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ABSTRACT

The focus of the study was to identify and describe environmental preconceptions held by preservice elementary teachers about three issues: greenhouse effect, ozone layer depletion, and acid rain. One hundred and thirteen junior or senior level elementary education majors enrolled in science methods courses at a large Midwestern university participated in this study. A 29-question survey was created by one of the authors. The question focused on the causes, effects, and interactions of three environmental issues, greenhouse effect, ozone layer depletion, and acid rain. Students answered the questions on a Likert Scale. Students were invited to explain their answers in the space provided below each question. In addition, five students agreed to an in-depth follow up interview to further explore their knowledge level and preconceptions. An analysis of the survey data indicates that the majority of preservice elementary teachers possess an array of incorrect ideas about the causes and effects of the greenhouse effect, ozone layer depletion, and acid rain. Recommendations are made for changes in the preparation of preservice elementary teachers to address the deficiencies identified in this study. (Contains 24 references.) (Author/YDS)

The Study of Pre-service Teachersí Alternative Conceptions Regarding Three Ecological Issues

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Pre-service Teachersí Alternative Conceptions Regarding Three Ecological Issues

ABSTRACT

The focus of the study was to identify and describe environmental pre-conceptions held by pre-service elementary teachers about three issues: greenhouse effect, ozone layer depletion and acid rain. One hundred and thirteen junior or senior level elementary education majors enrolled in science methods courses at a large Midwestern university participated in this study. A 29-question survey was created by one of the authors. The questions focused on the causes, effects, and interactions of three environmental issues, greenhouse effect, ozone layer depletion and acid rain. Students answered the questions on a Likert scale. Students were invited to explain their answers in the space provided below each question. In addition, five students agreed to an in-depth follow up interview to further explore their knowledge level and pre-conceptions. An analysis of the survey data indicates that the majority of pre-service elementary teachers possess an array of incorrect ideas about the causes and effects of the greenhouse effect, ozone layer depletion, and acid rain. Recommendations are made for changes in the preparation of pre-service elementary teachers to address the deficiencies identified in this study.

Introduction

> 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. ABut what holds up the turtle?@ the boy asks. After brief reflection, the father says, AA huge elephant.@ ABut,@ the boy continues, Awhat is under the elephant?@ Sensing that he is rapidly losing the control of the conversation, the father finally exclaims, ASon, it=s elephants all the way down from there!@ (Augustine, 1998, p1640).

When people observe natural phenomena, they try to explain them using their knowledge and intuition (Gallegos, Jerezano, & Flores, 1994). On the basis of this explanation, they develop certain perceptions of these phenomena. These perceptions may not be in conformity with the true or the scientific explanation. The above quotation is one of the examples of such alternative conception or misconception. People develop these incorrect conceptions as a result of either personal experience, from other people or through the media (Ausubel, 1968; Driver, Guesne, & Tiberghien, 1985). Research studies have revealed alternative conceptions regarding different natural phenomena held by the majority of people. These studies have concentrated on the alternative conceptions held by students, both before and during their school years, and at various levels of education (Review of Research in Education, 1990; & Handbook of Research in Science Teaching and Learning, 1994). These incorrect conceptions sometimes become a hindrance in acquiring the correct body of knowledge (Arnaudin & Mintez, 1985). Sometimes students have such strong preconceptions that even after learning the correct concepts in the classrooms, they resist modifying their pre-existing ideas. Instead, they try to interpret the new acquired knowledge using their preconceptions. As such, they keep their prior conceptions (Driver et al., 1985, A Private Universe, 1988).

Driver et al. (1985) have also reported studentsí alternative conceptions in different disciplines of science. However, little has been done so far to reveal students= alternative conceptions regarding the environmental issues. The researchers have found that students of various educational levels hold variety of misconceptions about the environmental issues.

Environmental education is taught at every level of formal education. One goal of environmental education is to provide students with the knowledge of various environmental problems and issues. As a result, it is expected that people will become aware of contemporary environmental issues and show their concern for problems such as pollution, deforestation and species extinction (Dove, 1996). There are, however, certain environmental issues, such as ozone layer depletion and the greenhouse effect, which are not only complex but also abstract in nature (Boyes, Chambers & Stanisstreet, 1995). Many students have only partial understanding of these concepts because many times they fail to comprehend the processes that cause these problems and their effects on human beings and on the planet. 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 in teaching these concepts. It is imperative that teachers provide an adequate knowledge base and clear conceptual understanding of these concepts.

Researchers have found that students at almost every level have incorrect conceptions about various global and environmental issues. This fact has also been highlighted in the National Science Education Standards (NSES). According to the NSES, students in the upper elementary grades start developing awareness of global issues. Therefore, teachers should discuss these global issues in their classrooms and try to eliminate their incorrect conceptions regarding these issues

(National Science Education Standards, 1996). Several studies done by Boyes, with Stanisstreet, Chuckran, and Chamber in England between 1992 and 1996 with middle school, high school and college students have supported the NSES document. These studies have revealed various preconceptions among students regarding the cause and effects of greenhouse effect, ozone layer depletion (Boyes Chamber & Stanisstreet, 1995) and acid rain (Dove, 1996). The result of these persistent wrong conceptions is an ill-informed citizenry and a reduced possibility of appropriate preventive actions by these citizens against these problems (Boyes et al., 1995). Despite the severe potential consequences of acid rain, greenhouse effect and ozone layer depletion on life on the earth, very little research has been done to determine students= understanding of these issues (Dove, 1996). The majority of the research studies on preconceptions about the three areas of greenhouse effect, ozone layer depletion, and acid rain have been done in England by Boyes et al. No study was found in the United States that dealt with all three ecological concepts at any level of education let alone with the pre-service teachers. Hence, this study will help determine various alternative conceptions 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 preconceptions in their classrooms (Hooper, 1988). The obvious result will be ill-informed citizenry in the future with several misconceptions. If they did not have proper knowledge of causes and effects of these and other environmental issues, it will be very hard for them to make correct decision to reduce and control these problems. This fact is evident in the research that indicates that if students have misconceptions about the causes of environmental issues, they, in most cases, suggested wrong or inappropriate measures to reduce the problems (Boyes, & Stanisstreet, 1992).

Definition of Key Terms:

Alternative Conception: Alternative conception or misconception is the variable used in this study. This term used to describe things that are misunderstood or interpreted incorrectly. This term has interchangeably been used as preconceptions, incorrect conceptions or perceptions and wrong conceptions in the article. At some places words terms like wrong ideas and incorrect ideas have also been used to describe the same idea. Description of the other major terms such as green house effect, ozone layer depletion, and acid rain is given below.

Greenhouse effect is a natural phenomenon that occurs when the gases in the surrounding atmosphere trap re-radiated solar energy. When the short-wave rays fall on the earth, some of them are re-radiated as long-wave rays. This long-wave infrared light in the form of heat energy is absorbed by the gases such as carbon dioxide, chlorofluorocarbons, methane, tropospheric ozone, nitrous oxide and water vapors present in the earth atmosphere (US Department of Energy, 1993). This trapped heat raises the earth=s temperature and makes it habitable. The gases that are responsible for trapping that heat are called greenhouse gases. Presence of these gases makes the earth warm enough for living things to survive. It is estimated that without greenhouse effect, the average temperature on the earth would be around -18^0 C (0^0 F) (Whyte, 1995). All the greenhouse gases are very rare in the atmosphere. However, the global trend of industrialization has resulted in excessive release of these greenhouse gases. This additional quantity of greenhouse gases help trap more re-radiated rays which results in more atmospheric warming than normal. This phenomenon is termed as global warming. If this global warming trends continues, it may bring about climatic changes and changes in the rainfall pattern on the planet (Kaufman & Franz, 1993)

Ozone is a gas made of three oxygen molecules. Presence of ozone gas in the atmosphere is a complex and abstract concept because it is found both in the lower atmosphere close to the earth surface, the tropospheric ozone, and in the upper atmosphere, the stratospheric ozone layer. The tropospheric ozone gas is Abad@ because it is a greenhouse gas. It absorbs UV rays from the sun and makes the atmosphere warmer than normal (Boyes et al., 1994). It is formed by the reaction of different pollutants in the presence of sunlight. Because of the presence of sunlight during the reaction, these chemicals are called photochemical smog. This gas is toxic in nature and causes eye irritation, damages skins and lungs, dries out mucous membrane of nose and throat, and many even cause asthma (Kaufman & Franz, 1993).

The stratospheric ozone layer occurs in the upper atmosphere where it acts as Agood@ ozone by absorbing the harmful UV rays from the sun. Its presence in the upper atmosphere is very important for life on earth. Excessive UV rays can cause sunburn, skin cancer, and eye cataracts. Longtime exposure may also damage the human immune system (Boyes et al, 1994). Certain innovative products like chlorofluorocarbons may damage the ozone in the stratospheric region. Chlorine atoms in the CFC molecules are the major culprits which combine with ozone (O_3) molecule and break them into oxygen molecules and keep themselves free to attack other CFC molecules.

Acid precipitation includes rain, snow, fog, mist or dust that is mixed with acids or compounds that are precursors of acids such as sulfuric acid, nitric acid or carbonic acid. Presence of these acids in the atmosphere increases the acidity of the precipitation. These acids in the atmosphere are formed by the oxides of sulfur, carbon and nitrogen, when they chemically combine with water vapors. The acidity of normal rain water is 5.6 on pH scale. This acidity is due to the presence of carbon dioxide in the atmosphere. Carbon dioxide when mixes with water forms weak carbonic acid. Below this pH, the precipitation is generally considered acidic (Somerville, 1996). Acid precipitation destroys the aquatic ecosystem, kills fish and other animals as well as aquatic plants. On land, the acid precipitation has harmful effects on corps, vegetation and on forests. It also harms the buildings made of marbles, limestone or calcareous cement (Dove, 1996).

METHODOLOGY:

Sample and Instrument:

The sample for this study was a sample of convenience. The subjects were 113 students majoring in elementary education at a large mid-western university. 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. Second, they will begin their professional career as elementary teachers in about one to one and a half years. The sample was quite homogenous, consisting mostly of Caucasian female students. There were 91 female and 22 male students in the sample.

The instrument was adopted from a survey questionnaire developed by Dove (1996). With the author=s permission, it was modified according to our needs and was used for the data collection. The questionnaire consisted of 29 statements, 12 were about greenhouse effect, 10 were about ozone depletion, and 7 statements were about acid rain. The questionnaire has both quantitative and qualitative components. For the quantitative part, a Likert Scale was used with three choices to respond to each statement, Yes, No, and Donít Know. For the qualitative part, the students were invited to explain their responses in the space provided below each statement. In order to get deep insight of students= knowledge, an interview protocol was also developed. However, most interview questions were based on students= answers to the survey questions.

Data Collection:

Data collection was undertaken during the Spring of 1998 from six sections of a science teaching methods class taught by four different instructors. During one class session, students filled out the survey questionnaire which took about 30 minutes to finish. For interview, a total of 23 students were randomly chosen from a pool of volunteers. The interviews were conducted individually and were tape-recorded. Each interview took about 20-30 minutes.

RESULTS

For the quantitative part of the survey, the responses were in three categories: Yes, No, and Donít Know. Results of the student responses to the survey questionnaire, both quantitative and qualitative are presented in the tabular form in the appendix. The quantitative results are given in table 1 and the qualitative responses are given in tables 2-4 in the appendix. For the sake of analysis, I have selected those statements that have frequency of responses (correct and incorrect) 50% or higher. I have ranked them in order of frequency of responses. These small tables have been inserted in the text. Complete tables are, however, given in the appendix. Responses have been discussed separately for each statement.

Table 1

Elementary Education Major Studentsí Understanding of the Greenhouse Effect

Frequency of Correct Answers

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

The above table provides the information of studentsí knowledge about the greenhouse effect. In the survey, first 12 statements are pertinent mainly to the greenhouse effect. In the above table, I have chosen only three statements because of their high percentage of responses. The numbers in the first column represent the numerical order in the survey. In the table, I have ranked the statements in the order of percentage of correct responses. These statements and their responses have been discussed below.

Statement two of the survey was meant to probe studentsí knowledge about the composition of the greenhouse gases in the atmosphere. It is ranked two in the above table because of the high percentage of correct responses. About 47% agreed with the statement that CO_2 is an abundant greenhouse gas and only 17% disagreed with it. About 37% chose the "Donít Know" response. In their qualitative responses, students mentioned various sources of CO_2 production such as burning of fossil fuels, respiration and cattle flatulence. They mentioned that because of these sources of production, 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 is why people know more about CO_2 as a greenhouse gas. This fact was mentioned by three respondents. They said "there are other greenhouse gases, CO_2 is the one I hear about the most, so I assume it is most abundant." Students also showed several incorrect conceptions. They mentioned names of different gases as the abundant greenhouse gases such as carbon monoxide, oxygen, and nitrogen. Few other misconceptions include "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."

The sixth statement of the survey has the highest percentage of correct responses in the greenhouse effect category. The purpose of this statement was to probe studentsí knowledge of consequences of the greenhouse effect. About 86% agreed with this statement and less than 4% disagreed whereas 10% chose Donít Know response. The reason for this huge number of correct responses is quite obvious, as the increase temperature as a result of the greenhouse effect is one major topic among the media discussions. Therefore, the majority of the students knew the correct response. It was also obvious from some of the responses that said that increased greenhouse effect means more heat will be trapped in the atmosphere which will raise the global temperature. Thatís the phenomenon called global warming. Several misconceptions were also seen in the studentsí explanations. The majority of them were because of the confusion that either greenhouse effect is caused by ozone holes or vice versa. Some of the statements 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 said " the greenhouse effect is due to the holes in the ozone layer which allow UV rays from sun to get through causing temperature to rise. Three students mentioned different explanations. One person said " thatís what experts say." Other student said " that ës 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 "experts" usually discuss the greenhouse effect and its potential threats of the global warming.

The ninth statement was meant to investigate some controlling measure for the greenhouse effect. It was rank third in the above table one because of the mixed response. More than 45% respondents chose "Yes" about 42% chose the Donít Know category to respond. Although, 45% agreed with the statement, they showed some misconceptions in their explanations. 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 two explanations indicate the common misconception of relating greenhouse effect and ozone depletion. The fact is that trees and plants will use up some of the CO_2 during photosynthesis and in this way they may help reduce the greenhouse effect. This was the argument given by 13% of the respondents who chose "No" response to this statement.

Table 2

Elementary Education Major Students, Understanding of Greenhouse Effect

Frequency of Incorrect Responses

No	Concepts	% Incorrect
04	The greenhouse effect is primarily the result of human activity.	62.83
05	Holes in the ozone layer will increase the greenhouse effect.	59.29
08	If the greenhouse effect increases, more people will get skin cancer.	53.98

The above table provides information about the incorrect responses of the subject regarding the greenhouse effect. Three statements with the highest percentage of responses were selected for analysis in this category.

The fourth statement of the survey has the highest percentage of incorrect responses in the greenhouse effect category. The intent of this statement was to ask students about the causes of the greenhouse effect. This statement has the highest percentage of incorrect responses in this section. About 63% respondents agreed and about 17% disagreed with the statement whereas 20% selected the Donít Know choice. The correct respondents who disagreed with the statement explained that the greenhouse effect is s natural phenomenon which might be caused by certain natural activities such as volcanic eruptions and animal flatulence. Ocean also gives off CO_2. One student blamed the media for these incorrect conceptions about the greenhouse effect. The student said "we always hear about he 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." Those students who agreed with the statement showed several incorrect conceptions. The most common wrong conception was that the human beings are destroying the ozone layer that is causing the greenhouse effect. This indicates the tendency among students that they thing that ozone depletion is causing the greenhouse effect or the increased greenhouse effect is depleting ozone. Many students gave correct explanation but to prove the wrong notion that human activities are 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. All of the above activities contribute toward the greenhouse effect, however, none of them is the sole responsible for causing the greenhouse effect. They are just contributors to the increased greenhouse effect or the global warming.

One purpose of the fifth statement was to probe the causes of the greenhouse effect. It was also meant to determine studentsí incorrect ideas regarding relationship between ozone depletion and the increased greenhouse effect. In the quantitative section, over 59% agreed with the statement and only about 17% disagreed, the correct response. About 24% chose the Donít Know response. This 59% "Yes" or agree response indicates studentsí misunderstanding that ozone depletion will increase the greenhouse effect. The qualitative section revealed several misconceptions among students. These misconceptions were given by those who agreed with the statement. For example, one statement " more sunlight (solar radiation) can get in" mentioned by nine students, and another statement ë they (the so-called ozone holes) allow greenhouse gases to enter the atmosphere" was mentioned by three respondents. These and a few other similar 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 ëholes in the ozone as mentioned by three students "it is the oppositeóthe greenhouse effect will increase holes in the ozone layer." Second, the students seem to have incorrect conceptions of the nature of the ozone and its depletion. When the students used the world hole and that rays and gases can get in through these holes in the ozone, it seems that they think of holes (s) as ruptures in a solid layer that allows sun rays and gases get through. This was on the common misconceptions found among the respondents. On the other hand some of the respondents who disagreed with the statement gave correct explanation. Two respondents said " ozone protects us from harmful rays. One person said " I donít fully understand how the two are connected."

The eighth statement of the survey was the third in the rank order in the table 2 above. About 54% respondents marked "Yes" to this statement, the incorrect response. The majority of the students gave very similar but incorrect explanations. For example, 12 students mentioned that the increased greenhouse effect will cause holes in the ozone layer which will let more UV rays through the atmosphere which will increase the incidence of skin cancer among people. Two students mentioned that " the earthís ozone will become less existent allowing more harmful rays to enter the earthís atmosphere. Four students said that the radiation 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 layer depletion vice versa. The fact is that the two phenomena are independent of each other. Skin cancer is caused by ozone depletion and not by the increased greenhouse effect or global warming. This argument given by 17% respondents who correctly marked the "No" choice. About 29% students chose "Donít Know" response.

Table 3

Elementary Education Major Studentsí Understanding of Ozone Depletion

Frequency of Correct Responses

No	Concepts	% Correct
20	Use of some household items causes destruction of ozone layer.	96.46
13	The ozone layer in the atmosphere is vital for life on the earth.	96.46
16	The ozone layer filters out UV light.	88.50
17	CFCs cause ozone layer destruction in the atmosphere.	76.11

Statements 13 through 22 pertained to ozone and its depletion in the atmosphere. In the above table, however, only four statements with the highest percentages of correct responses have been mentioned. In the following analysis, they have been discussed according to their numerical order and not their rank order. Statement 13 was a general statement about the importance of ozone for the planet. This was ranked second in the above table. As the role of ozone is frequently discussed in the media, the "Yes" response to this statement was 96%, one of the highest correct responses in the survey. This indicates that students had a good knowledge level as far as the vital role of ozone in the atmosphere is concerned. However, several correct respondents in the quantitative section showed misconceptions in the qualitative section. For instance "it protects from too much sun rays coming through", it maintains temperature, ensures life and growth", "without it we will have too much sunlight and we will die of heat stroke", " the ozone layer helps to shield the earth from some of the sunís light. It 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 mentioned by the students indicate studentsí confusion in understanding the nature and function of the ozone in the upper atmosphere. The fact is that the stratospheric ozone does control the 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 function of ozone was mentioned by the respondents who correctly explained their responses.

The next one in this category was statement 16, which was about the role of ozone in controlling UV light. This statement received more than 88% positive responses as compare to only 4% negative response which is a clear indication of studentsí understanding of this concept. This was ranked third in the above table 3. The possible explanation for the majority of correct responses to this statement is that the exposure to the UV rays causes skin cancer among human being. Because people are generally more aware of their body, and the things that may harm or damage their bodies, they want to learn more about them. Moreover, this fact is generally discussed in the media as well, which help people learn more about the problem and its solution.

The 17th statement was meant to probe the causes of the ozone depletion. No one disagreed with the statement that CFCs are the cause of ozone destruction. The "Yes" response was 76%, whereas 24% chose the "Donít Know" response. This was a surprise because this topic is frequently discussed in the media and also discussed in the school textbooks. One possible reason for this large number of "Donít Know" response is that in the media the term pollution is generally used and it is blamed for all evils. Therefore, common people consider pollution is blameworthy for every environmental problem including the ozone depletion. They sometimes fail to realize that CFCs are a type of pollution that destroy the atmospheric ozone. This factor was evident from some of the responses such as "I donít even know what CFCs are", and I have never heard of CFCs." Some of the correct respondents in the quantitative section showed certain incorrect conceptions in the qualitative section. For instance, one student said "aerosol can which produces CFCs are harmful to the ozone layer." Another student said 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 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 major culprit in the ozone destruction.

The 20th statement was meant to probe students understanding of causes of the ozone depletion. More than 96% agreed with this statement that some household items destroy the atmospheric ozone. No one disagreed whereas about 4% chose "Donít Know" response. That is why this statement was ranked first in the table three. However, response to this statement did not require a major conceptual understanding. Students were asked to mention the names of some items of household use 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, styrofoam, cleaners and deodorants.

Table 4

Elementary Education Major Studentsí Understanding of Ozone Depletion

Frequency of Incorrect Responses

No	Concepts	% Incorrect
19	One cause of ozone layer destruction is due to car emissions.	92.04
21	Pollution from factories is one of the causes of ozone depletion.	84.82
14	The ozone layer regulates the earthís temperature.	65.49
18	One cause of ozone depletion is the increased greenhouse effect.	43.36

The above table provides information of the incorrect responses given by the subjects. Four statement with a high percentage of incorrect responses were selected for the analysis. The 14th statement was meant to determine studentsí understanding regarding the function of ozone as a temperature regulator. Because of the percentage of incorrect responses, this statement was placed third in the above table. Over 65% students marked the "Yes" response as compare to only 11% "No" responses which indicates students incorrect understanding of the functions of ozone. This response is in coherence with the responses to the 13th statement. For this statement, no explanation was asked for, because this was an elaboration of the 13th statement.

The 18th statement is a direct statement which asks if increased greenhouse effect causes ozone depletion. Although this statement did not have a very high percentage of incorrect responses, the qualitative responses to this statement indicate studentsí incorrect ideas about the causes of ozone depletion. In the quantitative section, the "yes" responses were 43%, the "Noí responses were 16%, whereas 41% "Donít Know" responses. It means almost half of the respondents had the misconceptions that greenhouse effect is one the responsible factors in the ozone depletion which they showed in the explanation section. Some of the incorrect explanation were "just because one affects the other", " they work together increasing each other", more gases are trapped which eat away the ozone layer." Some of the respondents who disagreed with the statement also gave incorrect explanations. One student said that greenhouse effect does not cause the ozone depletion, the "ozone layer depletion causes greenhouse effect". This statement also indicates the some misconceptions that one problem causes the other, either 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 ë these two phenomena are not directly related to one another. They are separate phenomena that occur in the atmosphere.

About 92% gave a positive response to the 19th statement that car emissions destroy ozone. Only about 3% gave the negative but correct response whereas 5% chose "Donít Know" response. The studentsí responses to this statement indicate that students do not have correct idea of what actually destroys the ozone. They think that CO_2 from car emissions are responsible factors because "they eat away the ozone layer." They also think that "pollution especially that of car exhaust mainly CO_2 creates holes in the ozone layer." Some students who knew that CFCs are the main ozone destroyers, made the connection between car emissions and ozone depletion in a different way. They thought that "car emissions contain CFCs" and that is why car emissions are bad for the stratospheric ozone. Other respondents thought "all pollution can cause ozone destruction." Therefore, car emission is one of the causes of ozone destruction. The role of the media in causing confusion among peopleís mind can not be ruled out. Sometimes these issues are discussed on the media in such a way that they cause more confusion than clarification. For instance one students said "thatís why I hear people say like about smog and stuff." Generally these issues are not presented very clearly in the media and that sometimes causes these incorrect conceptions. For instance one student said " I remember hearing something about the car emitting and freon and it being harmful to the environment." As ozone is a part of the earthís environment, these emissions are supposed to be harmful to the ozone in the atmosphere. If people do not know the correct causes of a problem they can not suggest right measures to improve the situation. For instance, one student mentioned that because car emissions are hazardous to the ozone thatís why "environmentalists encourage car pooling." The fact is that car pooling can help reduce greenhouse effect or global warming but it can not control the ozone depletion. This was the argument given by the students who explained their responses correctly.

The 21st statement of the survey was the second highest I the frequency of incorrect responses. It was an extension of 19th statement. The 19th statement was about car emission and this statement was about factory emission and its effect on ozone depletion. The responses were not very different either. The "Yesí responses were 85% as compare to 92% in the 19th statement. The "No" responses were about 4% as compare to about 3% in the 19th statement. 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. Thatís why this statement was added to the survey. Apparently students responded the same way to both the statements and showed the similar misconceptions.

Table 5

Elementary Education Major Studentsí Understanding of Acid Rain

Frequency of Correct Responses

No	Concepts	% Correct
27	Acid rain damages some stone buildings more than others.	89.38
23	Burning some types of coal may lead to the production of acid rain.	68.14

Statements 23 through 29 pertained to the problem of acid precipitation. However, in the above table 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. The 23rd statement in the above table was about the causes of acid precipitation as a result of burning of fossil fuel. Although about 32% respondents chose the Donít Know category, no one disagreed with the statement. About 68% of the respondents marked the positive response to the statement. However, in the qualitative part, these there were only a few correct explanation and several incorrect conceptions. These incorrect explanations indicate studentsí misconceptions regarding the formation of acid rain. For instance, two students said "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 "the pollution is caught in the rain. It falls." Some students blamed the burning of coal for ozone depletion. For instance, one person said "when anything produces a smoke or harmful gas, it can produce and affects to our world and ozone layer. Two students, however, explained their responses correctly by blaming sulfur as the major culprit in the production of acid rain.

The 27th statement of the survey was the statement with the highest percentage of correct responses. It was about the effects of acid rain on buildings made of different types of stones. This was one of the three statements that no one disagreed with. Moreover, the frequency of correct responses quite high. About 89% chose "Yes" and about 11% chose "Donít Know" response. These responses are evidence of studentsí correct knowledge of the concept. However, in the qualitative sections, not all the explanations were correct. Students showed misconceptions about he nature of the stones. The mentioned that "some stones are softer", "some stone is more fragile than others" and "some stone is weaker." Students also showed misconceptions regarding the chemicals 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 that incorrect conception.

Dissolving is a physical change where a solute dissolves in solvent but the chemical composition of both solute and solvent remains the same. On the contrary chemicals reaction results in chemical change or change in the composition of the reactants. Therefore, the products of a chemical reaction are different from the reactants. This is what happens when rain become acidic. Acid reacts with the limestone which is basic in nature and the new compounds water and a salt are formed as a result of this chemicals reaction.

There were no statements with the significant incorrect responses in this category. However, the following statement 26 is worth mentioning here because it shows studentsí incorrect ideas in connecting one or more apparently independent issues. This statement was about the causes of acid rain. It was meant to determine whether students have a tendency to combine two or more of these issues. This statement is related to the 15th statement which was meant to probe the studentsí understanding regarding the relationship of ozone depletion and acid rain. The intent of this statement is to determine whether students have a tendency to relate greenhouse effect and acid rain. In the quantitative section, more than half of the students chose Donít Know response which indicates that not many students had heard of it before. About 27% students marked "Yes" and about 20% marked the "No" response. In the qualitative section there were few explanations with incorrect conceptions. 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 incorrect ideas that 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. The fact is that greenhouse effect or ozone depletion do not make the rain acidic. This was the argument presented by the correct respondents that these are separate phenomena.

Other researchers have reported the presence of similar type of misconceptions that are reported in this study. Boyes and Stanisstreet (1993) reported that their secondary school subjects had the conception that increased greenhouse effect will increase the incidence of skin cancer. Same incorrect conceptions were reported by Boyes, Chuckran and Stanisstreet (1993) with secondary school students and by Boyes and Stanisstreet (1992) with the college students in England. The other alternative conceptions similar to the ones found in this study, reported in the above mentioned three articles are:

- Hole in the ozone layer will increase the greenhouse effect;
- Acid rain may increase the greenhouse effect;
- Ozone has a hole/holes in it.

Likewise alternative conceptions about ozone depletion and acid rain, similar to the ones found in this study, are also reported by these and other researchers.

- Ozone layer is a protective covering.
- Ozone is made of air.
- Car emissions are responsible for ozone destruction.
- Ozone depletion would cause breathing problems.

(Boyes, Stanisstreet, 1995; Potts Stanisstreet & Boyes, 1996)

- Acid rain damages soft rocks more than others. (Dove, 1996)

Conclusion

The above mentioned account is an indicator of the presence o various alternative conceptions among he pre-service teachers. Several reasons can be given for these incorrect conceptions and the lack of knowledge of these fairly common environmental issues. Beside other reasons, the role of media in influencing students= knowledge and shaping up their thinking was quite obvious in this study. In response to the survey statements, some students said "thatís what I have heard" and "thatís what I have heard on the news media." This fact has been mentioned by other researchers as well (Dove, 1996). Other studentsí replies also indicated the media influence. For instance, students put all the blame on pollution for all these problems and issues. Some of them suggested car pools and recycling of paper and glass as a measure to control greenhouse effect and ozone layer depletion. Both of them are frequently discussed in the media and are portrayed as the key measures to reduce environmental problems. People are generally encouraged by the media Aexperts@ to adopt recycling and car pool as part of their daily life habits. Similarly, carbon dioxide gas is known in the media as the only greenhouse gas. Its role was in the headlines in December, 1997 during the Kyoto conference in Japan. Students= answers reflected that popularity of carbon dioxide in the media.

Some of the terms commonly used in the media as well as in the textbooks seem to cause confusion among students. The term Aozone layer@ for instance, is a fairly common term in the media today. This phrase gives people an idea that it is some type of covering that is all around the earth. It is a thin layer like or sheet-like thing 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 about one particle per one million particles of air (Somerville, 1996). 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 (ibid). Therefore, the word Alayer@ gives students an idea which is actually far from the reality and it causes wrong conceptions among students. This wrong conception was apparent in the studentsí answers to the survey question when they used analogy of "skin for the body as ozone for the earth."

The other term "hole in the ozone@ is also a very common term both in the media and in the textbooks. The use of this phrase causes confusion among students because they think of some type of damage or a rupture in the Alayer@. The fact is that there is a continuous process of destruction and re-construction of ozone molecules going on in the stratospheric region. If due to some reasons, the concentration of ozone gas molecules reduces in some areas, the correct term to describe that reduction in the concentration of the gas is either thinning of the ozone or the depletion of the ozone. It mens that the number of ozone molecules has reduced and there is no Ahole@ in the Alayer@.

Recommendations:

This array of misconceptions and this inadequate knowledge level of students raises several concerns in people=s mind. These students will be ready to teach in their classrooms in about a year or so. As the three issues discussed in the study are very closely related to science, students= incorrect conceptions about these issues reveal their lack of knowledge in the scientific concepts. 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. They take only a few science courses, generally three or four, during their course of study. They usually take these science courses with the students majoring in science (Anderson & Mitchener, 1994). Because these courses are designed for science major students and are a part of a series of courses, they do not have pre-requisite courses. Elementary education majors who take one or two courses out of that series, do not get the complete information of the material. To avoid this problem, some universities have developed special science courses for elementary teachers Abut often these courses are said to be watered down and inadequate@ (Anderson & Mitchener, 1994, p.14). This Ainadequate and watered down@ knowledge of science prepares teachers who do not have sufficient level of competence in science teaching. These teachers 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, and McClurg, 1998).

Therefore, researchers recommend that science be taught in a meaningful way and that learning can be used in addressing various environmental issues and problems (Littledyke, 1996). In these science classes, the pre-service teachers need to be engaged in class discussions on various environmental topics and issues. Students can be assigned one issue for in-depth research, and they will bring results to the classroom for presentation and open discussion. A similar strategy can be used in science teaching methods classes as well. For example, in science teaching methods class, students can be assigned to prepare lesson plans on alternative conceptions about various environmental issues to teach. Students are encouraged to do the extensive research on the assigned topic before they are ready to teach the topic (Dove, 1996) or present the lesson to their peers, The exercises of doing extensive research on one topic will help student teachers eliminate their preconceptions about a particular issue. Presentation of various topics in class will also serve the same purpose by broadening studentsí knowledge base.

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 Awatered down and inadequate@ they will be of no help for the teachers. Therefore, these courses should be comprehensive and inter-disciplinary with a project based curriculum. The classroom practice should feature more discussion and research. All the research done by the students on various contemporary environmental issues should be presented in classroom and open for discussion among students. Role of the teacher should be Aguide on the side@ and not Asage on the stage@. Students should also be given hands-on/field experience. They can visit various sites to observe the effects of acid rain on buildings, trees and crops. They can test various rock sample in their classroom to see how acids react with material of some rocks and not with the others. They can also watch simulated videos about the greenhouse effects and ozone depletion. This type of exercise will enhance students= learning and understanding of various environmental issues. By adopting these practices we can improve the knowledge level of our pre-service teachers and eliminate their altemative conception. In other words, they will be better prepared to teach the environmental issues in their classrooms.

We also need to look into the knowledge level of our in-service teachers. Researchers have found that teachers also have misconceptions about certain environmental issues (Hooper, 1988; Subbarini, 1991). The same survey questionnaire can be used to measure their knowledge of the three environmental issues. Upon determining their knowledge level, if alternative conceptions and lack in their knowledge about environmental issues are revealed, curative measures need to be taken. For in-service teachers, workshops and refresher courses should be held for the teachers in each school district during school year and during the summer. In order to check the improvement in their knowledge and reduction in the number of misconceptions, a post-test can also be administered. As a matter of fact, knowledge level of teachers should be determined for the presence of alternative conceptions regarding every contemporary environmental issue if we want to achieve the goal of environmental literacy among our future citizens.

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TABLE 1

Studentsí Responses to the Survey QuestionnaireóQuantitative Section

No.	Concepts	Yes Freq %	NO Freq %	Donít Know Freq %
1.	Greenhouse gases trap solar radiation.	50 44.25	8 7.08	55 48.67

2.	CO_2 is the most abundant greenhouse gas.	53 46.90	19 16.81	41 36.28
3.	The greenhouse effect is essential for life on the earth.	37 32.74	50 44.25	26 23.01
4.	The greenhouse effect is primarily the result of human activity	71 62.83	19 16.81	23 20.35
5.	Holes in the ozone layer will increase the greenhouse effect.	67 59.29	19 16.81	27 23.89
6.	If the greenhouse effect increases, the average temperature will rise.	97 85.84	4 3.54	12 10.62
7.	If the greenhouse effect increases, more people will have respiratory problems.	41 36.28	11 9.73	61 53.98
8.	If the greenhouse effect increases, more people will get skin cancer.	61 53.98	19 16.81	33 29.20
9.	The greenhouse effect will be reduced if we plant more trees.	51 45.13	15 13.27	47 41.59
10.	As a result of an increased greenhouse effect, the sea level will rise.	40 35.40	17 15.04	56 49.56
11.	The increased greenhouse effect might make plants grow faster.	20 17.70	31 27.43	62 54.87
12.	Name some of the common greenhouse gases.	No quantitative responses		
13	The ozone layer in the atmosphere is vital for life on the earth.	109 96.46	1 .88	3 2.65
14.	The ozone layer regulates the earthís temperature	74 65.49	13 11.50	26 23.01
15.	The ozone layer protects the earth from acid rain.	30 26.55	47 41.59	36 31.86
16.	The ozone layer filters out UV light.	100 88.50	5 4.42	8 7.08
17.	CFCs cause ozone layer destruction in the atmosphere.	86 76.11		27 23.89
18.	One cause of ozone layer depletion is the increased greenhouse effect.	49 43.36	18 15.93	46 40.71
19.	One cause of ozone layer destruction is due to car emissions in the atmosphere.	104 92.04	3 2.65	6 5.31
20.	Use of some household items causes destruction of ozone layer.	109 96.46	00 00	4 3.54
21.	Pollution from factories is one of the causes of ozone layer depletion in the atmosphere.	95 84.82	4 3.57	13 11.16
22.	Ozone is present at ground level.	16 14.29	45 40.18	51 45.54
23	Burning some types of coal may lead to the production of acid rain.	77 68.14	00 00	36 31.86
24	Water with pH of 5 is twice as acidic as water wit a pH of 6.	7 6.19	26 23.01	80 70.80
25	Normal rain is acidic.	44 38.94	33 29.20	36 31.86
26	Acid rain is caused by the increase in the greenhouse effect.	31 27.34	23 20.35	59 52.21
27	Acid rain damages some stone buildings more than others.	101 89.38	00 00	12 10.62
28	Trees in Canada have been badly damaged by acid rain.	36 31.86	2 1.77	75 66.37

29	What chemicals are responsible for acid rain.	No Quantitative responses		

TABLE 2

Studentsí Conceptions From the Qualitative Part of the SurveyóGreenhouse Effect

No	Concepts	Correct Responses	Incorrect Response
1.	Greenhouse gases trap solar radiation.	-It is like greenhouse holds sun in, the earth holds solar radiation in (4). -The sunlight comes down and the gases donít permit it to leave the atmosphere (5). -Greenhouse gases collect in the atmosphere so that heat cannot escape (2). -The trapped radiation is causing the greenhouse effect (2). -Yes, because it warms the planet (2). -Contribute to photosynthesis. -The earthís atmosphere traps the sunís heat. -Greenhouse gases donít let heat escape (3). -It is not the radiation that is being trapped.	-They trap solar radiation above the ozone layer contributing to the hole. - I think solar radiation is reflected off of a layer of something but I am not sure if it is called greenhouse gases. -Rays from the sun canít escape because they donít reflect. -That is why the earth is getting warmer and sun burning is getting worse. -They are "eating" the ozone layer. -I donít know what solar radiation is. -They let the radiation in. -This is due to hole in ozone. -The gases block radiation. -They trap UV rays. -Most solar radiation have short half-life but can immediately damage the skin. - Greenhouse gases destroy the ozone and therefore, allow solar radiation to come into our atmosphere. -Solar energy enters the greenhouse and is trapped inside by the plants and trees. -They donít block solar radiation which is why there is a hole. -The added heat traps the sunís rays in our atmosphere. -Solar radiation canít move through the greenhouse gases. The gases trap the sunís rays causing global warming.
2.	CO_2 is the most abundant greenhouse gas.	-From car exhausts and burning trees (2). -Much CO_2 is produced by automobiles, factories, and animals (3). -There are other greenhouse gases CO_2 is the one I here about the most, so I assume it is most abundant (3). -CO_2 is produced more than any other gas (3). -Humans exhale CO_2 when they breathe. Plants take in CO_2 to grow. If not enough plants, then there is too much CO_2 in the air, causing solar radiation to be trapped (greenhouse effect). -Plants need CO_2 to grow and liveóphotosynthesis (2).	-I think the most abundant greenhouse gas is carbon monoxide. Itís ozone. -I would think oxygen would be the most abundant gas (2). -All plants put out O_2 and take in CO_2, we breathe out CO_2 -Plants take in this gas for energy but they dispose of O_2. If CO_2 was the most abundant gas then it would be unsafe for humans to be in greenhouse. -75% of the atmosphere is CO_2. -Trees and plants give the earth CO_2. -CFCs are. -I think that is what plants give off (2). -This the gas that plants give off and is good for us. -Plants use CO_2 to breathe like we use oxygen.

3.	The greenhouse effect is essential for life on the earth.	-Not in excess. -Without it we would freeze. Too much of course harms by overheating us. -We need to have some heat trapped so we donít freeze to death (3). -It helps to warm the earth (4). -Without it the earth would not be warmed as it is by the sunís energy. -W/o he greenhouse effect, the earth would be too cold for certain types of life. -It allows the earth to trap some of the heat from the sun (2).	-Ozone layer will be destroyed without the greenhouse effect. -It is negatively affecting life on earth (4). -I thought it was a bad thing so it isnít essential. -It needs to stop b/c it is dangerous. -The planet would be too hot. -This is bad for the environment (6). -Not possible to get rid of it but would survive w/out it. -Greenhouse effect is not essential. -It is not essential, caused by human activity and did not always exist. -Greenhouse effect causes the earth to overheat. -It will destroy plants and our clean air. -Greenhouse effect has a detrimental effect as opposed to a good one (4). -It makes life worse. -We donít want all of this heat and CO_2 kept in our atmosphere. -The UV light trapped here is bad for human but great for plant life. -It helps protect the earth and inhabitants from harmful sun radiation and the vacuum of space. -It will kill us (3). -I heard it was bad (2). -It balances the oxygen and carbon dioxide level. -Greenhouse destroys the earth (2). -It is only essential for plant life, not human life. -This can be harmful because radiation canít be released. -The greenhouse effect is a recent effect (couple hundred years).

4.	The greenhouse effect is primarily the result of human activity	-It is natural (2). -Actually volcanoes and other natural phenomena including peopleís flatulence cause most of the gas. - There are environmental factors which cause the greenhouse effect, too. -I think the ocean also gives off CO_2. -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.	-Pollutants that put holes in our ozone (2), makes the greenhouse effect even worse. -We have been the ones contributing to pollution (12). -Automobiles, airplanes, and other factors emit gases that cause the greenhouse effect, so in this way, humans are the cause (2). -We destroy the ozone. -Due to CFCs and chemicals produced by humansócreate the greenhouse effect (3). -Pollution causes a layer to build up that causes greenhouse effect. -Our pollution is eating away at the ozone (2). -It is because of us that the ozone is partially depleting. -Destruction of tropical rainforests etc. -Due to the use of things such as aerosol cans and pollution caused by man this phenomenon occurred (3). -Pollution and deforestation are caused by humans and these things cause the greenhouse effect (2). -Due to the effects of industrialization (2). -Pollution and stuff produce the greenhouse gas (3). -Yes, because the more people we have breathing in oxygen the less there is available when there arenít sufficient plants producing oxygen. -We expel CO_2 (a major greenhouse gas) when we breathe which causes radiation to be trapped. By fossil fuels being burnt, we release gases into the atmosphere.
5.	Holes in the ozone layer will increase the greenhouse effect.	-Ozone protects us from harmful rays (2). -I donít fully understand how the two are connected.	-They allow greenhouse gases to enter the atmosphere (3). -More sunlight (solar radiation) can get in (9). -It is the oppositeóthe greenhouse effect will increase holes in the ozone layer (3). -They let in UV rays which add heat to the effect (4). -This will provide more of an opportunity for gases to escape (3). -The more radiation that penetrates through ozone, the greater the greenhouse effect (2). -Holes let bad stuff in and take away O_2. -Will allow more direct light more carbon dioxide. -The holes will allow dangerous rays to enter (2). -The ozone lets heat leave through this layer but if there are holes, it is trapped. -Holes in the ozone layer cause the sunís heat to be more powerful. When this happens, temps will increasingly rise. -The harmful gases are destroying his protective layer. -It will decrease it because the extensive exposure will harm the plants. -Because the holes in the ozone layer allow more solar radiation to enter our atmosphere. Gases then prevent this radiation from leaving. -Holes in he ozone allow more dangerous chemicals come into the earthís atmosphere.

6.	If the greenhouse effect increases, the average temperature will rise.	-Thatís global warming (5). -Picture a greenhouse® it is hot (2). -The heat is trapped (8) -It will cause the atmospheric temp to rise (4). -Less heat will be able to escape into space. -Al l of the heat entering and being held in our atmosphere will cause the rise in temperature (2). -Gases will trap in solar radiation (2). -More greenhouse equals more heat, more CO_2 traps more heat.	-More solar radiation being let in (8). -More sun rays being held in, causing the atmosphere to heat (4). -Because holes will have the heat escape. -Thatís what experts say. -Ozone layer will be breaking down. -More direct sunlight (2). -Thatís what I have been told. -The greenhouse effect is due to the holes in the ozone layer which allows UV rays from sun to get through causing temps to rise (2). -I think I heard this somewhere. -The gases will make it much warmer (2). -The gases will block some of the sun rays which results in cooler temp. -Because there will be more gases to re-radiate the heat. -The ozone will get a bigger hole causing more solar radiation on earth. -If there are holes in the ozoneóheat will radiate more.
7.	If the greenhouse effect increases, more people will have respiratory problems.	-Respiration relies most on lung capacity and air pressure in the air, which is not widely affected by the greenhouse effect. -Wefll just sweat more and be hotter. -It shouldnít . -The greenhouse effect does not affect respiratory problems.	-Harmful gases get into lungs. -Ozone gas causes these problems. -Less clean oxygen to breatheómore CO_2 in the air (4). -Because the oxygen will be mixed with other gases. -It will be harder to breathe (4). -The chemicals are trapped in our system and we breathe them. - The atmosphere is more polluted and the air is more muggy. -Air is thicker, denser, harder to breathe. -More pollution will be emitted causing more respiratory problems (4). -Because of heat and humidity. -There is going to be more CO_2 in the atmosphere that is not good for us to breathe. -The trapped gases will cause this problem. -It will be warmer, more people have problems breathing when it is warmer, due to mold and other organisms that live in the air an thrive on heat and moisture. -Heat ® humidity may cause problems for some peopleís health. -More oxygen and CO_2 will make breathing easier. -Harmful gases will remain in the atmosphere making it difficult for the lungs to receive the oxygen they need.

8.	If the greenhouse effect increases, more people will get skin cancer.	-Only heat will change-not sun rays. -Skin cancer would correspond more to holes in the ozone layer rather than the collection of more greenhouse gases. -The UV rays are not related to greenhouse effect (2). -Holes in ozone layer will cause more skin cancer, greenhouse effect will just cause the earth to become warmer. -Skin cancer is caused by exposure to sunlight not heat. -I donít think the greenhouse effect will cause skin cancer.	- Causes holes in ozone and there will be more exposure to UV rays (5). -Because more UV rays are coming in the atmosphere (7). -Because heat and sun rays will not get to the surface of the earth, only in the atmosphere. -Sun will be more intense. -B/c radiation will increase (3). -More direct sunlight, less chances of avoiding it. -The UV rays will become stronger and will not be as filtered. -No protection from harmful sun rays. -The earthís ozone will become less existent allowing more harmful rays to enter the earthís atmosphere (2). -Ifve heard of this before. -The trapped gases cause depletion of the ozone, which filters through rays. -Because the ozone layer causes cancer. -More dangerous rays from the sun are going to get to us from the holes in the ozone layer and will cause skin cancer easier (5). -The greenhouse actually protects people from the harmful radiation. -Because more of the bad rays are trapped. -There will be more infrared radiation.
9.	The greenhouse effect will be reduced if we plant more trees.	-We need this to provide natural balance. -They will take away some of the carbon dioxide (9). -Yes, but not completely, it will only slow it down. - Yes, trees and other plants consume CO_2 one of the major gases causing this affect. -More trees will definitely help take in the CO_2 and give off more oxygen (2). -It is good for the environment to plant more trees. -But that is not the only thing we have to do in order to reduce the effects. -Plants will use up some excess CO_2 (2).	-Trees can absorb some of the toxic gas produced by greenhouse effect. -Trees will put out more O_2 to combat the gases (2). -But we also need to cut back on our use of aerosols and exhaust. -I am not sure if it can be reversedóI donít think so though. -Trees filter out CO_2 and produce more oxygen. Less CO_2 means more ozone which means less greenhouse. -More trees will be affected by greenhouse effect. -Give off more carbon dioxide. -CO_2 emitted by plants and trees will help reduce greenhouse effect. -B/c there will be more carbon dioxide which helps humans breathe. -Trees provide ozone rich nutrients.
10.	As a result of an increased greenhouse effect, the sea level will rise.	-Ice caps will melt from increased temperature (24). -Glaciers will melt (2).	-I think the seas will just get warmer. -The sea level will lower b/c of evaporation (2). -I donít think it was an effect. -It will lower the sea level (2). -More water gets trapped in atmosphere. -Because more moisture will be on the earth due to a rise in temp. -What does it have to do with water. -No, does not effect sea level (2).

11.	The increased greenhouse effect might make plants grow faster.	-Warmer temp would promote growth (2). -It may cause some plants to grow faster. -Yes, because it will cause a better growing environment. -Because there is an excess of CO_2 produced by people, available (3).	-As the temp increases it will cause the plants to wither and die. -Because sunlight will be trapped and bouncing around in the atmosphere causing more resource for the trees to produce food with. -I think it kills plants (5)óhigh solar radiation. -I think it would do more harm to the plants. -Possibly b/c of more humidity. -More sun gets to them. -Pollution hinders plant growth. Because the oxygen will not be able to get to the plants. -No temp wonít matter. Amount of sun and rain will. -Plants will be destroyed more easily. -Will not affect plant growth (2). -I donít think this is correlated.
12.	Name some of the common greenhouse gases.		

TABLE 3

Studentsí Conceptions From the Qualitative Part of the SurveyóOzone Depletion

No	CONCEPTS	CORRECT CONCEPTIONS	INCORRECT CONCEPTIONS
13	The ozone layer in he atmosphere is vital for life on the earth.	-Without the ozone layer there wouldnít be an atmosphere to sustain life. -It blocks out UV rays -It protects us from dangerous rays and radiation from sun (5). -Protection from UV rays (12). -It keeps out harmful rays from the sun (15). -We would be subjected to way too much UV rays.	-It protects from too much sun rays coming through. -It maintains temperature, ensures life and growth. -It keeps the sunís strong rays from burning us. -We need the ozone layer so we have some protection from the sun. -Protects us from the sun (10). -Without it we will have too much sunlight and we will die of heat stroke (2). -It is a protective layer. -We would be burned up without the protection from the ozone layer (3). -It blocks harmful rays and lets heat out. -It filters harmful rays and keeps the temp from becoming too high. -The ozone layer helps to shield the earth from some of the sunís light. It helps the correct amount of energy to pass through the earth for plants to grow and animal to live. -Without it, no CO_2 and we would die. -It helps filter dangerous toxins. -It is a protective coating. -Without it there is an increase in harmful rays and other bad things coming into our world. -The ozone layer protects us and plants from harmful chemicals. -Keeps in oxygen. -It contains oxygen, which is vital for life. -The ozone layer is kind of like the cell membrane. It controls what enters and exits the atmosphere. -It protects our atmosphere.

			-The ozone layer protects us from UV rays and dangerous gases.
14.	The ozone layer regulates the earthís temperature		
15.	The ozone layer protects the earth from acid rain.		
16.	The ozone layer filters out UV light.		
17.	CFCs cause ozone layer destruction in the atmosphere.	-They make holes in the ozone by breaking it down (9). -They eat away at the layer (6). -Make holes in the ozone layer. -Attacks the ozone. -Hairspray type items are examplesóit is a pollutant. -CFCs are bad for environment. -They deteriorate the ozone through chemical reactions (4). -Aerosol cans emit the CFC molecules which destroy the layer of ozone in the atmosphere. -CFCs are found in household items such as aerosol cans. These break up the ozone layer if used. -The CFCs float around and breakdown the ozone layer.	Come from pollution. -There is no certain evidence that this true, but I suppose anything is possible. -I donít even know what CFCs are. -I have never heard of CFCs. -Iíve heard this. -Yes, aerosol cans which produce CFCs are harmful to the ozone layer. -These things like hair spray, air conditioners, which cause destruction to the ozone. -They cause the ozone layer to dissolve. -Exhausts and other pollutants. -Pollution eats holes in the ozone layer b/c they are harmful. -All I know is that CFCs are or were used in aerosol cans and I heard that it was bad for the ozone layer. -CFCs get into the atmosphere and fall to the south polar atmosphere and "eat" away at the ozone layer. -I just know Iíve read that somewhere. -CFCs in aerosol cans and car fumes eat away at the ozone layer.
18.	One cause of ozone layer depletion is the increased greenhouse effect.	-CFCs are the cause. -I donít think greenhouse has anything to do with the ozone (3). -These two phenomena are not directly related to one another. They are separated phenomena that occur in the atmosphere (4). -I donít think this is true.	-Actually I donít think that the ozone is being depleted so I really canít attribute the depletion to it. -Just b/c one affects the other. -They work together increasing each other. -I think Iíve hear that on some TV show. -Ozone layer depletion causes greenhouse effect (2). -The greenhouse effect has contributed to the depletion of the ozone layer (3). -I believe I have heard this on the news. -More gases are trapped which eats away the ozone layer (3). -All of the CO_2 that the ocean gives off and the bad effects from things humans do. -Depleting on the small scale does not highly affect the greenhouse effect. -It has caused the earth to heat up.

19.	One cause of ozone layer destruction is due to car emissions in the atmosphere.	-Car emission can cause the greenhouse effect. -Iím not sure if car exhaust contains chemicals that destruct the ozone. I do know that it contributes to the greenhouse effect. -Pollution and greenhouse gas. -Cars pollute the air. -I think car emissions are related to global warming. -	-Car emissions contain CFCs (5). -Carbon monoxide (3). -They eat away the ozone layer (6). -Carbon dioxide contributes to ozone layer destruction (3). -Dangerous chemicals deteriorate the ozone layer (3). -Pollution makes holes in the ozone layeróthis why is we have car pools. -Thatís what I hear people say like about smog and stuff. -Produce harmful gases that cause pollution. -The fumes from a car are toxic (2). -Supposedly, pollution, especially that of car exhaust (mainly carbon dioxide) create holes in the ozone layer. -That is why environmentalists encourage car pooling. -All pollution can cause ozone destruction (2). -Chemicals in car exhaust travel up and break apart the ozone layer. -They have standards placed in some states, so maybe it does destruct the ozone. -Produces pollution or toxins in the air® can not be good for environment including ozone (2). -The ozone layer is being destructed by many things, this is only one of them. -The gases given off from cars (4). -The carbon compounds can cuase damage. -Those fumes from car exhaust break stuff down in the ozone (4). -I remember hearing something about the cars emitting fumes and freon and it being harmful to the environment. -Pollution in the air causes the ozone layer to destruct. Car emission is a pollution (3). -Chemical reactions b/w the emissions and the ozone layer. -I think b/c when the sun hits these gases that a car emits it caused a sort of a reaction, causing the ozone to deteriorate. -The release of hramful fossil fuel destructs the layer.
20.	Use of some household items causes destruction of ozone layer.	-Aerosol cans/ sprays that contain CFCs, hair and paint sprays (55). -Refrigerator coolants, air conditioners (7). -Chemicals in aerosol sprays break apart the ozone layer.	-Ammonia (2) -Styrofoam (3). -Cleaners (8). -Gasoline -Bleach. -Deodorants (6).

21.	Pollution from factories is one of the causes of ozone layer depletion in the atmosphere.	-That adds to greenhouse effect. -Factories which produce CFCs, for example, cause ozone layer depletion. -Certain chemicals emitted eat away at ozone layer. Certain molecules attach themselves to ozone layer and deplete it over there. - I always heard that it was CFCs alone.	-Pollutants work to breakdown ozone (5). -It is dangerous. -Too much pollution destroys the ozone. -Thatís what everyone keeps telling us. -The gases from factories are very harmful and deplete the ozone layer (7). -Toxins in smoke or waste are harmful to sky including ozone. -They give off poisonous gases such as CO_2 that destroy ozone (3) -Release of carbon compounds can cause damage. -Emissions from factories breakdown ozone layer (3). -Smoke breaks it (ozone) down. -These gases that they excrete are in large doses and can be very harmful when mixed with the sunís heat. -The toxic fumes released as emissions cause ozone layer depletion.
22.	Ozone is present at ground level.	-Smog -I think at certain times, when very hot and sunny out, ozone levels may be high and dangerous to people at ground level. -	-Probably not (2). -Out in the atmosphere (5). -The plants can produce it. -Ozone can be produced, usually, by lightening strikes with other oxygen molecules in the air. -

TABLE 4

Studentsí Perceptions From the Qualitative Part of the SurveyóAcid Rain

No	Concepts	Correct Conceptions	Incorrect Conceptions

23	Burning some types of coal may leads to the production of acid rain .	-There is sufficient evidence that the gases produced when coal is burnt can have harmful effect. -Gas and chemicals released from burning (6). -Especially Indiana coal, which has sulfur in it. Burning the coal with sulfur can lead to the production of sulfuric acid, which is in acid rain. -If the coal contains pollutants then this may contribute to acid rainóalso coal contains sulfur which is a main chemical in acid rain.	-The pollution is caught in the rain it falls. -Coal is distributed throughout air. -Coal mixes with water, evaporated and then released as acid rain. -Emissions from the burnt coal rise to the clouds and mix with the rain (2). -Ifve heard this. -Itfs dirty. -Coal gives off bad gases (2). -Ash and miniature dust can be caught in clouds to produce acid rain. -Pollution is released into the air to produce an acidic rain (2). -The coal burns and gives off smoke that goes up in the atmosphere and comes back down as acid rain in the form of precipitation. -The remaining coal gas is pushed up into the atmosphere where it sits. -I think b/c the smoke may cause a mixing reaction with the atmosphere, then mixes with precipitation causing acid rain. -When anything produces a smoke or harmful gas, it can produce and effects to our world and ozone layer. -It probably would give off some type of dirty smoke with chemicals. -Chemicals from burning deplete the ozone. -B/c coal is mainly made of carbon and that gets into the clouds to cause acid rain. -Gases from the coal burning mix with the rain/moisture in the atmosphere and increase the levels of acid in the rain.
24	Water with pH of 5 is twice as acidic as water wit a pH of 6.	-Itfs ten times (2). -Isnft even more acidic?	-Only one time as acidic. -Water with pH of 5 is not very acidic, definitely not twice as much as a pH of 6. -More acidic but not twice as much (2). -Never studied it. -Lower numbers on the pH scale are more basic. -

25	Normal rain is acidic.	-It can be slightly acidic (8). -All rain has at least a little acid in it (6). -Slightly acidic, not harmful. -I assume it is neutral, but perhaps it is slightly acidic. -I am sure it is not pure. -Normal rain is not 100% pure. -Rain has a pH level of below 7 and anything with a pH level less than 7 is acidic.	-Slightly acidóI think around pH 56acid rain at about pH 7 or 8. -Not all rain is pure water. There are pollutants in the rain from smog. -Not normal but most rain on earth because there is too much pollution for it to be normal. -If it was acidic then wouldnít it be classified as acid rain. -Water evaporation does contain some pollutants such as acid. -it has a very slight pH, itís not completely pure, especially somewhere very polluted. -Itís pure (2). -Rain would be normal, but the bad gases (acids) in our atmosphere causes the rain from up in the air collects acid and brings it down. -Rain water will normally attract acidic material and be more acidic than 7. -You can drink rain water so it must be neutral. -Iíve never heard of this. It wouldnít be OK to play out in the rain if it contained acid. -Normal rain should only contain water.
26	Acid rain is caused by the increase in the greenhouse effect.	-There is no proof so far now (2). -Chemicals in the atmosphere cause acid rain. -I donít think there is a link (4). -They may work hand in hand, but I donít think the presence of greenhouse gases can cause acid rain. -It is caused by pollutants humans produce (5).	-Maybe. -More CO_2 and other gases are abundant, causing the rain to be acidic. -Depletion of ozone causes build up of chemicals. -It just sounds right. -More gases are trapped in the atmosphere. -Because chemicals are trapped in the atmosphere. -Chemicals are trapped in the atmosphere so when it rains, these chemicals come down with the rain. -The ozone is depleted so some acid gets through with the rain.

27	Acid rain damages some stone buildings more than others.	-Acid reacts with limestone (13). -Breaks stone down (11). -Acid eats away at limestone and many buildings are made of limestone (2). -Because limestone is a base and reacts with acids. -Maybe more vulnerable to those chemicals. -It reacts with the make up of some materials and not others (3). -Acid breaks down stone due to chemical reaction (3). -The sulfuric acid in acid rain reacts differently with differently material. I think that limestone is one type of stone that is especially affected by acid rain. -Some buildings (limestone) are affected by the acid in the rain. When they come in contact with each other, the acid bubbles (eats away) the stone (3).	-Because some stones are softer and some are more easily corroded due to their chemical composition. -Limestone, for example, is dissolved by acids (2). -Because acids wear away the stone just like in natural environment. -Because it eats away at buildings. -Limestone can be damaged easily. -Because of what some substance are made of can easily damaged. -Some stone is more fragile than others. - Limestone is more susceptible to breakdown. -Some stone is more perceptible like limestone. -Some stone degenerates easily. -Depending on how it dissolves. -It breaks down certain materials. -Because acid can decompose some stones quicker than others. -Some are more susceptible to chemical weathering. -Some materials are more susceptible to certain acids that others, due to what the stone is made up of (metamorphic, igneous etc.) -Some stone is weaker (sedimentary). -Weaker stones such as limestone.
28	Trees in Canada have been badly damaged by acid rain.		
29	What chemicals are responsible for acid rain.		

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