

## Turkish Students' Ideas about Global Warming

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**Abstract:** A questionnaire was used to explore the prevalence of ideas about global warming in Year 10 (age 15-16 years) school students in Turkey. The frequencies of individual scientific ideas and misconceptions about the causes, consequences and 'cures' of global warming were identified. In addition, several general findings emerged from this study. Firstly, many students believed that radioactivity is causally linked to global warming; they believed that radioactive leakage from nuclear power stations exacerbates global warming, and that reducing the global nuclear arsenal could reduce it. Secondly, students appeared to confuse the causes and consequences of global warming with those of ozone layer depletion. For example, global warming was associated by many students with skin cancer, in reality a consequence of ozone layer damage. Furthermore, there seemed to be a general conflation of ideas whereby many pro-environmental actions that are not, in reality, connected with global warming were seen by students as helping to reduce it. More generically, many students accepted the scientific mechanism of global warming while simultaneously believing erroneous explanations. Thus, acceptance of scientific ideas does not lead automatically to elimination of misconceptions about the same issue. On a more practical level, relatively few students realised that saving electricity would contribute to a reduction in global warming. Encouraging students to use electricity economically would be a way of educating them about the importance of pro-environmental actions by individuals and empowering them to undertake some such actions.

**Key words:** Climate Change, Global Warming, Students' Ideas, Turkey

### INTRODUCTION

Fifteen years ago it would have been prudent to discuss global warming<sup>1</sup> in tentative terms. More recently, what was once considered a debatable effect has become regarded by most scientists to be not only a real phenomenon, but also one that is an increasing threat to the world's environmental, social (IPCC, 1997; 2001) and economic (Stern, 2006) stability. Although it is difficult to ascribe any specific climatic change or environmental event to global warming, it is becoming clear that we are now beginning to see some of its consequences (IPCC, 2007). Thus, we observe changes in weather patterns and melting of the polar ice caps. In addition, it is anticipated that thermal expansion will result in a rise in sea levels and, as a result, coastal flooding in some areas. Global warming will cause geographical redistribution of some organisms whose ecological range is limited by temperature, and such

organisms may include crop pests and disease-carrying insects. Furthermore, it is likely that some of these changes will continue even if greenhouse gas concentrations could be stabilised (IPCC, 2007).

In the case of Turkey, it is anticipated that different regions, because of their characteristic geographic features, will be affected by global warming in different ways. Thus, the climate of Turkey may change over a relatively short time to become similar to that of the last geologic period, and Turkey may effectively enter the 'hot and dry' climatic zone of North Africa (Türkeş, 1994). This could result in a multiplicity of consequences. In physical terms there could be decreases in precipitation and water resources, with a concomitant increase in desertification. In biological terms, such changes could cause a decrease in forest areas and have negative impacts on biodiversity. In social terms, there could be detrimental impacts on agricultural activities, resulting in reduced income and increased unemployment (Türkeş, 1996).

Within these global and national contexts, Turkey is examining how it might contribute to a reduction in the production and emission of greenhouse gases. This effort is set against a background in which total energy consumption has risen since 1984 from about 37,000

<sup>1</sup> In this paper, for economy of words, we use the term 'global warming' to refer to the exacerbation of the natural greenhouse effect by the addition of anthropogenic pollutants to the atmosphere.

'gross oil equivalents' to 125,000 in 2005. Furthermore, this consumption is predicted to continue rising (Demirbaş, 2003). At present, Turkey produces less than half of its energy needs; the rest is imported. Much of Turkey's home-produced energy is generated from lignite and poor-quality coal which are energy-inefficient in terms of greenhouse gas emission. Almost two thirds of current home-generated energy is produced from biomass, but this proportion will decrease as limits to deforestation are imposed. More positively, Turkey is well-placed geographically to exploit various forms of renewable energy production. The west coast, along with other regions, is suitable for wind power (Hanağasioglu, 1999; Hepbaşlı and Özgener, 2004) to the extent that Turkey could, in theory, supply its likely energy needs from wind power alone (Aras, 2003). There is also considerable potential to use more hydropower (Kaygusuz, 2003). Finally, Turkey is the seventh richest country in the world in terms of potential geothermal power. Thus, although Turkey has insufficient hydrocarbon resources for its energy needs, it has a significant potential to exploit various forms of renewable energy which could allow it to meet its energy requirements while avoiding increasing carbon emissions. The problem Turkey now faces is the need for financial investment to effect large-scale transfer to the use of renewable energy sources. In a complementary fashion, it will be necessary for the citizens of Turkey, as in other countries, to make individual changes to lifestyles to conserve energy. For example, energy use in transport can be reduced by a shift to public rather than private transport, and domestic energy consumption can be decreased by changes in patterns of heat and light usage.

Such pro-environmental expenditure and actions to reduce global warming will require both political will and public assent. However, it may not appear politically expedient to governments to introduce measures which are expensive in terms of public finance or personal inconvenience to their citizens. Furthermore, because these actions are likely to be costly to individuals in terms of financial sacrifice and lifestyle restrictions, there might well be resistance to accepting them. The link between an understanding of environmental issues and a willingness to undertake pro-environmental action is somewhat tenuous, in that understanding does not necessarily lead to action (Courtney-Hall and Rogers, 2002; Kollmuss and Agyeman, 2002). However, we suggest that the introduction and acceptance of restrictions and a change in lifestyle will be eased if the public understands the need for them. In particular, it would seem important to have some comprehension of the nature of the problem of global warming, the likely consequences of inaction, and the ways in which it can be ameliorated (Boyes and Stanisstreet, 1993; Boyes, Stanisstreet, Yongling, 2007). Given this, it is important that those responsible for communicating ideas about major environmental issues have an appreciation of the pre-existing 'understanding' of the target population, including possible misconceptions, about global warming. The aim of this study is to explore the

prevalence of such ideas in a cohort of secondary students, the up-coming generation of decision-making citizens.

## METHODS

Year 10 students aged 15-16 from two secondary schools, one in Ankara, the other in Nevşehir, completed a questionnaire designed to probe their ideas about the possible consequences of, causes of, and cures for global warming. The instrument used in this study was derived from the questionnaire devised by Boyes and Stanisstreet (1993). The main part of the questionnaire was in three sections containing items about the consequences, causes and cures of global warming. Each section contained six items expressing scientifically orthodox ideas and six items expressing idiosyncratic ideas; these were in random order. The available responses to these closed questionnaire items were 'I am sure this is right', 'I think this is right', 'I don't know about this', 'I think this is wrong' and 'I am sure this is wrong'. In addition, the questionnaire included items which asked students to report how much knowledge about global warming they felt they had gained from television, the Internet, school, newspapers and the radio. One of the questionnaire items consisted of a free-response question; students were asked briefly to explain their understanding of the mechanism of global warming. The questionnaire was in Turkish; the wording and an English translation are shown in Appendix 1.

The cover sheet of the questionnaire explained and exemplified the response procedure. Students were informed that the questionnaire was not a test and no information about individuals' responses could be gained. Students completed the questionnaire individually, under the supervision of their normal classroom teachers. The responses were encoded into, and analysed using SPSS.

## RESULTS AND DISCUSSION

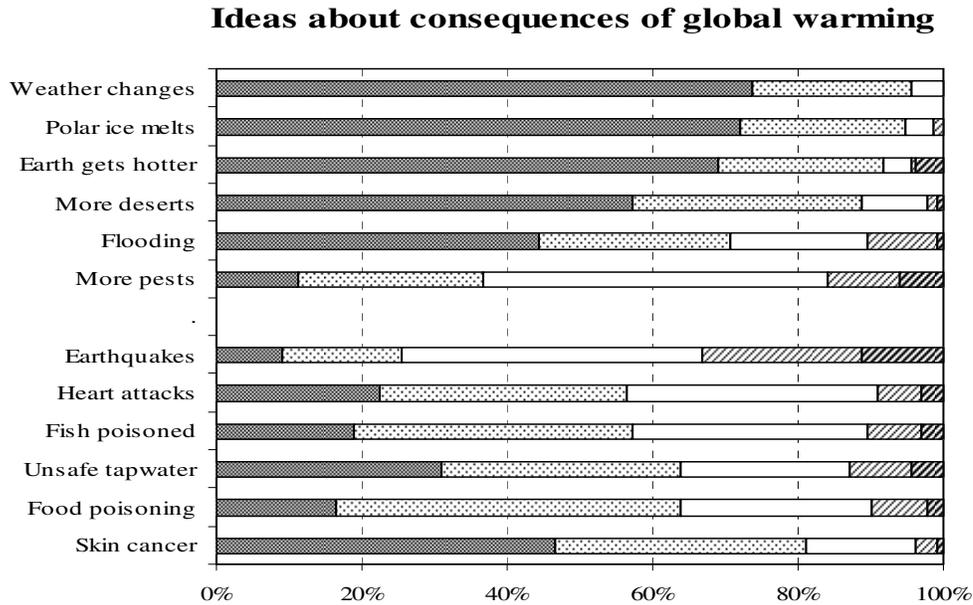
The results are illustrated graphically in Figures 1 through 3 and are described below. In the figures, the left hand, darkly shaded area of each bar indicates the proportion of students who were sure that the statement was correct, the next, lighter shaded area represents the percentage of respondents who thought the statement was correct, the central white area signifies the proportion of those who did not know, the right hand lightly cross-hatched area denotes the percentage of those who thought the statement was wrong, and the right hand, heavily cross-hatched area represents the fraction of students who were sure that the statement was wrong. The scientifically acceptable statements are in the upper part of each figure, arranged in descending order of the proportions of students who accepted the statement (combined 'sure right' and 'think right' responses). The lower part of each figure contains the scientifically unacceptable statements, arranged in

ascending order of students who accepted the statements. Thus, the most popular scientific statements are towards the top of each figure, and the most common misconceptions are towards the bottom

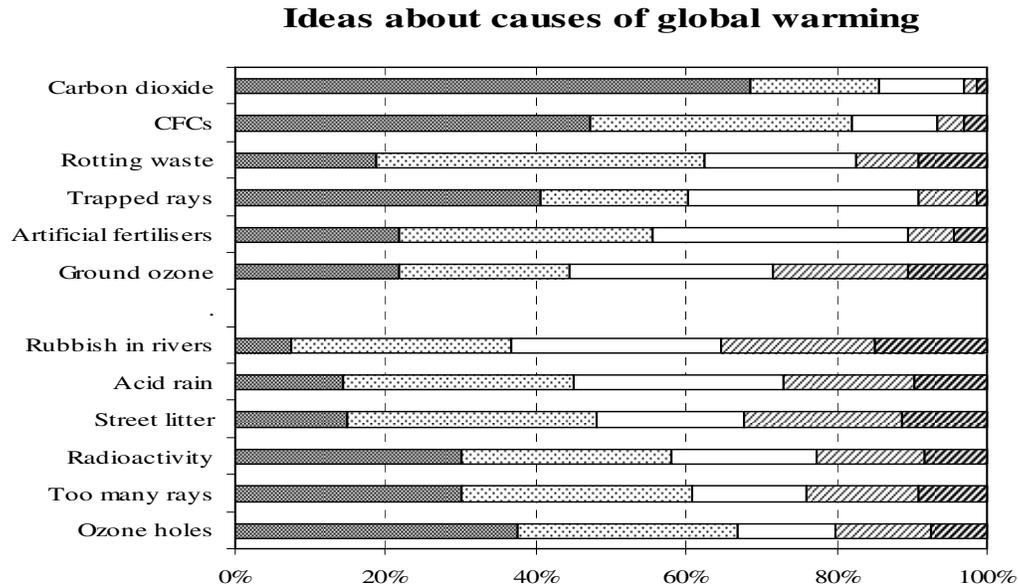
**Turkish students' ideas about the consequences of global warming**

The prevalences of students' ideas about the

*Figure 1 Turkish students' ideas about the possible consequences of global warming*



*Figure 2 Turkish students' ideas about the possible causes of global warming*



of each figure. In the descriptions below, the percentages reported are for those students who accepted the statement.

possible consequences of global warming are shown in Figure 1. The most popular idea about the consequences of global warming was that it would result

in changes to the weather (96%). Similarly, most students appreciated that global temperatures would rise (92%) and that there would be increased desertification (89%); the term ‘global warming’ is self-explanatory, and it is easy to imagine how students would make a mental link between deserts and high temperatures. The idea that the polar ice cap melting is a consequence of global warming was also popular (95%). About three quarters of the students (71%) knew that global warming would result in flooding. Rather fewer of the respondents, about a third (37%), realised that increasing global temperatures could extend the geographical range of insects, including crop pests. In general, then, Turkish students appear well informed about the physical consequences of global warming, probably through a combination of descriptive terminologies and strong media images.

In addition, the questionnaire also explored the prevalence of certain misconceptions which had been raised by students in previous studies using more open instruments (Boyes and Stanisstreet, 1993). Only about a quarter of the students (26%) associated global warming with an increased incidence of earthquakes. Greater proportions of the respondents, between about a half and two thirds, associated global warming with diseases such as cardiac problems (56%), fish poisoning (57%), unsafe drinking water (64%) and food poisoning (64%). However, the most common misconception, held by more than three quarters of the students (81%), was that global warming will result in an increase in the prevalence of skin cancer.

**Turkish students’ ideas about the causes of global warming**

The questionnaire also explored the prevalence of students’ ideas, both scientific and idiosyncratic, about

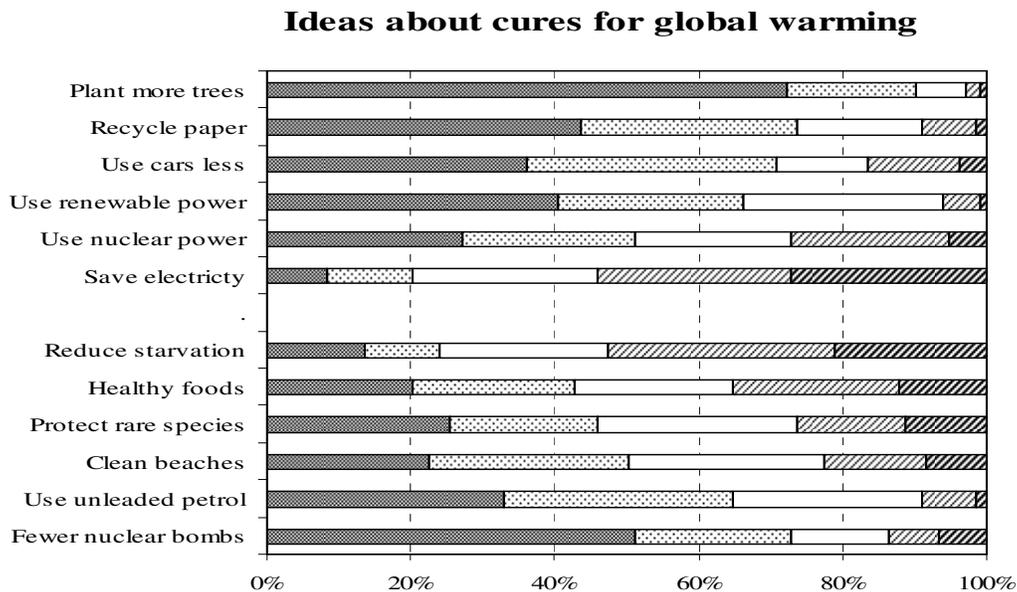
possible causes of global warming (Figure 2). Carbon dioxide was well known as a greenhouse gas (86%), as were CFCs (82%). Over half of the students recognised that gases from rotting waste (62%) and artificial fertilisers (56%) could exacerbate global warming, although it is not possible to know from this questionnaire whether students knew what these gases were (methane, and nitrogen oxides, respectively). Fewer of the students, less than half (44%), realised that ozone low in the atmosphere could act as a greenhouse gas, perhaps because ozone is envisaged as a ‘desirable’, ‘protective’ gas rather than a pollutant and because students do not distinguish between stratospheric and tropospheric ozone.

Fewer than half of the students thought that physical debris, either in the form of rubbish in rivers (37%) or street litter (48%) could exacerbate global warming. It might be that students are not tempted to ascribe a concrete cause to a phenomenon which is affectively abstract, and that can be detected only with sophisticated scientific instrumentation and computer calculations. A slightly higher proportion (58%) thought that radioactivity could aggravate global warming.

**Turkish students’ ideas about the mechanism of global warming**

Figure 2 also shows that almost two thirds of the students (60%) held the more acceptable view of the mechanism of global warming, whereby the ‘sun’s rays’ were said in some way to be ‘trapped’ by the earth’s atmosphere. However, similar proportions affirmed clearly erroneous mechanisms in which it was suggested that too many solar rays penetrate the atmosphere (61%) or, possibly connected, that ozone holes allowed solar radiation to penetrate (67%). Further analysis showed that 51% of the students affirmed both the scientifically

*Figure 3 Turkish students’ ideas about the possible cures for global warming*



more acceptable mechanism and the more erroneous views, demonstrating that acceptance of a scientific mechanism does not necessarily lead to the elimination of alternative ideas about the same issue.

The final item of the questionnaire was a free-response item which asked students to explain, briefly and in their own words, the mechanism of global warming. About a quarter of the students (28%) gave an explanation which could be considered to be congruent with scientific understanding. About a third of the students either gave no response (8%) or an explanation which was inadequate (28%). The major misconception seemed to confuse global warming with another major environmental problem, ozone layer depletion; this explanation was offered by about a third of the students (30%).

#### **Turkish students' ideas about the cures for global warming**

The third section of the questionnaire was designed to examine the distribution of students' ideas about how global warming might be ameliorated (Figure 3). Almost all of the group (90%) realised that planting more trees would reduce global warming. About three quarters of the students (74%) thought that recycling paper would help to decrease global warming, and a similar proportion (71%) appreciated the contribution that a reduction in car use could make. In terms of power generation, the benefits of renewable power were seen by two thirds of the students (66%). However, the advantages of nuclear power in this context were appreciated by only half of the respondents (51%). This may be because nuclear power has a rather negative environmental image, possibility due to accidents at nuclear power stations such as those at Chernobyl, or because of an association with nuclear warfare. Only a fifth of the students (20%) realised that saving electricity could help to reduce global warming. This is disappointing since economy in the use of electrical power in the home is within the locus of control of school students; there may be opportunities for effective environmental education here. Only a quarter of the students (24%) made an erroneous connection between global warming and the problem of food shortages in certain parts of the world. Nearly half of the cohort (46%) thought that protecting rare species might help to reduce global warming. Habitat degradation from global warming might well endanger certain species, but protecting rare species would not reduce global warming; here, then, students appear to be confusing cause and effect. About half of the group (50%) apparently made some sort of erroneous link between marine pollution and global warming, thinking that cleaning up beaches would reduce global warming. The most prevalent misconceptions, however, were those connected with cars and nuclear materials. Two thirds of the respondents (65%) imagined that using unleaded petrol would reduce global warming and more, nearly three quarters (73%) thought that reducing the world's nuclear arsenal could help.

#### **Turkish students' reported sources of information about global warming**

The final section of the questionnaire asked students about their sources of information about global warming. The most frequent source of information about global warming was school; on average, 39% of the students reported that they obtained information about global warming from this source. Television was the next most popular source, with 24% of students reporting that they obtained their information from television. Newspapers (17%) and the internet (14%) played less of a role in providing information about this issue, and radio apparently played only a minor role (3%).

#### **Themes in Turkish students' thinking**

In addition to the analyses above, the data were also subjected to Factor Analysis. This method offers a way of exploring themes in students' thinking by grouping questionnaire items according to the students' responses. The results of Factor Analysis are interpreted by examining each factor in turn and noting the questionnaire items with high loadings. Themes common to these items within a factor are sought and, if possible, the factor is given a name (shown in italics below) to encapsulate its theme.

Factor Analysis extracted 68% of the variance and produced 11 factors (Figure 4). The strong loadings on Factor 1 appeared to embrace some misconceptions about 'cures' which, although generally helpful pro-environmental actions in themselves, do not contribute to a solution for global warming. We might call this factor *Misconceptions about cures for global warming*. Factor 2 included the *Well-known consequences of global warming*. Embedded in this factor was the scientific idea, also well-established in this group of students, that carbon dioxide contributes to global warming. The next factor, Factor 3, appeared to centre on *Misconceptions about consequences of global warming*. Interestingly, the factor included the scientifically acceptable but less well known idea that global warming will increase the number of crop pests. Since some of the other ideas also included some relatively unpopular misconceptions about 'biological' consequences, such as poisoning of fish and humans; it may be that a reluctance to believe that a physical phenomenon can have biological consequences is responsible for the relative unpopularity of the idea that global warming could increase the prevalence of crop pests.

Figure 4 Themes in Turkish students' thinking revealed by Factor Analysis

Questionnaire item	1	2	3	4	5	6	7	8	9	10	11
Cure XXX More healthy foods	787										
Cure XXX Reduce world starvation	760										
Cure XXX Clean up beaches	715										
Cure XXX Protect rare species	622										
Cure XXX Reduce nuclear bombs	521										
Cure √√√ Recycle paper											
Cause XXX Ozone layer holes											
Cons √√√ Polar ice cap melting		760									
Cons √√√ Increased desertification		717									
Cons √√√ Changes in weather		666									
Cure √√√ Plant more trees		664									
Cons XXX Unsafe tap water			785								
Cons XXX River fish poisoned			766								
Cons XXX More food poisoning			618								
Cons √√√ More crop pests			561								
Cause XXX Rubbish in rivers				712							
Cause XXX Litter in streets				707							
Cause √√√ Ozone near the ground				575							
Cause XXX Radioactivity											
Cause √√√ Gas from artificial fertilisers					740						
Cause √√√ Gas from rotting waste					710						
Cause √√√ CFCs					577						
Cause XXX Acid in the rain											
Cause XXX Too many of sun's rays						-719					
Cure √√√ Renewable power						625					
Cure XXX Use Unleaded petrol						562					
Cons √√√ More flooding							678				
Cons √√√ Earth will get hotter							591				
Cause √√√ Sun's rays get trapped							546				
Cause √√√ Carbon dioxide											
Cons XXX More skin cancer								744			
Cure √√√ Use cars less								687			
Cons XXX More heart attacks									874		
Cure √√√ Save electricity										817	
Cons XXX Earthquakes										539	
Cure √√√ Nuclear power											808

'Cons' indicates a consequence of global warming, 'Cause' indicates a contributory cause of global warming, 'Cure' indicates an action that would reduce global warming. √√√ indicates an idea congruent with scientific understanding. XXX indicates an idiosyncratic idea. Only factor loading above 0.5 are shown, negative factor loadings are shown in italics, and factor loadings are shown x1000, for clarity.

## CONCLUSIONS

News items about global warming, its environmental consequences, and political manoeuvring to attempt to reduce it, occur frequently in the popular media, often accompanied by striking images. One might expect, therefore, that the majority of people would at least be aware of the problem of global warming that the Earth is facing. Indeed, an international survey of 21 countries has shown that overall about two thirds of the population claim to know at least something about global warming, and this situation is broadly reflected in the adult population of Turkey (BBC/PIPA/Globescan, 2007). The findings of the present study suggest that the majority of secondary school students are aware of the physical consequences of global warming. In part, this may be due to the fact that the nomenclature, global warming, describes the Earth getting hotter and, as an intuitive consequence, polar ice caps melting. Similarly, the fact that the term 'climate change' has become almost interchangeable with the term 'global warming' means that changes to weather patterns are a well-known consequence of global warming. Nearly three quarters of the students also seemed aware of the possibility of more flooding, although this may be based on the simplistic idea that as ice melts it increases the volume of the sea. These findings may be compared with those of Bozkurt and Cangüsü (2002) who studied the prevalence of similar ideas in 12 to 13 year old Turkish students. In general, their results suggested that a rather smaller proportion of students thought that global warming would cause flooding, polar ice melting and desertification than in the present study. In part, this difference may be due to the fact that these researchers used a three-point scale (true, don't know, false) – students may have been reluctant to reply that an idea was definitely true – but it also may represent a genuine increase in knowledge over the last five years or so since their work was published, as the effects of global warming have become more apparent and received greater publicity.

Rather fewer of the students in the present study, only about a third, were aware of one biological consequence of global warming, a possible increase in the range and number of insect pests. This may be because this idea requires some appreciation of the way in which the geographical distribution of poikilothermic organisms is limited by temperatures. Interestingly, some misconceptions about biological consequences were held by more than half of the respondents. Thus, students held the ideas that global warming would cause heart attacks, fish poisoning, and food poisoning in humans. The most prevalent misconception, however, was that global warming would result in more skin cancers. We suspect that this misconception is based on a deeper confusion between global warming and ozone layer depletion. As with English students (Boyes and Stanisstree, 1994; 1997), most Turkish students are aware that ozone layer depletion will increase the incidence of skin cancer, but many think that global warming is linked to ozone layer depletion, either causing it, or being caused by it (Pekel and Özay, 2005).

Similarly, many Turkish students confuse the scientific idea that carbon dioxide is a greenhouse gas with thinking that it also causes ozone layer damage (Pekel, Demir and Kaya, 2007).

About two thirds of the adult Turkish population believe that human activity in general terms has contributed to global warming (BBC/PIPA/Globescan, 2007). The results of the present study explore in more detailed the ideas of students about the specific causes of global warming. Carbon dioxide was well known as a greenhouse gas, as were CFCs, although the latter idea may be based partly on an erroneous mental link being drawn between global warming and ozone layer depletion, together with the fact that many Turkish students know that CFCs are a cause of ozone depletion (Pekel and Özay, 2005). About half of the students in the present study appreciated that gas from rotting waste (in reality, methane) and gas from artificial fertilizers (in fact, nitrogen oxides) could exacerbate global warming. Approximately two thirds of the students affirmed the scientific mechanism of global warming, the 'trapping' of solar energy by the Earth's atmosphere. This section of the questionnaire also showed that certain misconceptions about the causes of global warming were prevalent. There was some confusion between the causes of global warming and physical waste such as litter. Radioactivity was held by more than half of the students to be a cause of global warming. Nearly two thirds of the students thought that global warming was caused by holes in the ozone layer, again revealing a conflation in the minds of students of these two major environmental issues. Interestingly, a similar proportion of the respondents thought that global warming was caused by too many of the sun's rays reaching the Earth, suggesting that students might hold an apparently logical model for this misconception, in which the 'extra' rays are envisaged as coming through holes in the ozone layer. In addition, the fact that more than half of the students affirmed the correct mechanism and more than half affirmed an erroneous mechanism demonstrate that at least some students held the two in concert. This has important implications for teaching, in that assurance through assessment mechanisms that students have gained the scientific idea does not necessarily indicate that all students have had misconceptions displaced.

Other surveys have shown that more than half of the Turkish adult population accept that major steps to reduce global warming will have to be taken in the near future (BBC/PIPA/Globescan, 2007). This general support for pro-environmental action will, however, be frustrated in its purpose if the population do not understand what sorts of specific actions will be needed, because the link between general environmental knowledge and intention to act is weak (Rajcecki, 1982). The results of the present study reveal which particular actions Turkish young people think will be effective in reducing global warming. The most prevalent ideas were planting more trees and, perhaps related to preserving trees, recycling paper. Although recycling is not a particularly popular action in Turkey at present, the topic of recycling is included in the new Turkish

education curriculum, indicating the importance with which it is considered. Furthermore, there is increasing provision for recycling by various organisations. It is to be hoped that the combination of being an idea that is well-known by young people, increased emphasis of this action within the formal school curriculum, and improved provision for recycling (Corraliza and Berenguer, 2000) will increase the extent to which people are prepared to undertake this pro-environmental action. The idea that reduction in car use would help to reduce global warming was also affirmed by many of the students. When it came to alternative energy sources, renewable power was affirmed by more students than nuclear power, perhaps because radioactivity is seen by some as a cause of global warming. Rather few students thought that making economies with electricity use could contribute to a reduction in global warming. This is disappointing because this is one action that falls partly within the locus of control of students themselves. Furthermore, establishment of good habits during teenage years might well persist into lifetime practice. Clearly, there is an opportunity to improve the effectiveness of teaching in this area, especially since this topic is embedded in the new education curriculum in Turkey. One limitation to education about global warming, however, may be the confidence of teachers in this area. In England, for example, trainee teachers hold misconceptions about global warming (Boyes, Chambers and Stanisstree, 1995; Hillman, Stanisstree and Boyes, 1996). In Turkey too, a relatively small proportion of trainee teachers could accurately describe the mechanism of global warming (Soran et al, 2000). Relatively few students held the erroneous idea that reducing world starvation would help to decrease global warming although more, nearly half, thought that a healthy diet could have a role here. About two thirds of the respondents thought that using unleaded petrol would help to reduce global warming, apparently confusing global warming with air pollution with lead compounds. The most prevalent misconception, held by nearly three quarters of the students, was that reducing the world's nuclear arsenal would contribute to a decrease in global warming; presumably this idiosyncratic idea rests partly on the belief that radioactivity is a cause of global warming.

Some general findings concerning students' ideas about environmental problems emerge from this study, then. First, it appears that Turkish students, like those in other countries (Boyes and Stanisstree, 1993; 1994; Boyes, Stanisstree and Yongling, 2007), tend to confuse the phenomena of global warming and ozone layer depletion (Pekel, Demir and Kaya, 2007). Furthermore, there seems to be a more generalised conflation of ideas in that actions that are generally environmentally sympathetic, such as keeping beaches clean, and those that are advantageous for human health, such as using unleaded petrol, are connected in the minds of students to reducing global warming. The fact that radioactivity is thought by students to exacerbate global warming might be part of this general conflation of ideas, or it might be linked to the fact that we sometimes speak of

radioactive materials as being 'hot', with an ability to cause radiation 'burns'.

### Educational Implications

Some implications for teaching are raised by this study. One finding that may be of general application is that some students can apparently hold a scientific understanding of a phenomenon, the mechanism of global warming in this case, in concert with erroneous ideas about the same mechanism. In other words, incorporation of scientific ideas into students' mental frameworks does not preclude the inclusion of erroneous ideas about the same phenomenon. In the light of this, it might be helpful for teachers not just to enquire whether students have understood scientific notions, but also whether they have eliminated misconceptions. It is now clear that the exacerbation of global warming by anthropogenic greenhouse gases is a real phenomenon with serious consequences. Despite this, measures can be taken to provide some mitigation of the effects of global warming. Some of these measures will require political action, but others can be undertaken by individuals, even school students. The economic use of electricity in the home is one such action, although rather few of the students understood this. There is a teaching opportunity here to encourage students that individual actions can, if undertaken by many people, contribute to reducing global warming. Such teaching may both empower students and contribute to the quality of their future.

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ISSN: 1306 3065

**Appendix 1** *Wording of the questionnaire items (Turkish version as used and English translation)*

**English version**

1. Do you know about the 'greenhouse effect'? Can you explain it in a few sentences?
2. How much about the greenhouse effect do think you have learned ...
  - %... from television?
  - %...from internet?
  - %... from school?
  - %... from newspapers and magazines?
  - %... from the radio?
3. If the greenhouse effect gets bigger ...
  - ... the Earth will get hotter
  - ... more people will get food poisoning
  - ... there will be more flooding
  - ... more fish will get poisoned in the rivers
  - ... more people will get skin cancer
  - ... some of our tap water will become unsafe to drink
  - ... there will be more 'bugs' and 'pests' on crops
  - ... there will be changes in the world's weather
  - ... more people will die of heart attacks
  - ... there will be more deserts in the world
  - ... some of the ice at the North and South Poles will melt
  - ... there will be more earthquakes
4. The greenhouse effect is made worse ...
  - ... by rubbish dumped in rivers and streams
  - ... because too many of the Sun's rays get to the Earth
  - ... by too much carbon dioxide in the air
  - ... by too much ozone near the ground
  - ... by too much litter in the streets
  - ... by gas from rotting waste
  - ... by radioactive waste from nuclear power stations
  - ... by acid in the rain
  - ... by CFC gas from spray cans
  - ... by gas which comes from artificial fertilisers
  - ... by holes in the ozone layer
  - ... because the Sun's rays cannot escape from the Earth
5. The greenhouse effect can be made smaller ...
  - ... by having more nuclear power stations instead of coal power stations
  - ... by eating healthy foods
  - ... by keeping beaches clean
  - ... by using unleaded petrol
  - ... by reducing the number of nuclear bombs in the world
  - ... by planting more trees in the world
  - ... by making our electricity from wind, waves and tides
  - ... by using recycled paper more
  - ... by protecting rare plants and animals
  - ... by not wasting electricity
  - ... by reducing starvation in the world
  - ... by not using cars so much

**Turkish version**

1. Sera etkisi denen olayı biliyor musunuz? Birkaç cümleyle açıkla mısınız?
2. Sera etkisini öğrendiğiniz kaynağı %100 lük bir bütünü paylaşarak belirtiniz.
  - %...televizyondan
  - %...internetten
  - %...okuldan
  - %...gazete ve dergilerden
  - %...radyodan
3. Sera etkisi ile,
  - ....dünya ısınacak
  - ....çoğu insan besin zehirlenmeleri yaşayacak
  - ....büyük seller olacak
  - ....balıkların çoğu zehirlenecek
  - ....çok fazla insan deri kanseri olacak
  - ....içme sularımız kirlenecek
  - ....tahıl ürünlerindeki böcek ilacı oranı artacak
  - ....dünyanın havası değişmeye başlayacak
  - ....kalp krizlerinden çok fazla kişi hayatını kaybedecek
  - ....dünyada çölleşme oranı artacak
  - ....kutuplardaki buzulların bir kısmı eriyecek
  - ....çok fazla deprem olacak
4. Sera etkisinin kaynağı,
  - ....nehir ve denizlere bırakılan atıklardır
  - ....dünyaya ulaşan güneş ışınlarıdır.
  - ....havadaki aşırı CO2 gazıdır.
  - ....dünya yüzeyindeki aşırı ozon birikimidir.
  - ....şehirlerdeki çöplerdir.
  - .... atıkların çürümesiyle oluşan gazlardır.
  - ....nükleer enerji santrallerinin ürettiği radyoaktif atıklardır
  - .... asit yağmurlarıdır.
  - .... spreylerde bulunan CFC(cloroflorocarbon) gazıdır.
  - ....yapay gübrelerin ürettiği gazlardır.
  - ....ozon tabakasındaki deliklerdir.
  - ....dünya yüzeyinden yansıyan ancak uzaya dağılmayan ışınlarıdır.
5. Sera etkisinin tesirini azaltmak için,
  - ....kömürle güç üreten santraller yerine nükleer santraller kurulmalıdır.
  - ....sağlıklı besinler yenmelidir.
  - ....sahiller temiz tutulmalıdır.
  - .... .kurşunsuz petrol kullanılmalıdır.
  - .... dünyadaki nükleer bombaların sayısı azaltılmalıdır.
  - .... dünyadaki yeşil alan oranı arttırılmalıdır.
  - .... elektrik enerjisi gelgit,akıntı ve rüzgar gibi doğal yollarla karşılanmalıdır.
  - ....geri dönüşüme uğrayan kağıtlar kullanılmalıdır.
  - ....nadir görülen bitki ve hayvanlar korunmalıdır.
  - ....elektrik enerjisi kullanılmamalıdır.
  - .... dünyadaki açlık azaltılmalıdır.
  - .... arabalar ile ulaşım oranı azaltılmalıdır.