dioxide causes the greenhouse effect. A similar proportion (53%) saw CFCs as a greenhouse gas. Almost half of the students (48%) based their answer on the erroneous idea that heat from car exhaust contributes to the greenhouse effect. More than two-third (69%) of the students considered acid vapor a cause of global warming.

Few (17%) saw water vapor as a factor for increasing the greenhouse effect. According to Hillman et al. (1996) and Boyes and Stanisstreet (1997), "it might be the reason that students imagine water as something which is 'clean' or even 'pure' and so an unlikely candidate for a 'pollutant'. In fact, water vapor *does* contribute to the greenhouse effect, although the water vapor in the atmosphere originating from vehicle exhausts forms only a small proportion of that in the atmosphere compared with that provided by evaporation of the oceans and other surface water."

Three-fourths (76%) of the students erroneously held the idea that carbon monoxide is responsible for acid rain. More than half (55%) saw carbon dioxide as a factor for more acid rain. Nearly half of the students (48%) thought that CFCs cause acid rain. Although only less than a tenth (9%) saw water vapor as a cause of acid rain, most (79%) imagined that acid vapor contributes to acid rain. About a quarter (23%) of the students thought that heat causes acid rain. Half (50%) of the students knew that sulphur dioxide contributes to acid rain and a third (%35) held the idea that nitrogen oxide is factor for acid rain.

The results showed that the majority of the total sample of the students (79%) erroneously thought that carbon monoxide damages the ozone layer. 57% of the

students saw carbon dioxide as a factor of ozone layer damage. More than half (52%) believed that sulphur dioxide damages the ozone layer. Data about erroneous ideas on the factors of ozone layer damage breaks down to: 35% for nitrogen oxide, 9% for water vapor, 73% for acid vapor and 32% for heat. More than half (56%) of the students knew that CFCs contribute to ozone layer destruction.

The detailed answers of the students were presented in Table 3 (components of car exhaust emissions) and Table 4 (the relationship between gasses and global environmental problems).

Table 3. *Questions about components of car exhaust emissions*

EXPRESSIONS	True		False		No idea	
	f	%	f	%	f	%
Car exhaust emits carbon monoxide (CO)	222	74.5	28	9.4	48	16.1
Car exhaust emits carbon dioxide (CO2)	118	39.6	110	36.9	70	23.5
Car exhaust emits chlorofluorocarbons (CFCs)	92	30.9	40	13.4	166	55.7
Car exhaust emits sulphur dioxide (SO2)	112	34.2	28	9.4	168	56.4
Car exhaust emits nitrogen oxide	50	16.8	54	18.1	184	65.1
Car exhaust emitst water vapor	76	25.5	112	34.2	120	40.3
Car exhaust emits acid vapor (acid gases)	130	43.6	46	15.4	122	40.9
Car exhaust emits heat	250	83.9	14	4.7	34	11.4

Table 4. *Questions about the relationship between gasses and the environmental problems*

EXPRESSIONS	True		False		No idea	
	f	%	f	%	f	%
Carbon monoxide gases increase global warming	238	79.9	12	4.0	48	16.1
Carbon monoxide gases cause more acid rain	226	75.8	22	7.4	50	16.8
Carbon monoxide gases damage the ozone layer	234	78.5	12	4.0	52	17.4

Carbon dioxide gases increase global warming	206	69.1	40	13.4	52	17.4
Carbon dioxide gases cause more acid rain	164	55.0	58	19.5	76	25.5
Carbon dioxide gases damage the ozone layer	170	57.0	78	26.2	50	16.8
CFC gases increase global warming	158	53.0	12	4.0	128	43.0
CFC gases cause more acid rain	144	48.3	14	4.7	140	47.0
CFC gases damage the ozone layer	168	56.4	16	5.4	114	38.3
Sulphur dioxide gases increase global warming	154	51.7	16	5.4	128	43.0
Sulphur dioxide gases cause more acid rain	148	49.7	22	7.4	128	43.0
Sulphur dioxide gases damage the ozone layer	156	52.3	24	8.1	118	39.6
Nitrogen oxide gases increase global warming	114	38.3	16	5.4	168	56.4
Nitrogen oxide gases cause more acid rain	104	34.9	16	5.4	178	59.7
Nitrogen oxide gases damage the ozone layer	104	34.9	28	9.4	166	55.7
Water vapor increases global warming	52	17.4	196	65.8	50	16.8
Water vapor causes more acid rain	28	9.4	210	70.5	60	20.1
Water vapor damages the ozone layer	28	9.4	204	68.5	66	22.1
Acid vapor increases global warming	206	69.1	26	8.7	66	22.1
Acid vapor causes more acid rain	234	78.5	10	3.4	54	18.1
Acid vapor damages the ozone layer	218	73.2	26	8.7	54	18.1
Heat increases global warming	144	48.3	66	22.1	88	29.5
Heat causes more acid rain	68	22.8	104	34.9	126	42.3
Heat damages the ozone layer	96	32.2	92	30.9	110	36.9

It is interesting that, in addition to the common misconceptions, some of the trainee teachers made logical errors that seem to be based on poor understanding of gases and their environmental effects. The misconceptions and paradoxical ideas (logical errors) of the students are summarized as follows:

Misconceptions about global warming:

A quarter of the students who saw cars a source of global warming accepted that this might happen via CFCs. Although CFCs make the greenhouse effect worse, cars do not emit CFCs. The same proportion of students thought that cars contribute to global warming via sulphur dioxide. In reality, sulphur dioxide from car exhaust is a small proportion of the total atmospheric load, and sulphur dioxide is not a greenhouse gas.

The major misconception, held by more than two-fifths of the students who realized that cars increase global warming, is that heat from car exhaust causes the greenhouse effect. In the previous research, similar misconception were found (Hillman et al., 1996; Boyes and Stanisstreet, 1997).

Logical errors about global warming:

4% of the students had a logical error specified by the following route (I? II? III);

(I) Cars give out sulphur dioxide; (II) Sulphur dioxide contributes to global warming; (III) Cars do not contribute to global warming.

Misconceptions about acid rain:

Half (52%) erroneously thought that CO from car exhaust causes acid rain. A quarter (23%) accepted that cars cause acid rain via carbon dioxide. A third (30%) of the students held the idea that acid vapor, which is emitted by cars, cause acid rain. Only a few (7%) thought that cars cause acid rain by emitting water vapor. A small number (14%) imagined that heat from car exhaust causes acid rain. A fifth (%20) of the students erroneously held the idea that cars contribute to acid rain by emitting CFCs.

Logical errors about acid rain:

4% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit heat; (II) Heat causes acid rain; (III) Cars don't cause acid rain.

8% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit carbon monoxide; (II) Carbon monoxide causes acid rain; (III) Cars don't cause acid rain.

4% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit CFCs; (II) CFCs cause acid rain; (III) Cars don't cause acid rain.

5% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit acid vapor; (II) Acid vapor causes acid rain; (III) Cars don't cause acid rain.

Misconceptions about the ozone layer:

The majority of the students held the erroneous view that car exhaust damages the ozone layer. The dominant idea (61%) appeared to be that carbon monoxide from car exhaust is responsible for ozone layer damage. More than a quarter (28%) accepted the idea that carbon dioxide from car exhaust causes ozone layer damage. A fifth of the students (21%) saw sulphur dioxide from car exhaust as a factor of ozone layer damage. Only 13% thought that cars damage the ozone layer via nitrogen oxide. Few (4%) imagined that water vapor from car exhaust damages the ozone layer. A third (34%) accepted the acid vapor route (cars→acid vapor→ozone layer damage). A quarter believed that cars damage the ozone layer by giving out heat.

Logical errors about the ozone layer:

3% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit heat; (II) Heat damages the ozone layer; (III) Cars don't damage the ozone layer.

4% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit carbon monoxide; (II) Carbon monoxide damages the ozone layer; (III) Cars don't damage the ozone layer.

3% of the students had a logical error specified by the following route (I? II? III);
(I) Cars emit CFCs; (II) CFCs damage the ozone layer; (III) Cars don't damage the ozone layer.

2% of the students had a logical error by the following route (I? II? III);
(I) Cars give out acid vapor; (II) Acid vapor damages the ozone layer; (III) Cars don't damage the ozone layer.

The limitation of this study is that, as in most of the similar studies, the results obtained from the present study cannot be generalized to a large population because of the small sample of students. Also, the results, which are based only on a questionnaire, cannot enable the researchers to deeply understand the students' perceptions. Air pollution is a problem that irritates society. There are different attitudes in the world to cope with this problem that integrate principles of sustainable development.

Conclusions and recommendations

This study offers a useful warning to science educators about some of the learning problems some trainee science teachers may be facing as they enter the classroom as environmental educators themselves.It is important for teachers to provide scientifically accurate or reliable knowledge about environmental problems. It is suggested that education should focus on scientifically accurate or reliable knowledge during teacher training and learning processes. Complicated and confusing issues should be examined together and trainers should discuss the differences in the issues. It is concluded in this study that Turkish undergraduate students have some confused ideas and little specific knowledge about the effects of cars on the environment. Also, little knowledge exists about the way in which students view the motor vehicle as an environmental problem. Perhaps trainee science teachers obtain scientifically inaccurate or unreliable knowledge through the media.

The results of such a study can guide and support environmental education curriculum. It is suggested that the Turkish environmental curriculum should be improved to include required knowledge about cars and the environment. Scientifically accurate or reliable knowledge is necessary for the students, who are the next generation of car drivers and owners, to protect the environment.

Activity-based science classrooms should play an active role in environmental education. Teachers should help students realize how they can prevent or manage environmental problems caused by cars. Some students' misconceptions may arise from scientifically inaccurate or unreliable understanding passed along by their teachers (Groves and Pugh, 1999). Environmental education should involve the largest possible section of the society, including parents and pre-school teachers (Daskolia et al., 2006). To strengthen students' environmental knowledge, which

improves environmental attitude (Asunta, 2003; Pe'er et al., 2007), they should be engaged in some environmental activities.

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