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Chemical Literacy and Learning Sources of Non-Science Major Undergraduates on Understandings of Environmental Issues

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Abstract

Exploring chemical literacy and learning experiences is becoming important for chemical education. For 100 non-majors undergraduates' understandings of three popular environmental issues, greenhouse effect (GHE), ozone layer depletion, and acid rain, and their learning sources were investigated in this study. The students were asked to fill in a questionnaire that is composed of three parts to each of three environmental issues. Descriptive statistic was used for data analysis. The main findings were that 99% of them clearly understood CO_2 and then 35% of them understood CH_4 was GH gases; 50% of them understood chlorofluorocarbon (CFC) and 34% of them misunderstood CO_2 were the cause of ozone layer depletion; moreover, as to the acid rain, 64% of them overestimate the contribution of CO_2 and 56% of them understood that SO_2 is the major source. Informal sources, such as, 'TV news', 'Internet', and formal sources, such as 'teachers', and 'textbooks' were four main sources for learners to acquire information related to these three environmental issues. These results imply that we need to pay more attention to these informal sources and to clearly recognize the similarities and differences among these three hot environmental problems, especially the role of CO_2.

Introduction

Gilbert and Treagust (2009) [1] subsumed many researchers' studies on acquiring chemical literacy, and then they claimed that there were many facets of chemical literacy. For example, chemical literacy might involve learning the chemistry 'that has direct application in everyday life', 'that enables a person to become a more informed citizen' and 'that enables a person to understand reports and discuss about chemistry in the media' and so on[2]. The 'everyday life' environmental issues, such as greenhouse effect, ozone depletion and acid rain, become more popular not only in chemistry and other disciplines in the formal education, but also in the media, for example, newspapers, TV programs, internet and so on in the informal education. From these learning sources, a person becomes a more informed citizen on

chemical literacy relevant to environmental issues.

These environmental issues involve many concepts of chemistry and other science concepts as well. However, most of the previous studies concerned concepts from environmental perspectives. Some of the main findings focus on students' or teachers' conception on the famous gases of major contribution and their effects on environment, for example, CO_2 on greenhouse effect 'Chlorofluorocarbon' (CFC) on ozone layer depletion, and SO_2 on acid rain [3] [4] [5]. Nevertheless, the common GH gases in the earth's atmosphere include not only CO_2 (55%) but also CFC (24%), CH_4(15%), N_2O (6%), H_2O, and O_3; the common ozone depletion gases is CFC as well as HCFCs, Halon, CCl_4, CH_3CCl_3, HBFC and CCl_3Br; the common acid rain gases are NO_x and SO_2. Based on the previous studies and according to my teaching experiences, I found that learners seem to be confused quite easily by the complex contributions of these common gases on these three environmental issues. That is, students are confounding the contributions of some gases on three seemingly related but actually different environmental issues. Therefore, exploring students' understandings of gases by their distinguishing a set of chemical compounds together is important. Although previous studies have shown the impact of some learning sources on environmental issues[4] [5], they didn't display the coherence of learning sources on these three environmental issues. Hence, the coherence of learning sources on these three environmental issues will be searched as well here.

Objectives

The main purpose of this article is to investigate non-science major undergraduates' understandings of seemingly related but in fact different concepts of environmental issues—the greenhouse effect, the ozone layer depletion, and the acid rain in terms of the chemical compounds (gases), as well as their learning experiences of these three environmental issues in regards to some major formal and informal learning sources. Furthermore, their coherence of learning sources among the three environmental issues also explores here.

Methodology

Participants and Instrument

This study was conduct with 100 non-science major undergraduates. Non-science majors were selected to participate here because education for 'chemical literacy' in respect of 'the public' and they were satisfied to attend this goal. They were asked to fill in a written questionnaire including three parts. From the first part to three part of this questionnaire was tasks relevant to greenhouse effect, to ozone depletion, and then to acid rain. In every part, there presented a same set of chemical compounds and a same set of learning sources in the

same way (Appendix 1).

Data Collection and Analysis

All participants finished filling out the questionnaire within 5 minutes. They chose the answers which reflected their understandings and their learning experiences, and then their every response was counted one. At last, the descriptive qualitative analysis was used for data analysis.

Results and Discussion

Gases of Environmental Issues

The great majority of participants showed they well understood the greenhouse effect caused by CO_2 (99%), the ozone layers depletion caused by CFC (50%), and the acid rain caused by SO_2 (56%) (Fig. 1). However, this is seriously concerned that above 30% of them misunderstood that CO_2 influences ozone layers depletion (34%) and that they even overestimated the contribution of CO_2 on the acid rain (64%). Regarding to the other GH gases, such as CFC, CH_4, N_2O, H_2O, and O_3, they understood a little bit well only on the influence of CH_4 on GHE (35%). Additionally, very interesting, some of them (19%) thought that O_3 would induce ozone layers depletion.

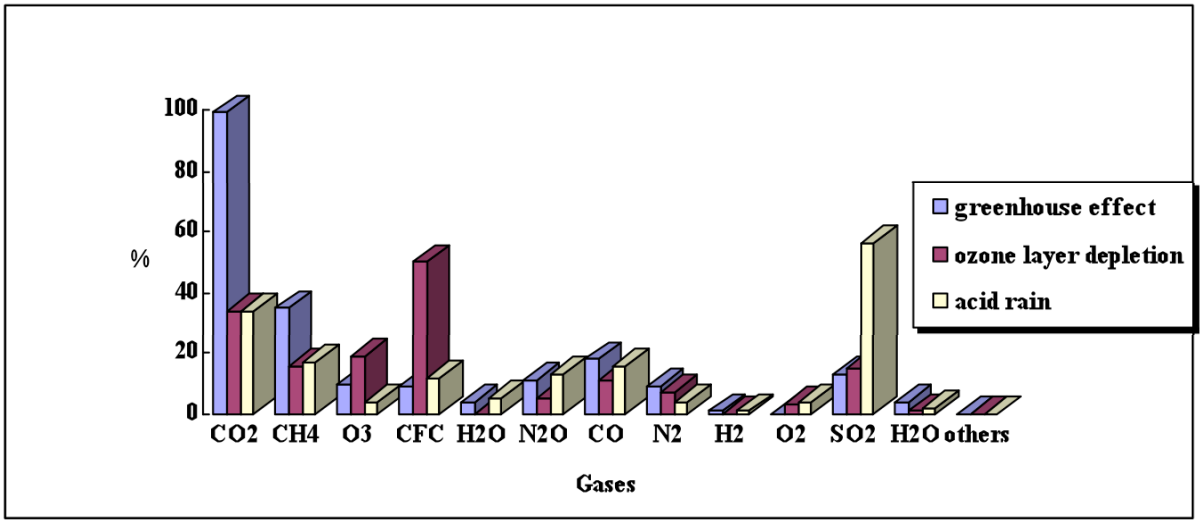

Figure 1 Students' Understandings of Gases Contributed on GHE, Ozone Layers Depletion and Acid Rain

Education for 'chemical literacy' with respect to 'the public of all ages'- is now widely seen as a general goal for chemical education, regardless of their way of learning. If we transform the ideas of Bybee (1997) [6] on scientific literacy to chemical literacy, and then the chemical literacy from the lowest to the highest levels are 'nominal chemical literacy', 'functional literacy', 'conceptual and procedural chemical literacy' and 'multidimensional

chemical literacy'. The participants' understandings of these three environmental issues need to be enhanced more in order to reach the level of 'conceptual and procedure chemical literacy'.

Sources of Environmental Information

According to the profile of Fig 2, their learning experiences of these three environmental issues were very coherent. This result reveals that students learned environmental information from the similar sources. Regarding to informal learning experiences, 'TV news' and 'Internet' were two main mass media reported as sources in this study (Fig. 2). According to formal learning experiences, 'Teachers' and 'Textbook' were two main school experiences used as sources of the environmental information (Fig. 2). It should be noticed also that above half of students got the information from these four sources: they are TV news, Teachers, Textbooks, Internet. Majority of them especially learned form the TV news.

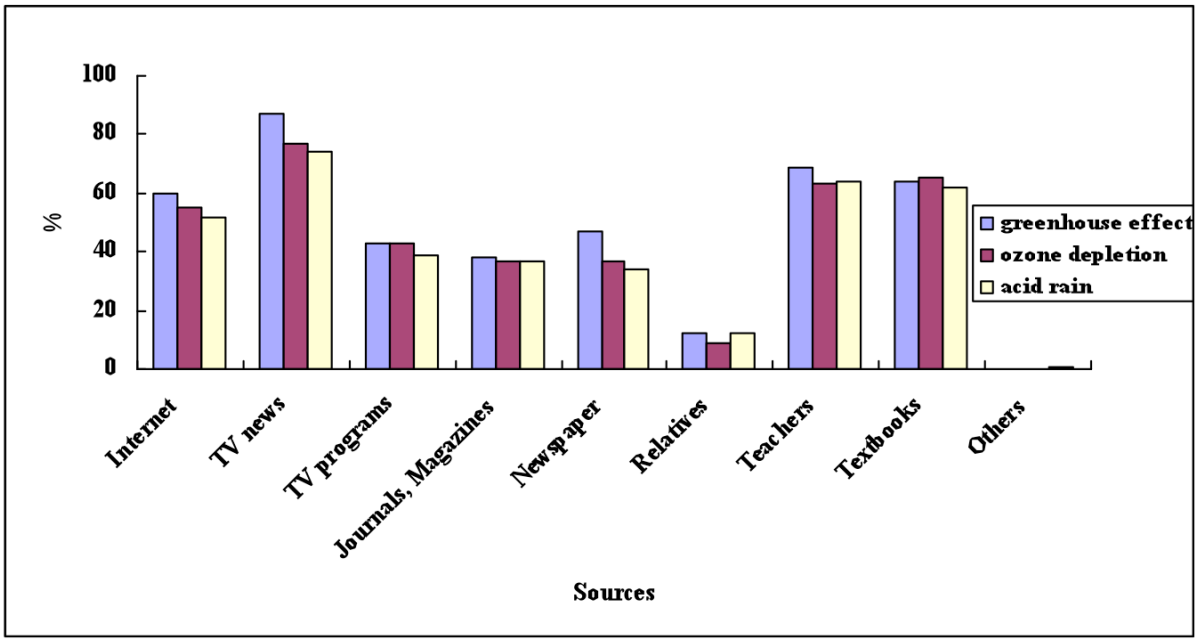

Figure 2 Sources of Environmental Information on Greenhouse Effect, Ozone Layer Depletion, and Acid Rain

Implication

Traditionally, we focus on decoupling of actions from perceptions, and decomposition through ethical reflection [7]. If we want to achieve the higher goal of ethical reflection, we should stand on the base of the chemical literacy from exploring their understandings and their learning experiences. Above 30% of them misunderstood that CO_2 influences ozone

layers depletion (34%) and seem to overestimate the contribution of CO_2 on the acid rain (34%). They understood little on the other GH gases, such as CFC, CH_4, N_2O, H_2O, and O_3. Moreover, some of them (19%) thought that O_3 would induce ozone layers depletion. These results implicate that we need to carefully differentiate the contribution of these gases on different environmental issues, especially the role of CO_2. They mainly focus on the role of CO_2 impact on environmental issues; however, they seem to be very unfamiliar to the common GH gases in the earth's atmosphere. Not only include CO_2 (55%), but also CFC (24%) have different influenced on greenhouse 'enhanced' effect and climate change (Table 1). If we emphasized on their differentiations of GHE and "enhanced" GHE together in instructions and literates, their understandings on global warming maybe more better. From the results, we require to develop some approaches from informal sources and formal sources, especially from TV news, Teachers, Textbooks, Internet, to improve learners' understandings and cleared distinguish the contributions of different gases. Besides, from these four sources--TV news, Teachers, Textbooks, Internet, we specifically need to concern about the quality and influence of information from TV news on students' understandings and chemical literacy.

Table 1 The GH Gases on Enhanced GHE and their Proportion on the Atmospheres

Gases	Enhanced GHE (based on CO_2)	Proportions on GH gases (%)
CO_2	1	55
CH_4	10	15
N_2O	100	6
O_3	1000	unknown
CFC	10000	24
H_2O	unknown	unknown

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Appendix 1 The Questionnaire of Causes Gases and Information Sources on Three Environmental Issues

Part 1 the **'Greenhouse Effect'**

1-1. According to the following gases, which caused the **'Greenhouse Effect'**?

☐CO_2 ☐CH_4 ☐O_3 ☐CFC ☐H_2O ☐N_2O ☐CO ☐N_2
☐H_2 ☐O_2 ☐SO_2 ☐H_2O ☐others_____

1-2. Where do you known about the information related to the **'Greenhouse Effect'**?

☐Internet ☐TV news ☐TV programs ☐Journals, Magazines
☐Teachers ☐Textbooks ☐Newspaper ☐Relatives and Friends ☐Others_____

Part 2 the **'Ozone Layer Depletion'**

2-1. According to the following gases, which caused the '**Ozone Layer Depletion**'?

☐CO_2 ☐CH_4 ☐O_3 ☐CFC ☐H_2O ☐N_2O ☐CO ☐N_2
☐H_2 ☐O_2 ☐SO_2 ☐H_2O ☐others_____

2-2. Where do you known about the information related to the '**Ozone Layer Depletion**'?

☐Internet ☐TV news ☐TV programs ☐Journals, Magazines
☐Teachers ☐Textbooks ☐Newspaper ☐Relatives and Friends ☐Others_____

Part 3 the **'Acid Rain'**

3-1. According to the following gases, which caused the '**Acid Rain**'?

☐CO_2 ☐CH_4 ☐O_3 ☐CFC ☐H_2O ☐N_2O ☐CO ☐N_2
☐H_2 ☐O_2 ☐SO_2 ☐H_2O ☐others_____

3-2. Where do you known about the information related to the '**Acid Rain**'?

☐Internet ☐TV news ☐TV programs ☐Journals, Magazines
☐Teachers ☐Textbooks ☐Newspaper ☐Relatives and Friends ☐Others_____