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ABSTRACT

Students are currently exposed to world environmental problems--including global warming and the greenhouse effect--in science classes at various points during their K-12 and college experience. However, the amount and depth of explosure to these issues can be quite variable. Students are also exposed to sources of misinformation leading to misunderstanding and confusion. This study focuses on the idea that some student misconceptions may arise from incorrect understandings passed along by teachers. A questionnaire about the greenhouse effect was administered to 330 college students at a regional university from the colleges of Education, Pure and Applied Sciences, Pharmacy and Health Sciences, and Liberal Arts. Only juniors or seniors were selected to ensure that a substantial portion of their science coursework had been completed. Analysis of college assignment found that science majors scored higher than education majors and there were no other significant differences between the colleges. No significant differences were found between elementary education students and other education majors (excluding the science education majors). Future research needs to examine teaching approaches that best promote solid understanding of these complex issues. The Environmental Issues Questionnaire is included as an appendix. (PVD)

COLLEGE STUDENTS' MISCONCEPTIONS OF ENVIRONMENTAL ISSUES RELATED TO GLOBAL WARMING

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INTRODUCTION

Both in the United States and in Europe, the general public has developed an increasing awareness of world environmental problems, and one of the most acknowledged concerns is global warming, especially that aspect known as the "greenhouse effect". Currently, students are exposed to these issues in their science classes at various points during their K-12 school experiences, and also in many college courses. However, the amount and depth of exposure to these issues can be quite variable. These issues are also addressed in the printed media as well as through television programs, but as pointed out by Adler (1992), such sources of information are often filled with misconceptions or errors which exacerbate the problem of learning about such complex issues. Indeed, even the term "greenhouse effect" is misleading because the causal factors of global warming are not the same as those which cause greenhouses to become hotter (Nelson et al., 1991). Even when all of the various sources of information are correct, many aspects of atmospheric phenomena in general, and global warming in particular, are still confusing to both students and the general population (Boyes, Chuckran, and Stannisstreet, 1993; Arons, et al., 1994). These environmental problems can be very complex and they often interrelate in many ways, and this complexity further leads to misunderstandings among students as well as the general public.

How do such misconceptions arise? Hills (1989) suggested that misconceptions can come from "untutored beliefs", i.e., that people lack sufficient understanding because of lack of exposure to environmental issues, rather than from "primitive" scientific reasoning. Thus, rather than reasoning from inadequate or improperly developed scientific premises, they simply lack sufficient information with which to develop correct understandings. This challenges the idea that students (and the general public) receive an adequate education from either schools or from popular media presentations.

Do these misconceptions arise from incorrect instruction given by teachers who do not have correct understandings of these phenomena for themselves? A study that included elementary level, physical science, and geography pre-service teachers found that these groups held many misconceptions about atmospheric phenomena, and these researchers expressed concern about the ability of such teachers to instruct their own students correctly since they, themselves, did not have proper understandings (Arons et al., 1994). This question of incorrect instruction forms the basis for this study, which focused on the idea that some student misconceptions may arise from incorrect understandings passed along by their teachers.

PROCEDURE

This study employed the Environmental Issues Questionnaire which was developed by Boyes, Chuckran, and Stannistreet (1993). This instrument was administered to 330 college students from the

colleges of Education, Pure and Applied Sciences, Pharmacy and Health Sciences, and Liberal Arts at a regional university, as a partial replication of the Boyes, et al. study. In order to examine the effect of college study, only juniors or seniors were selected. This provided a set of participants who had received a substantial portion of the science coursework required by their respective programs. This also ensured that the education majors were students who had completed their science methods course.

The questionnaire consists of 36 statements divided into three subgroups: the first 12 statements deal with consequences of the greenhouse effect, the second set of 12 deal with causes of the greenhouse effect, while the last 12 focus on ways to alleviate the greenhouse effect. The Likert scale used five steps ranging from "I am sure this is right" to "I am sure this is wrong". Demographic data included gender, college assignment, teaching background and GPA, and was analyzed by Scheffe ANOVA. Cell responses were collapsed, with "I am sure this is right" grouped with "I think this is right", and "I am sure this is wrong" grouped with "I think this is wrong".

RESULTS AND DISCUSSION

Analysis of college assignment found that science majors scored higher than education majors ($p < .05$), as was expected from their greater exposure to science courses. There were no other significant differences between the colleges. No significant differences were found between elementary education students and other education majors (excluding the science education majors).

Item analysis

Table 1 lists an item-by-item comparison of the four college groups in this study with the Boyes, Chuckran, and Stannistreet data (1993).

Table 1. Distribution of Responses by College Assignment

#	Education (N = 193) X	Pharmacy (N = 62) X	Sciences (N = 46) X	Liberal Arts (N = 39) X	Boyes, et al. (N = 702) X
1.	80	76	93	79	89
2.	58	54	67	54	52
3.	27	39	48	28	39
4.	32	36	39	38	35
5.	17	15	07	03	08
6.	19	18	29	29	19
7.	40	23	18	26	35
8.	92	84	95	79	92
9.	49	50	50	38	51
10.	56	48	46	44	55
11.	70	81	85	56	81
12.	24	38	52	28	46
13.	45	29	43	33	48
14.	14	16	17	18	19
15.	53	52	61	49	60
16.	34	39	33	26	22
17.	58	53	57	51	58
18.	51	48	50	49	61
19.	15	13	22	21	16
20.	16	19	17	23	27
21.	78	90	80	77	83
22.	53	52	48	49	46
23.	05	00	11	05	07
24.	41	44	50	36	64
25.	20	18	48	23	32
26.	59	59	67	54	72
27.	38	32	48	41	39
28.	13	15	20	18	09
29.	24	20	48	39	28
30.	78	71	85	79	87
31.	35	35	54	51	68
32.	59	50	65	69	68
33.	20	24	37	28	34
34.	43	37	37	36	47
35.	56	55	59	59	67
36.	67	73	70	69	83

Means expressed as percentages of students responding correctly.

The "sure right/think right" and "sure wrong/think wrong" responses were clumped because of anecdotal evidence from student interviews that some students did not feel comfortable with the extreme ends of the Likert scale, and thus chose the less extreme position instead, even though they actually felt confident about their understanding of the question.

For the 36 questions, the number of statements responded to correctly by at least 70% of the students of each group is very low, and the number of statements incorrectly responded to by at least 70% of students in these groups is high (Table 2). These results parallel the findings of the Boyes et al. study, and suggest that these students do not, as a group, have a strong understanding of these environmental issues and their possible interrelationships. Instead, they show a strong tendency to assume a number of causal relationships between these issues which do not in fact exist.

Table 2. The Number of Statements Answered Correctly/Incorrectly by at Least 70% of Students in Each Group.

	70% Correct	70% Incorrect
Education -	5	12
Pharmacy -	6	9
Sciences -	6	12
Lib. arts -	4	8
Boyes -	7	13

Consequences of the Greenhouse Effect

For some of the statements, more than 80% of the responses were incorrect. Statements dealing with consequences revealed considerable confusion over the relationship of the greenhouse effect to skin cancer (#5) and to safety of drinking water (#6). Only 7% of science majors and 3% of liberal arts majors responded correctly to statement #5, thus revealing a strong belief that greenhouse warming will increase chances of getting skin cancer. All five groups listed in Table 1 also showed very low scores for #23, which dealt with ozone depletion, and this may be related to the low responses to #5 (see further comments below). A rather high percentage (76%) of education majors believed that a consequence of an increasing greenhouse effect will be more earthquakes (#12).

Eighty percent of education majors and 93% of science majors correctly recognized that if the greenhouse effect increases, the earth will get hotter, and more generally, 92% of education majors and 95% of science majors correctly recognized that an increase in the greenhouse effect will result in changes in the world's weather (#8). Also, 70% of education majors and 85% of the science majors concur with current scientific belief that an increase in the greenhouse effect will result in melting of some of the polar ice (#11).

Causes of the Greenhouse Effect

Confusion about causal factors was shown by incorrect responses regarding radioactive waste (#19), acid rain (#20), and holes in the ozone layer (#23). Statement #14, about too many of

the sun's rays getting to the earth, is probably related to statement #23. Boyes, Chuckran, and Stannistreet suggested that students believe that too many of the sun's rays are reaching the earth's surface because of holes in the ozone layer. Thus, they also incorrectly believe that solar imput, rather than heat entrapment, is the cause of global warming. Boyes et al. (1993) also found a possible connection between the idea that skin cancer will increase from an increasing greenhouse effect (#5) and these two statements, and this is supported by the results for the four sets of college students in this study. Students have some awareness that ozone depletion may contribute to increases in skin cancer, and from this they develop a general belief that ozone depletion, the greenhouse effect, and skin cancer are causally related.

The college majors scored much higher on statement #21 which asserts that use of CFC gases will worsen the greenhouse effect, with education, science, and pharmacy majors scoring 78%, 80%, and 90%, respectively. This could indicate that they have learned that these gases act to hold heat energy near the earth's surface, but it may indicate, as Boyes et. al. (1993) suggest, that they are incorrectly linking the effect of CFC's on high altitude ozone with their greenhouse properties.

Ways to Alleviate the Greenhouse Effect

Students also revealed several misunderstandings about how greenhouse warming can be alleviated, but overall, they scored better here than on the previous two categories. Statement #28, that the greenhouse effect can be made smaller by using unleaded

gasoline, received the lowest scores in this section for all five student groups listed in Table 1. Only 20% of science majors (the highest score) and 13% of education majors responded correctly to this statement. This data suggests that students probably understand that use of unleaded gasoline is better than using leaded gasoline, but they seem to confuse the reason why, attributing it to lowering greenhouse warming, rather than to removing a heavy metal pollutant from the environment.

At least three other environmental problems, nuclear bomb stockpiles, the endangered species issue, and beach pollution, also appeared to be incorrectly associated with the greenhouse effect. Seventy-six percent of the education majors indicated that reduction of nuclear stockpiles would reduce the greenhouse effect (#29) and 80% disagreed with statement #25 which said that use of nuclear power plants instead of coal powered plants would reduce the greenhouse effect. Eighty percent said that protecting rare plants and animals would help (#33), and 72% believed that keeping beaches clean was also helpful (#27).

A majority of the college students properly recognized that planting more trees (#30; education majors = 78%, science majors = 85%), and using cars less (#36; education majors = 67%, science majors = 70%) could help alleviate the greenhouse effect. However, this study did not reveal if these students have proper understandings of why these actions are considered helpful.

The results of this study and the Boyes et.al. (1993) study are not encouraging. These results suggest that a number of alternative conceptions, or misconceptions, are at work.

However, Atwood and Atwood (1996) follow Hills' (1989) idea that students may be exhibiting "untutored conceptions" instead. In their study of elementary education students' conceptions of the causes of day and night they found that many of the students could not recall having studied that topic. It is possible that the college students in the present study have similarly not formally encountered environmental issues. Rather, their experiences with these issues may be limited to what they have learned informally through various media sources such as television and popular magazines. Another explanation is that students do study these subjects in school, but they do not effectively transfer that knowledge to the "real world". Lave (1988, p.14-15) points out that knowledge is context-bound, and that "everyday experience is the major means by which culture impinges on individuals". thus, students' everyday experiences, which includes their encounters with popular media descriptions and explanations of current environmental issues, may play a stronger role than their experiences in the science classroom. Adler's "little green lies" that children are taught through television programs and various science education materials are a part of their everyday experience which contribute to the development of misconceptions about global warming, ozone depletion, and other current issues (Adler, 1992).

Conclusions

Regardless of how elementary education majors develop their misconceptions regarding these environmental issues, they are likely to pass along these misunderstandings to their own

students.

How important is this to science education? Hazen and Trefil (1991, pp.267-276) specifically identify these issues as important for science literacy. The National Science Education Standards (National Research Council, 1996) identifies these issues as important, but only in the section on grades 9 - 12 content standards (p.186). Boyes, et al. (1993, p.541), citing various sources, describe the greenhouse effect as "Of all such problems facing humankind, perhaps the most damaging in its consequences . . ."

At this time, the greenhouse effect is a controversial topic in the scientific community, with disagreements over its existence, its magnitude, and potential effects still continuing. Even so, the potential for serious consequences is large, and that makes this and other related environmental issues important to science education. Therefore, science teachers need to be sufficiently aware of these issues and their interrelationships so that they can more properly guide their students to correct understandings. Future research needs to examine teaching approaches which best promote solid understanding of these complex issues.

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Environmental Issues Questionnaire

1. If the greenhouse effect gets bigger the earth will get hotter.
2. If the greenhouse effect gets bigger more people will get food poisoning.
3. If the greenhouse effect increases there will be more flooding.
4. If the greenhouse effect gets bigger more fish will be poisoned in the rivers.
5. If the greenhouse effect gets bigger more people will get skin cancer.
6. If the greenhouse effect gets bigger some of our tap water will be unsafe to drink.
7. If the greenhouse effect gets bigger there will be more bugs and pests on crops.
8. If the greenhouse effect gets bigger there will be changes in the world's weather.
9. If the greenhouse effect gets bigger more people will die of heart attacks.
10. If the greenhouse effect gets bigger there will be more deserts in the world.
11. If the greenhouse effect gets bigger some of the ice at the North and South Poles will melt.
12. If the greenhouse effect gets bigger there will be more earthquakes.
13. The greenhouse effect is made worse by rubbish dumped in rivers and streams.
14. The greenhouse effect is made worse because too many sun's rays get to earth.
15. The greenhouse effect is increased by too much carbon dioxide in the air.
16. The greenhouse effect is made worse by too much ozone near the ground.
17. The greenhouse effect is made worse by too much litter in the streets.
18. The greenhouse effect is made worse by gas from rotting waste.
19. The greenhouse effect is made worse by radioactive waste from nuclear power.
20. The greenhouse effect is made worse by acid in the rain.
21. The greenhouse effect is made worse by CFC gas from spray cans.
22. The greenhouse effect is made worse by gas from articial fertilizers.
23. The greenhouse effect is made worse by holes in the ozone layer.
24. The greenhouse effect is made worse because the sun's rays cannot escape earth.
25. The greenhouse effect can by made smaller by nuclear instead of coal power stations.
26. The greenhouse effect can by made smaller by eating healthy foods.
27. The greenhouse effect can be made smaller by keeping beaches clean.
28. The greenhouse effect can be made smaller by using unleaded gasoline.
29. The greenhouse effect can be made smaller by reducing the number of nuclear bombs.
30. The greenhouse effect can be made smaller by planting more trees in the world.
31. The greenhouse effect can be made smaller by electricity from wind, waves, tides.
32. The greenhouse effect can be made smaller by using recycled paper more.
33. The greenhouse effect can be made smaller by protecting rare plants and animals.
34. The greenhouse effect can be made smaller by not wasting electricity.
35. The greenhouse effect can be made smaller by reducing starvation in the world.
36. The greenhouse effect can be made smaller by not using cars too much.

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