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Student teachers' conceptions about global warming and changes in their conceptions during pre-service education: A cross sectional study

Sabiha Odabaşı Çimer^{1*}, Atilla Çimer¹ and Nazihan Ursavaş²

¹Karadeniz Technical University, Trabzon, Turkey.

²Rize University, Rize, Turkey.

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Global warming is one of the important environmental problems whose dangerous effects are increasing gradually. The study reported herein aimed to reveal student teachers' conceptions about global warming and the effect of biology teacher education program on their awareness of this environmental issue. An open-ended questionnaire was used to collect the study's data. Participants were 32 first and 37 fifth year biology student teachers. The results showed that both groups had some confusions and concerns about global warming. All of the student teachers were under the impression that ozone layer depletion was the main cause of global warming and they assumed that greenhouse effect was completely an anthropogenic phenomenon rather than a naturally occurring process. In addition, the pre-service education did not seem to have an important effect on student teachers' awareness of global warming. Discussion of the findings and suggestions for teacher education and future research are included at the end of the paper.

Key words: Global warming, green house effect, ozone layer, biology student teachers.

INTRODUCTION

Global warming is one of the most important as well as complex environmental problems that have been receiving considerable attention from media, public focus as well as from scientists and policy makers worldwide for the last two decades. Simply put, global warming is an artificial increase in the temperature of the earth due to the intensified greenhouse effect occurring as a result of greenhouse gases (mainly carbon dioxide, methane, nitrous oxide, chlorofluorocarbons and ozone) produced from human activities, such as, burning of coal, oil, and natural gas, deforestation and various agricultural and industrial practices (Gül et al., 2009; GCRI, 2011).

Earth has a blanket of natural green house gases allowing sunlight to filter through while trapping heat. This phenomenon is known as the green house effect and it is

the key factor in earth's ability to maintain a temperature that sustains life. Although the greenhouse gases are effective in warming the earth, too many greenhouse gases increase global temperature. An increase in the human produced green house gases results in intensified greenhouse effect leading to global warming. Such increase in the green house gases also contributes to depletion or even disappearing of the ozone layer over some parts of the world. The ozone layer absorbs the ultraviolet radiation from sun, which has the capacity to seriously harm planet earth, including its life forms.

Although, the problem of global warming and the related issues such as green house effect and ozone layer depletion are frequently addressed in the printed media and television programs and students are taught these issues in their schools and at related college education courses, there are still some misconceptions, misunderstandings and confusions about the issues as identified by many research studies (Dove, 1996; Meadows and Wiesenmayer, 1999; Grove and Pugh,

*Corresponding author. E-mail: sabihaodabasi@gmail.com.
Fax: 00 90 462 248 73 44.

1999; Jeffries et al., 2001; Rebich and Gautier, 2005; Kahraman et al., 2008; Papadimitriou, 2004; Demirkaya, 2008; Shepardson et al., 2009).

Most of these studies researching into misconceptions of students about global warming and related issues have been conducted with students at elementary and secondary schools. A common finding of the studies was that students' conceptions about these issues did not coincide with the expert scientific knowledge. The main misconception reported in these studies is that students relate ozone layer depletion directly with the global warming.

There are few studies conducted with pre-service teachers (Groves and Pugh, 1999; Arsal, 2010; Cakır et al., 2010). Researching into elementary pre-service teachers' perceptions and concerns of green house effect, Groves and Pugh (1999) found that all of the participants in their study confused green house effect with ozone layer depletion and related skin cancer and ozone layer depletion with global warming.

Misconceptions can be gained by pupils' own experiences in life, even before they started school or through media, parents, and people around them, school books, and poor teaching in the classroom or from teachers who are less competent in subject matter knowledge (Yip, 1998; Tekkaya et al., 2000; Köse et al., 2006). If science education aims to educate students who are knowledgeable about environmental issues such as global warming and take responsibility for the management and policymaking decisions about the problems facing the planet (Brown, 1992; Bybee, 1993), then it is essential to reveal their misconceptions about these issues and to plan curriculum and instruction that builds on or challenging their existing conceptions (Driver et al. 1994).

According to constructivism, learning science requires determining learners' existing cognitive structures and building new understanding through modifying or restructuring (Glynn and Duit, 1995; Mintzes et al., 1998). Thus, revealing learners' existing knowledge and understanding will pave the way to plan curriculum and instruction that challenges and further develops their cognitive structures.

At this point teacher education has an important role in terms of educating future teachers. If student teachers have any misunderstandings about such important environmental issue they may spread this confusion and misconceptions to their future students. Thus, it is important to reveal and correct any misconceptions pre-service teachers may have before they start their teaching post. Hence, the study reported herein aimed to reveal student teachers' perceptions and their future concerns about global warming. The research questions of the study are:

1. What are the student teachers' perceptions about global warming?
2. Is there any difference between the perceptions of

student teachers who are at the beginning and at the end of their pre-service education?

This study is important for several reasons. First is that as indicated above most of the studies investigating conceptions about global warming and the concepts related to it are with elementary and secondary school students and there are few studies conducted with student teachers at colleges. This study investigated the conceptions of secondary biology student teachers. Second, most of the studies in the literature employed closed-ended response surveys to collect data while the present study used open-ended questionnaire to receive qualitative data which provided deeper insights into the student teachers' accounts of aspects of the issue of global warming. Finally, this study is also important as it is a developmental study researching into the conceptions of pre-service teachers at the beginning and at end of their college education.

METHODOLOGY

Sample

The study aimed to find out about student teachers' perceptions of global warming as well as to reveal if pre-service education had any impact on their perceptions. In order to reveal the difference between the perceptions of student teachers who are at the beginning and at the end of their education, the study was conducted as a cross sectional study. Cross sectional studies involve studying groups of participants in different age groups at the same point in time (Cohen et al., 2007). Thus this study was conducted with biology student teachers at the beginning (Year 1) and at the end (Year 5) of their pre-service education. Student teachers who agreed to participate in the study were given the questionnaire. They completed the questions individually and were assured anonymity.

Data collection instrument

In order to reveal student teachers' perceptions and concerns about global warming, an open-ended questionnaire was developed. The use of questionnaire was found to be useful as it added scope and breadth to the study by allowing for gathering information from more participants. Using only individual interviews to collect data from the same number of teachers would make completing the research unrealistic. In addition, open-ended nature of the questions provided deeper understanding of student teachers' accounts of aspects of the issue of global warming. The questionnaire consisted of 6 open-ended questions on the meaning and causes of the global warming, and the relationship between the global warming and green house effect and global, local and individual effects of global warming. The questions were designed to give student teachers the opportunity to provide extended answers related to the issues of concern.

Data analysis

The open ended questionnaire provided qualitative data in this study. The content analysis was conducted in an inductive manner in order to identify concepts and patterns in the written responses (Patton 2002). Throughout the paper, each student teacher is

identified as ST followed by two numbers; one is for the order of the student teacher and the other is to indicate at which year group the student teacher was. For example, ST 8-1 means that the order of the student teachers is 8 and that the student teacher was at Year 1.

RESULTS

The concept of global warming is defined as an increase in the temperature of earth's and ocean's surfaces due to the increase in the amount of the greenhouse gases in the atmosphere. In this study, the responses of the student teachers were analyzed by adhering to this definition. The analysis of the student teachers' accounts in the open-ended questionnaire showed that 10 (27%) of the Year 5 and only one of the Year 1 student teachers could provide a definition close to the expert definition given above. Nevertheless, their answers were either too general or not completely correct. One of the Year 5 student teachers' response below exemplifies this; "Global warming is the increase in the earth's temperature as a result of an increase in the atmospheric carbon dioxide level" (ST 5-5). A Year 1 student said; "global warming is the climate change as a result of increase in the earth's temperature" (ST 10-1). The accounts of the other student teachers from both groups contained various unempirical conceptions. Besides, their responses were not consistent, a student teacher whose response to one question coincided with the scientific view could provide an explanation that is not scientific as a response to another question. This may mean that the student teacher did not have a good understanding of the subject matter (global warming). The unempirical conceptions held by the student teachers that participated in this study is categorized into five groups and they are presented in Table 1 according to the year groups.

The accounts of the student teachers in both groups involved misunderstandings and considerable confusion over the relationship between global warming and the concepts of greenhouse effect and ozone layer depletion. Considerable number of student teachers from both groups tended to mix global warming with today's popular concept of ozone layer depletion. As much as 75% of the Year 1 and 62% of Year 5 student teachers actually wrote that global warming occurred as a result of ozone layer depletion in their responses to the questions asking the reasons for and or definition of global warming. In fact, it was clear from the overall analysis of their responses as a whole that they were of the impression that the ozone layer depletion was the main cause of global warming. One of the Year 1 student teacher indicated; "Global warming is the depletion of ozone layer by harmful gases which allows the sun's harmful rays to reach the earth" (ST 5-1). Similarly, a Year 5 student teacher said; "Global warming is the increase in world's temperature as a result of the sun's rays entering from

the holes in the ozone layer, which occur as a result of several reasons, for example, using and harming nature unconsciously" (S.31-5). Such assumption that the ozone layer traps excess heat from the sun is a false assumption. Rather than keeping heat out of earth's atmosphere, actually, the ozone layer filters out some key wavelengths of ultraviolet light from the Sun, which otherwise could seriously harm the world and all of its life forms. Another unempirical conception that was revealed in terms of the relationship between the ozone layer and global warming was that aerosol sprays, deodorants or hair sprays caused global warming. More than half of the student teachers in both groups indicated aerosol sprays in their responses to the questions about the causes and resolutions of global warming. A typical response to the question of "What are the reasons of global warming?" was "use of pollutants like perfume, deodorant, hairspray.... If we continue to damage ozone layer through using deodorants, perfumes, we will speed the global warming up and eventually, will face drought" (ST 3-1). Clearly, the student teachers' idea that these sprays contribute to global warming not because they contained greenhouse gases, but because they damaged the ozone layer indicates a belief that the ozone layer depletion was closely related or even equivalent to global warming. This belief was also evident in student teachers' comments related to their concerns of increasing cancer rates. More than 10% of each group of student teachers indicated that as a result of global warming cancer rates in the world increased. One of the Year 1 student teachers indicated; "as a result of global warming harmful chemicals reach the planet, which has resulted to cancer incidences in recent times" (ST 6-1). It was also evident in both Year 1 and Year 5 student teachers' comments that they confused ozone layer depletion with the intensified greenhouse effect. Over 20% of Year 1 student teachers and 10% Year 5 student teachers indicated that the ozone layer depletion would lead to climate change. Below account is the representative of most of these students; "Global warming is the disappearance of the seasons as a consequence of the depletion of ozone layer, and it is an event that effects life" (S.26-5).

Greenhouse effect was the least mentioned and also mostly misunderstood concept by both Year 1 and Year 5 student teachers. None of the Year 1 and only 8% of the Year 5 student teachers used the term "green house gas" in their definitions of the global warming. In addition, the questionnaire asked; "Do you think there is a relationship between the global warming and green house effect? If yes, please explain". More than half of the student teachers did not respond to this question. Five of the Year 1 student teachers wrote that there was no relationship between the two concepts. The responses of those who answered the question indicated that none of them really knew what green house effect was. The main assumption behind their accounts about the green house effect was that it was completely an anthropogenic phenomenon

Table 1. Student teachers' misconceptions about global warming.

Conceptions	Year 1 (n= 32)	Year 5 (n=37)
	(%)	(%)
Ozone layer depletion is the main cause of global warming	75	62
Ozone layer depletion causes climate change	20	10
Global warming causes green house effect	25	10
Green house effect causes global warming	21	18
Increase in the amount of atmospheric CO ₂ results in the green house effect	21	-
Increase in the amount of atmospheric CO ₂ destroys ozone layer	35	12
Aerosol sprays and deodorants contribute to global warming through destroying ozone layer	62	65

rather than a naturally occurring process. None of the student teachers' accounts showed an indication of the awareness about the real meaning of the green house effect. The responses of the student teachers regarding the green house effect fall into two groups. First group consisted of 21% of the Year 1 student teachers and 18% of the Year 5 student teachers who believed that the green house effect caused global warming. A Year 5 student teacher said; "Greenhouse gases cause an increase in the temperature of the earth" (S32-5). Similarly, a Year 1 student teacher said; "Global warming occurs as a result of green house effect which is a result of an increase in the atmospheric carbon dioxide level" (S.14-1). The second group, mostly Year 1 student teachers, believed that the green house effect was a consequence of global warming. One said; "Global warming affects our lives negatively. It causes drought, hunger, greenhouse effect, acid rains and something like that" (S.20-1).

As it is clear from the above accounts of the student teachers, there were two common misconceptions in the student teachers' accounts in this group. One is that they defined green house effect as an increase in the amount of atmospheric carbon dioxide which resulted in global warming. It should also be emphasized here that the only green house gas they identified was carbon dioxide. The second is that they were under the impression that green house effect was something harmful to the earth. Conversely, the greenhouse effect is a naturally occurring phenomenon which is actually useful as it regulates atmospheric temperature to keep the temperature on our planet suitable for living things. However, what is not good is the increase in the amount of greenhouse gases, which can cause the temperature to increase out of control. Seven of the Year 1 student teachers and one of the Year 5 student teachers provided responses that are not related to the concept of global warming. One of the student teachers' comment below exemplifies this; "(global warming) is a kind of statistical data measuring annual rates of temperature" (S.5-1). In addition, three of the Year 1 student teachers said that there was nothing called global warming. One said; "In my opinion, there is no global warming. However, nowadays the level of the

temperature is higher than before" (S.23-1).

On the whole, the findings showed that both groups of student teachers at Year 5 and Year 1 had unempirical conceptions about global warming and related issues. However, the level of knowledge and awareness of Year 5 student teachers seems higher than those of Year 1 student teachers. This may mean that pre-service teacher education made a difference, but, obviously, not sufficient as the student teachers who will soon graduate still have important unempirical accounts. This finding is important as the subject of the study are teachers of next generation. Global warming is a part of secondary school biology curriculum and the student teachers are expected to teach it when they start their teaching post. If they do not know what global warming is how can one expect them to teach it to their pupils. Likewise, if their misunderstandings are not revealed or corrected they may convey them to their pupils. Thus the results of this study present important implications for teacher education courses at both pre-service and in-service levels.

DISCUSSION

This study aimed to reveal student teachers' perceptions and future concerns about global warming. In addition, the study also aimed to investigate if pre-service education had any impact on the student teachers' awareness about an important environmental issue, the global warming. Data was collected from biology student teachers who were in their first and the last years of pre-service education, through a written questionnaire including open-ended questions.

According to the results of the study, the student teachers in both groups did not show an accurate understanding of global warming and its relationship with the concepts of ozone layer depletion and greenhouse effect. They had various misunderstandings and concerns, but they were more evident in the Year 1 student teachers' comments than those of Year 5 student teachers. All of the student teachers in both groups were of the impression that global warming was the result of

increased ultraviolet radiation due to the ozone layer depletion. Hence, the main cause of global warming was considered to be the ozone hole. They believed that the ozone layer formed a cover over the earth and when there was a hole in this cover, sun's rays entered the earth directly and that was what caused global warming. That is why it was a common idea in the student teachers' accounts that aerosol sprays and air pollutants contributed to the global warming as they adversely affected the ozone layer.

The concept of greenhouse effect also seemed to be problematic for both groups. The student teachers in the study knew little about the greenhouse effect and could not identify greenhouse gases beyond carbon dioxide. Furthermore, they were under the impression that greenhouse effect was completely an anthropogenic phenomenon rather than a naturally occurring process and it is something not good for the earth. Some of them indicated that the green house effect caused global warming while some thought that global warming resulted in green house effect. According to the researchers there are two important sources of unempirical conceptions of students; 1) daily life and 2) formal learning events (Strauss, 1981; Osborne and Cosgrove, 1983; Soyibo, 1993; Hanif, 1995; Rickinson, 2001; Shephardson et al., 2009). According to Rickinson (2001) television is the main source of information for students on environmental issues through nature programs, documentaries and movies. Thus, the student teachers' erroneous idea that ozone layer depletion is the main cause of global warming and climate change may be a result of television programs or the popular media that give more attention to ozone layer 'hole' (Hanif, 1995), as well as instruction in schools which integrates the concepts of global warming and ozone layer (Koulaidis and Christidou, 1999). Former studies also reported similar misunderstandings that learners had in relation to the ozone layer depletion, green house effect and global warming (Plunkett and Skamp, 1994; Dove, 1996; Boyes and Stanisstreet, 1997; Fisher, 1998; Meadows and Wiesenmayer, 1999; Groves and Pugh, 1999; Jeffries et al., 2001; Papadimitriou, 2004; Darçın et al., 2006). Plunkett and Skamp (1994) for example, interviewed 45 students, from grades 4 through 8, about the ozone layer and ozone hole. They reported that the students in their study had a conceptual framework that confuses ozone layer depletion and the greenhouse effect. However, an important point that should be born in mind here is that the subjects of most of these studies were pupils in schools while the subjects of the study reported herein were pre-service teachers who will soon be teaching pupils these concepts. Thus, they should have known the meaning of global warming and other related concepts. This finding presents important implications for pre-service education. Obviously, there is an urgent need to review the contents of instruction and textbooks in schools and in the pre-service biology teacher education courses in terms of the

teaching of the concept of global warming and related environmental issues. As insufficient formal instruction and textbooks can be sources of misconceptions, those who are responsible for designing curriculum and instruction as well as teaching should take care of the research results and design the content and methods of teaching accordingly.

Conclusions

On the whole, comparing the two groups based on their perceptions, it can be said that year 5 student teachers had more knowledge and less misconceptions than Year 1 student teachers. This result is expected as student teachers take the modules of Environmental Education and Ecology, in which the topic of global warming is covered in their fourth year of pre-service education program. However, although Year 5 student teachers had taken these modules, most of them still do not know what global warming really is. At this point, one can say that pre-service education contributed to the student teachers' awareness about global warming but, obviously, not sufficiently. Hence, the content and instructional methods of these modules should be reconsidered and student teachers' misunderstandings should be corrected before they start their teaching post so that they do not transfer those misunderstandings to their students and grow as environmentally conscious teachers.

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