Pre-service Teachers' Misconceptions Regarding Three Environmental Issues

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Abstract

This study identifies and describes misconceptions held by pre-service elementary teachers about three environmental issues: the greenhouse effect, atmospheric ozone, and acid precipitation. One hundred and thirteen students participated in this study. A 29-statement survey was used to probe students on the causes, effects, and interactions of the three issues. Responses were obtained both quantitatively and qualitatively. The major misconceptions found in the study include:

- the increased greenhouse effect may cause skin cancer,
- ozone depletion may cause global warming,
- ozone is a multifunctional layer, and
- pollutants evaporate with water, later come down as acid rain.

Recommendations regarding the changes in the curriculum and the classroom teaching practices are made for elementary teacher education programs to address the deficiencies identified in this study.

Résumé

Cette étude cerne et décrit des interprétations erronées entretenues par des stagiaires en enseignement primaire à propos de trois enjeux environnementaux : l'effet de serre, l'ozone atmosphérique et les précipitations acides. Vingt-neuf énoncés ont servi à sonder 113 étudiants sur les causes, les effets et les interactions de ces trois enjeux. Des réponses tant quantitatives que qualitatives ont été obtenues. D'après l'étude, les principales idées fausses sont, notamment :

- l'augmentation de l'effet de serre peut causer le cancer de la peau,

- l'amenuisement de la couche d'ozone est à l'origine du réchauffement planétaire,
- l'ozone est une couche multifonctionnelle, et
- les polluants s'évaporent avec l'eau et retombent ensuite sous forme de pluie acide.

Les recommandations concernant les modifications à apporter au programme d'études et aux pratiques d'enseignement visent les programmes de formation des enseignants du primaire afin de résoudre les lacunes cernées dans cette étude.

In an oft-told variation of Hindu myth of cosmology, a young boy asks his father what holds up the earth. Amused, the father assures his son that the world rests on the back of a very large turtle. "But what holds up the turtle?" the boy asks. After brief reflection, the father says, "A huge elephant". "But," the boy continues, "what is under the elephant?" Sensing that he is rapidly losing the control of the conversation, the father finally exclaims, "Son, it is elephants all the way down from there!" (Augustine, 1998, p.1640).

When people observe natural phenomena, they may try to interpret them using knowledge and intuition (Gallegos, Jerezano, & Flores, 1994). On the basis of this interpretation, they develop certain understanding of these phenomena. This understanding may not be in conformity with the scientific explanation. The above quotation is one of the examples of such alternative conception or misconception. People develop these misconceptions as a result of either personal experience, from other people, or through the media (Ausubel, 1968; Driver, Guesne, & Tiberghien, 1985). Research studies have revealed misconceptions regarding different natural phenomena held by the majority of people. These studies have concentrated on the misconceptions held by students, both before and during their school years, and at various levels of education (Wandersee, Mintzes, & Novak, 1994). These misconceptions sometimes become a hindrance in acquiring the correct body of knowledge (Arnaudin & Mintez, 1985). Sometimes students have such strong conceptions that even after learning the correct concepts, they resist modifying their pre-existing ideas. Instead, they try to interpret the new acquired knowledge using their preconceptions. As such, they keep their misconceptions (Driver et al., 1985; Pyramid Film & Video, 1988).

This study focuses on three environmental issues with a great impact on human beings: the greenhouse effect, stratospheric ozone depletion, and acid rain. Previous studies indicate that these phenomena are not only

complex but also abstract in nature (Boyes, Chambers, & Stanisstreet, 1995; Dove, 1996). Many students have only partial understanding of these issues because many times they fail to comprehend the processes that cause these problems and their effects on human beings and on the planet (Groves & Pugh, 1999). As a result, they develop a conception not in conformity with the scientific explanations. Moreover, research studies have found that the textbooks used in schools have inadequate or sometimes incorrect information (Soyibo, 1995). In this situation, teachers can play an important role by providing students adequate knowledge and clear conceptual understanding of these issues.

The fact that students at various educational levels have misconceptions regarding various natural phenomena has also been highlighted in the National Science Education Standards (National Research Council, 1996). According to the National Science Education Standards, students in the upper elementary grades start developing awareness of the issues related to various natural phenomena. Therefore, teachers should discuss these phenomena in their classrooms and try to eliminate student misconceptions. Several studies done by Boyes and associates in England between 1992 and 1996 with students at different educational levels, have supported the National Science Education Standards document's argument. These studies suggest that the persistence of misconceptions may result in an ill-informed citizenry with a reduced possibility of appropriate preventive actions by these citizens (Boyes et al., 1995). Despite the severe potential consequences of acid rain, greenhouse effect, and ozone depletion on life on Earth, very little research has been done to determine student understanding of these global issues (Dove, 1996). The majority of the research studies on misconceptions about the three areas have been done in England by Boyes and associates. No study was found in the United States that dealt with all three environmental concepts at any level of education, let alone with the pre-service teachers. Hence, this study will help determine various misconceptions held by American elementary pre-service teachers. If future teachers are misinformed or have poor understanding of the concepts, it is quite likely they will perpetuate these incorrect conceptions in their classrooms (Hooper, 1988).

The purpose of this study was to determine pre-service elementary teachers' knowledge level regarding the three environmental issues: the greenhouse effect, ozone depletion, and acid rain. I also wanted to determine their misconceptions regarding the nature, causes and effects of the three issues, and if they had a tendency to interrelate the two or more separate issues.

Methodology

Sample and Instrument

The sample for this study was one of convenience. The subjects were 113 students, 91 female and 22 male, majoring in elementary education at a large Mid-western university in USA. They were either juniors or seniors (third or fourth year of their undergraduate degree) and were taking a science teaching methods course. There were two reasons for choosing this population for data collection. First, by the time these students enroll in the science teaching methods course, they have taken all the required science courses for a bachelor's degree. Second, they will begin their professional career as elementary teachers in one to one and a half years.

The instrument was adapted from a survey questionnaire developed by Dove (1996). The questionnaire consisted of 29 statements; 12 were regarding the greenhouse effect, 10 were about ozone depletion, and 7 statements were about acid rain. Both quantitative and qualitative methods were used for data collection. The students had three choices to respond to each survey statement: "Yes," "No," and "Don't Know." The students were invited to explain their responses in the space provided below the statements. The pilot data were collected in the fall of 1997 and reviewed to determine the content validity of the questionnaire. In order to determine the construct validity, a panel of experienced faculty members from biology, environmental science, and science education critically reviewed the survey questionnaire. Data collection was undertaken during the spring of 1998 from six sections of a science teaching methods class.

Results and Discussion

The following account discusses the results from the analysis of the student responses to the survey questionnaire. Both quantitative and qualitative data are presented in this section. The quantitative data consist of students' categorical selections to each of the three responses in the survey statements: "Yes," "No," or "Don't Know." The qualitative data are based on students' written responses in which they explained their categorical selection. For the sake of analysis, I have presented sample statements with the highest frequency of responses, correct and incorrect, in each category: the greenhouse effect, ozone depletion and acid rain. Responses to the survey statements are discussed separately for each statement.

The Greenhouse Effect

Table 1 provides the percentage of students' correct responses to the statements regarding the greenhouse effect. Three statements with a high percentage of correct responses were chosen for the analysis. The numbers in the first column represent the numerical order of the statements in the survey. In the third column, the numbers represent the percentage of correct responses. The qualitative responses to these statements are discussed below.

No	Concepts	% Correct
02	CO_2 is the most abundant greenhouse gas.	46.90
06	If the greenhouse effect increases, the average temperature will rise.	85.84
09	The greenhouse effect will be reduec if we plant more trees.	45.13

Table 1. Elementary education major students' understanding of the greenhouse effect, percentage of correct responses.

Several students responded correctly to the second statement in the survey "CO_2 is the most abundant greenhouse gas." In their responses, the students stated various sources of CO_2 production such as burning of fossil fuels, respiration, and car exhausts. They mentioned that because of these production sources, CO_2 is an abundant greenhouse gas. The probable reason for these many correct responses is the influence of media. The role of CO_2 is frequently discussed in both the electronic and the print media. That may be why people know more about CO_2 as a greenhouse gas. This fact was mentioned by three respondents. One of the respondents said "there are other greenhouse gases, CO_2 is the one I hear about the most, so I assume it is most abundant." In their incorrect responses students mentioned names of different gases as the abundant greenhouse gases such as carbon monoxide, oxygen, and nitrogen. Other incorrect responses included "75% of the atmosphere is CO_2," "plants use CO_2 to breath like we use oxygen," and "this is the gas that plants give off and is good for us." In fact, even though carbon dioxide is the most abundant greenhouse gas, it is certainly not the most abundant gas in the atmosphere.

In response to the sixth statement in the survey, "If the greenhouse effect increases, the average temperature will rise," students gave both correct and incorrect explanations. The correct respondents said that an increased

greenhouse effect means more heat will be trapped in the atmosphere, which will raise the global temperature. The incorrect responses indicated the presence of several misconceptions among the students. The majority of those misconceptions were due to the confusion that either the greenhouse effect is caused by ozone holes or vice versa. Some of the respondents said "The ozone will get a bigger hole causing more solar radiation on earth," "ozone layer will be breaking down" which will result in "more direct sunlight." Two students provided a similar statement that the greenhouse effect is due to the holes in the ozone, which allow more UV rays from the sun to get through causing temperature to rise. Three students gave somewhat different explanations. One student said, "That's what experts say." Another student said, "That's what I have been told." Another person said, "I think I heard this somewhere." These words like "experts" and "somewhere" imply the source of information is the media where these issues are frequently discussed by the "experts."[1]

In response to the ninth statement "The greenhouse effect will be reduced if we plant more trees," students displayed some misconceptions in their explanations. These misconceptions were regarding the role of the trees in reducing the greenhouse effect. For example, "trees absorb some of the toxic gas produced by greenhouse effect," "Trees will put out more O_2 to combat (greenhouse) gases," and "trees provide ozone rich nutrients." The last explanation indicates the common misconception of relating the greenhouse effect and ozone depletion. The fact is that trees and plants use up some of the CO_2 during photosynthesis and in this way they may help reduce the greenhouse effect. However, the trees neither provide any ozone-rich nutrients nor release combatant gases to fight against the greenhouse effect.

Table 2 provides the percentage of incorrect responses from the students regarding the greenhouse effect. Three statements with the highest percentage of responses were selected for the analysis.

No	Concepts	% Correct
04	The greenhouse effect is primarily the result of human activity.	63
05	Holes in the ozone will increase the greenhouse effect.	59
08	If the greenhouse effect increases, more people will get skin cancer.	54

Table 2. Elementary education major students' understanding of the greenhouse effect, percentage of incorrect responses.

The responses to the fourth statement, "The greenhouse effect is primarily the result of human activity," indicate the influence of media on student thinking. For instance, one student blamed the media for providing the incorrect information about the greenhouse effect. The student said, "we always hear about the negative effects of the greenhouse effect b/c it can be detrimental. However, prior to the human activity causing an over abundance of CO_2, the greenhouse effect still existed." Student explanations for this statement displayed several misconceptions. The most common misconception was that human beings are destroying the ozone and that is causing the greenhouse effect. This statement indicates a tendency among students to believe that ozone depletion is causing the greenhouse effect or the increased greenhouse effect is depleting ozone. Many students incorrectly suggested that the human activities were the primary cause of the greenhouse effect. For instance, 12 students mentioned that human beings were contributing to the pollution. Others mentioned deforestation, automobiles and airplanes exhausts as the causes of the greenhouse effect. It is true that all of the above activities contribute toward the greenhouse effect; however, none of them is the primary cause of the greenhouse effect, a natural phenomenon.

There were a few correct responses to the fifth statement "Holes in the ozone will increase the greenhouse effect." Two of the correct respondents said that the ozone protects us from harmful rays. One person said, "I don't fully understand how the two are connected." On the other hand, the incorrect respondents displayed several misconceptions regarding the relationship between ozone depletion and the increased greenhouse effect. For example, nine students had a similar idea that hole in the ozone will let more sunlight (solar radiation) in the earth atmosphere. Similarly, three other students thought that the ozone holes allow greenhouse gases to enter the atmosphere. Three students mentioned that the ozone would not increase the greenhouse effect, the increased greenhouse effect would increase holes in the ozone. These statements reveal at least two major misconceptions among students. First, they think that either ozone depletion increases the greenhouse effect or an increased greenhouse effect will increases holes in the ozone. Second, the students seem to have incorrect conceptions of the nature of the ozone and its depletion. When the students used the word "hole" and that rays and gases can get in through these holes in the ozone, it seems like they think of hole(s) as ruptures in a solid layer that let sunrays and gases get through. This was one of the common misconceptions found among the students.

Responding to the eighth statement, "If the greenhouse effect increases, more people will get skin cancer," four correct respondents mentioned that skin cancer is caused by an increased intensity of UV rays and not by the increased greenhouse effect. One student explained, "I don't think the greenhouse effect will cause skin cancer." Another student said, "Skin cancer is caused by exposure to sunlight not heat." However, many students displayed misconceptions in their explanations. For example, 12 students mentioned that the increased greenhouse effect would cause holes in the ozone. These holes will let more UV rays through the atmosphere, which will increase the incidence of skin cancer among people. Two students mentioned that, "The earth's ozone will become less existent allowing more harmful rays to enter the earth's atmosphere." Four students said that the radiation will be stronger and there will be less chance of avoiding the direct sunlight. All these explanation indicate the incorrect conceptions among students that either greenhouse effect causes the ozone depletion or vice versa.

Ozone

Statements 13 through 22 of the survey pertained to ozone, its functions, and its depletion in the atmosphere. In Table 3, however, only four statements with the highest percentages of correct responses have been selected for the analysis.

No	Concepts	% Correct
13	Ozone in the atmosphere is vital for life on the earth.	96
16	The ozone filters out UV light.	89
17	CFCs cause ozone destruction in the atmosphere.	76
20	Use of some household items causes destruction of ozone.	96

Table 3. Elementary education major students' understanding of ozone depletion, percentage of correct responses.

For statement 13, "Ozone in the atmosphere is vital for life on the earth," several respondents displayed misconceptions in their explanations. These misconceptions include, "It (ozone) protects from too much sun rays coming through," "It (ozone) maintains temperature, ensures life and growth," "Without it (ozone) we will have too much sunlight and we

will die of heat stroke," "It (ozone) helps the correct amount of energy to pass through the earth for plants to grow and animals to live," and "The ozone layer is kind of like the cell membrane." It controls what enters and exits the atmosphere." All of the above and other similar statements indicate students' confusion in understanding the complex nature and function of the ozone in the upper atmosphere. The fact is that the stratospheric ozone does reduce the intensity of harmful UV rays but has nothing to do with the temperature regulation or controlling the energy level or the entrance or exit of "chemicals" in the atmosphere. This was mentioned by the students who explained their responses correctly.

No explanation was solicited for statement 16, "Ozone filters out UV light." This statement was an elaboration of statement 13.

Responses to statement 17, "CFCs cause ozone destruction in the atmosphere," display the lack of student knowledge of this concept. This factor was evident from some of the responses such as, "I don't even know what CFCs are," and "I have never heard of CFCs." Another student said, "Aerosol cans which produces CFCs are harmful to the ozone layer." One student said that CFCs "cause the ozone layer to dissolve." In fact the ozone molecules do not dissolve. There is a chemical reaction involved in the breakdown of ozone that releases oxygen molecules in the atmosphere. Many of the correct respondents gave the right explanation by saying that the CFC molecules breakdown the ozone up in the atmosphere. No one, however, mentioned chlorine in the CFC molecule, which is the main culprit in the ozone destruction.

In statement 20, "Use of some household items causes destruction of ozone," students were asked to write the names of some household items that may cause ozone depletion. Many of the respondents (about 50%) mentioned spray pumps that contain CFCs. Seven respondents mentioned refrigerators and coolants that contain CFCs. The incorrect names of the household items mentioned by students include ammonia, cleaners, and deodorants. Students mentioned ammonia probably because it is used in domestic cleaning purposes and many students were familiar with it. However, ammonia has not been reported to be harmful to ozone in the atmosphere.

Table 4 provides the percentage of the incorrect responses given by the subjects. Four statements with a high percentage of incorrect responses were selected for the analysis. The 14th statement, "Ozone regulates the earth's temperature" was meant to determine student understanding regarding the function of ozone as a temperature regulator. However, no explanation was asked for, because this was an elaboration of the 13th statement, "Ozone in the atmosphere is vital for life on the earth."

No	Concepts	% Correct
14	Ozone regulates the earth's temperature.	65
18	One cause of ozone depletion is the increased greenhouse effect.	43
19	One cause of ozone destruction is due to car emissions.	92
21	Pollution from factories is one of the causes of ozone depletion.	85

Table 4. Elementary education major students' understanding of ozone depletion, percentage of correct responses.

Statement 18, "One cause of ozone depletion is the increased greenhouse effect," is a different version of statement 5, which asked whether the ozone hole would increase the greenhouse effect. The qualitative responses to this statement reveal student misconceptions about the causes of ozone depletion. They were, ". . . one affects the other," "they (the greenhouse effect and ozone depletion) work together increasing each other," "(as a result of an increased greenhouse effect) more gases are trapped which eat away the ozone layer." These statements reveal the same misconceptions that one problem causes the other, either the greenhouse effect causes the ozone depletion or vice versa. Some of the explanations also reveal the fact that students got the incorrect conceptions through the media. One student mentioned that, "I think I have heard that on some TV show," and "I believe I have heard this on the news." The correct respondents, however, mentioned that these two phenomena are not directly related to one another. They are separate phenomena that occur in the atmosphere.

The responses to statement 19, "One cause of ozone destruction is due to car emissions," indicate the presence of misconceptions among several students regarding the causes of the ozone destruction. They think that CO_2 from car emissions are responsible factors. For instance, one student thought, "pollution especially that of car exhaust mainly CO_2 creates holes in the ozone layer." Another respondent said, "all pollution can cause ozone destruction." Therefore, according to their claim, car emission is one of the causes of ozone destruction. The role of the media in causing confusion cannot be ruled out. Sometimes these issues are discussed in the media in such a way that they cause more confusion than clarification. For instance one student said, "that's why I hear people say like about smog and stuff (in connection with ozone depletion)." Generally these issues are not

presented very clearly in the media and that sometimes causes these misconceptions. For instance one student said, " I remember hearing something about the car emitting and freon and it being harmful to the environment." Although freon is harmful for ozone, it is not the regular car emission. However, in the popular media, these subtle clarifications are not often made. As such the audience get incomplete and often confusing information.[2]

Another noticeable factor is that if people do not know the correct causes of a problem, they cannot suggest the appropriate measures to reduce it (Boyes & Stanisstreet, 1992). For instance, in this case, one student mentioned that because car emissions are hazardous to ozone that's why "environmentalists encourage car-pooling." The fact is that car-pooling can help reduce greenhouse effect or global warming, but it may not control the ozone depletion.

Statement 21, "Pollution from factories is one of the causes of ozone depletion in the atmosphere," was a different version of the 19th statement, which referred to car emissions. The responses for these two statements were not very different. Very similar explanations and misconceptions were seen in both the statements. The reason for using two conceptually similar statements was to determine if students had different perspectives for car and factory emissions. The analysis reveals that the majority of students responded to both statements 19 and 21 incorrectly and displayed the similar misconceptions.

Acid precipitation

Statements 23 through 29 in the survey pertained to the problem of acid precipitation. However, in Table 5 only two statements with the highest frequency of correct responses have been mentioned, because there were not many statements with a high percentage of correct responses in this category.

No	Concepts	% Correct
23	Burning some types of coal may lead to the production of acid rain.	68
27	Acid rain damages some stone buildings more than others.	89

Table 5. Elementary education major students' understanding of acid precipitation, percentage of correct responses.

Responses to Statement 23, "Burning some types of coal may lead to the production of acid rain," indicate student misconceptions regarding the formation of acid rain. For instance, two students said that emissions from the burnt coal rise to the clouds and mix with the rain. One student said, "Gases from the coal burning mix with the rain/moisture in the atmosphere and increase the level of acid in the rain." Another student said, "Pollution is caught in the rain. It falls." Some students blamed the burning of coal for ozone depletion. For instance, one respondent said, "When anything produces a smoke or harmful gas, it can produce and affects to our world and ozone layer." This statement indicates the presence of the misconception that ozone depletion and acid rain are related. Only two students explained their responses correctly by mentioning sulfur as the major culprit in the production of acid rain.

Students displayed some misconceptions while responding to statement 27, "Acid rain damages some stone buildings more than others." They showed misconceptions regarding the nature of the stones. They mentioned the statements such as, "Some stones are softer," "Some stone is more fragile than others," and "Some stone is weaker." Students also showed misconceptions regarding the chemical reaction between acids and the limestone. Some of them mixed up the chemical reactions with the dissolving. For instance, the statement, "Limestone, for example, is dissolved by acids," indicates this misconception. Dissolving is a physical change whereas the reaction between limestone and the acid is chemical. In a physical change, the chemical composition of both solute and solvent remains the same. On the contrary, chemical reaction results in change in the composition of the substances.

There were no statements with the significant incorrect responses in the "acid preciptation" category. However, statement 26, "Acid rain is caused by the increase in greenhouse effect," is worth mentioning here because it reveals some misconceptions among students in connecting the two apparently independent phenomena. Explanations such as "More CO_2 and other gases are abundant, causing the rain to be acidic" and "Chemicals are trapped in the atmosphere so when it rains these chemicals come down with the rain" indicate students' misconception that an increased greenhouse effect may make the rain acidic. Other explanations such as "Depletion of ozone causes build up of chemicals" and "The ozone is depleted so some acid gets through with the rain" reveal that students relate all three issues and think they are causative of each other.

Conclusion

The results from the qualitative part of the survey reveal student misconceptions regarding the nature, causes, and effects of the three environmental issues, the greenhouse effect, ozone depletion, and acid rain. The major misconceptions found in this study are summarized below.

- The greenhouse effect and ozone depletion are related. They have a causal relationship.
- An increased greenhouse effect will increase the incidence of skin cancer.
- Ozone is a multifunctional layer. It performs several functions, such as controlling temperature, balancing the amount of gases in the atmosphere.
- Pollutants such as car and factory exhausts can destroy the stratospheric ozone.
- CO_2 is one of the causes of ozone depletion.
- Ozone depletion may result in an increase in temperature on the Earth.
- Pollutants and chemicals evaporate with water and mix with clouds and come down as acid rain.
- Acids have a higher pH level than bases.

Similar findings were reported by other researchers. Dorough, Rye, and Rubba (1995) reported the presence of misconceptions among the elementary school subjects that ozone depletion and the greenhouse effect had a causal relationship. Boyes and Stanisstreet (1993) reported that their secondary school subjects had the misconception that an increased greenhouse effect will increase the incidence of skin cancer. Similar misconceptions were reported by Boyes, Chuckran and Stanisstreet (1993) with secondary school students and by Boyes and Stanisstreet (1992) and Khalid (2000) with college students.

Several reasons can be given for the presence of these misconceptions among the pre-service teachers in the present study, and their lack of knowledge of these fairly common environmental issues.

One major reason for the presence of misconceptions is the abstract nature of the concepts, such as the greenhouse effect and ozone depletion. Students generally receive verbal information regarding the nature and functions of these phenomena. As discussed earlier, students claimed that they did not receive complete information either from their classes or from the media. As a result of this incomplete information, the students made their own conceptual models to explain these abstract concepts.

Most of those models, however, were not consistent with the scientifically accepted explanations. The following example illustrates the presence of these mental models among students.

In the study it was obvious that the students knew the role of the greenhouse gases as heat absorbers. They also knew that ozone depletion would result in the entry of more UV rays to the earth atmosphere. In order to explain the occurrence of these phenomena, a large majority of students mistakenly developed a mental model that as a result of ozone depletion, more UV rays will enter the earth atmosphere where these rays will be absorbed by the greenhouse gases. Hence, they mistakenly concluded that ozone depletion would raise global temperature. Using the same mental model, some students concluded that ozone depletion would increase the greenhouse effect. Some other students, who appeared to be thinking on the same lines, concluded that the increased greenhouse effect would increase the incidence of skin cancer because more UV light would be absorbed by greenhouse gases. Because of ineffective classroom instruction and incomplete information from the media, the students failed to realize that greenhouse gases do not absorb solar radiation including UV rays. The scientifically accepted fact is that greenhouse gases are transparent for incoming solar radiation. However, they absorb the reradiated long wave heat energy to make the atmosphere warmer (Somerville, 1996). The presence of one incorrect conception resulted in the development of several incorrect mental models and many misconceptions among the students.

The role of the media can be considered an important factor in creating confusions and misconceptions among these students. The influence of the media was seemingly a major factor in developing student knowledge and shaping their thinking. In response to the survey statements, the students gave statements such as, "That's what I have heard" and "That's what I have heard on the news media." They blamed the media for inappropriate coverage by saying, "I am a victim of the media." Other researchers have also mentioned the media influence on student knowledge (Boyes & Stanisstreet, 1995; Dove, 1996) and its effects on people's opinion (Somerville, 1996). Similarly, carbon dioxide gas is known in the media as the only greenhouse gas. Its role was in the headlines during the fall and winter of 1997 during the time of the Kyoto conference in Japan. Student responses reflected this familiarity with carbon dioxide. Some of them mentioned that there might be other greenhouse gases, but as they pointed out, carbon dioxide is the one that is most frequently discussed in the media. This suggests the reason why everyone mentioned carbon dioxide;

but no one mentioned methane, a more powerful greenhouse gas than carbon dioxide, because it is not discussed in the media.

It was also noticed that the use of some common terms was a possible cause of confusion and misconceptions among students. For instance, the term "ozone layer" is a common term used to describe the atmospheric ozone. This phrase seems to give people an idea that ozone is some type of covering around the earth. The students thought of ozone as a thin layer like a membrane, or like a sheet around the Earth. In fact, it is a rare gas, which is spread in the stratospheric region among other gases such as nitrogen. Ozone makes up only a small component of gases in that region where its concentration is just a few particles per million. This concentration of ozone may vary according to its location around different geographical regions of the earth. At or near the equator, the concentration is higher than it is in the polar region (Somerville, 1996). However, the word "layer" gives students an idea, which is far from the reality and causes misconceptions. This misconception was apparent in the student responses to the survey statements when they used the analogy of "skin for the body as ozone for the earth" and "the ozone layer is kind of like the cell membrane." The term "layer" also gives students incorrect ideas about the functions of ozone in the atmosphere. These students thought of ozone as a multifunctional layer. Some of them thought that ozone helps control the temperature by keeping the sunrays out. Others thought that it maintains the balance of gases in the atmosphere.

Another related term "hole" is also a common term, used to describe the thinning or depletion of ozone. The use of this term seemingly causes confusion among students because they think of some type of damage or a rupture in the layer. The use of this term also gave students the incorrect idea that if the so-called hole or holes get bigger, there might not be enough oxygen on the planet; some students mentioned that oxygen gas would escape through the hole. Other students mentioned that heat would escape through these so-called holes in this imaginary layer, and this would make the environment colder.

The presence of misconceptions can also be attributed to ineffective classroom science instruction. Some students, during the conversation, complained that their science classes did not have any real impact on their knowledge. That is why, as they claimed, they did not remember the information. Instead, they remembered the information from the media. Some students complained that the environmental topics were not discussed in detail in their classrooms. This was a possible reason why these college students had some of the similar misconceptions that were identified by

Francis, Boyes, Qualter and Statnisstreet (1993) among 5th grade students, and by Christidou and Koulaidis (1996) among 5th and 6th grade students. These students retained their misconceptions unchanged up to the college level.

Recommendations

This array of misconceptions and inadequate knowledge of students raises several concerns in people's minds. These students will soon be teaching in their own classrooms. If they continue to hold these misconceptions, it is quite likely that they will perpetuate them in their classrooms (Hooper, 1988). As the three issues discussed in the study involve science concepts, student misconceptions about these issues reveal their lack of scientific knowledge. Therefore, before we begin thinking about future improvement, we have to review the present situation of teaching of science in our teacher education programs. At present, elementary education major students do not have an adequate science background, taking only a few science courses, usually with the students majoring in science (Anderson & Mitchener, 1994). These courses for science majors are generally a part of a series of courses. Elementary education majors, who take one or two courses out of that series, do not get the complete content. To avoid this problem, some universities have developed special science courses for elementary education major students. Sometimes these special science courses are basic in nature, and they do not provide sufficient scientific information to the students. As some researchers pointed out, "Often these courses are said to be watered down and inadequate" (p.14). This "inadequate and watered down" knowledge of science is not sufficient to help these student teachers clarify their confusion caused by the media. The research indicates that when these students become teachers, they are fearful of teaching science concepts in their classrooms. They either neglect science topics or depend too much on text book learning without its contextualization with the real world (Beiswenger, Stepans, & McClurg, 1998).

Considering the importance of environmental issues, some universities have started a separate required course in environmental education for every pre-service teacher (Maurice, 1996). This is a very practical step to help pre-service teachers improve their environmental knowledge. However, if these courses are "watered down and inadequate" they will be of no help to the pre-service teachers. The classroom practice also needs to be reviewed. Lord (1999) describes the problem with the current science classroom instruction. He says, "One of the reasons students do not retain

the information they learn is that science educators teach ineffectively" (p. 23). He further describes this ineffectiveness as teacher-centered science classrooms where teachers spend most of the time lecturing. According to Lord, this approach helps students get a good grade, but does not help eliminate their misconceptions. For teacher education programs, Lord (1999) cites Shymansky (1992) and says, ". . . in many of the most celebrated teacher-training programs in the nation, science education professors are schooling students about innovative and effective methods of teaching but doing so in a pedantic, traditional teacher-centered fashion. Because many professors of pre-service teachers do not use the innovative methods they espouse, it is not surprising that their students do not use these methods more when they become teachers" (p. 24). Lord's description of science classroom instruction makes it clear why the students in this study kept their misconceptions through their academic career and why they were influenced by the media misinformation.

By making these changes in our teacher education program, we can improve the knowledge level of our pre-service teachers and eliminate their alternative conception. In other words, they will be better prepared to teach the environmental issues in their classrooms.

Notes

[1] The word "expert" is commonly used in the media. Two examples explain the frequent use of this word in the media.

- "Experts doubt rise of greenhouse gas will be curtailed." (cover story); By: Stevens, William K., New York Times, 11/03/97
- "Experts on climate change ponder: How urgent is it?" By: Stevens, William K., New York Times, 09/09/97.

[2] During the verbal communication, the students were found to be upset with the media coverage of these important issues. One student said "if you were depending on the media (for their coverage of the environmental issues) they'd be for the worst." Another student showed her anger over the incomplete media coverage. She said, "I think in the media we hear about all of this, how this is happening, there is a hole in the ozone, blah, blah, blah. But they never go into the why and what. So, I think I am a victim of the media."

Notes on Contributor

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