Jour. Korean Earth Science Society, v. 27, no. 7, p. 705-714, December 2006

Elementary Students' Perceptions of Earth Systems and Environmental Issues

Hyonyong Lee[1,*] and Rosanne W. Fortner[2]

[1]Department of Earth Science Education, Kyungpook National University, Daegu 702-701, Korea
[2]COSEE Great Lakes Director and Professor Emeritus at The Ohio State University, Columbus, OH 43210, USA

Abstract: The purpose of this study was to explore the elementary students' perceptions of Earth systems and environmental issues. A survey was conducted to determine the students' perceptions on the following aveas: (1) the concepts of certainty and tangibility, (2) self-reported knowledge level, (3) perceived danger level of selected eight Earth systems and environmental issues, and (4) their primary information source on these issues. Results indicated that ozone hole, acid rain, El Niño, and global warming were identified by the students as uncertain and intangible issues. Perceived certainty and perceived tangibility were highly positively correlated with self-reported knowledge compared to other relationships. The results also showed that learning from school was the most frequent information source for environmental issues. The second most frequently used source of information was television among several mass media sources. It is hoped that this study contributes to understanding the elementary school students' perceptions toward the selected Earth systems and environmental issues.

Keywords: Earth systems, environmental issues, certainty, tangibility

Introduction

Over the past decades, advanced technology and scientific research data (e.g., satellite images) have led to tremendous understandings of planet Earth and reinterpretation of the emerging environmental issues (Mackenzie, 1998). For example, Global Climate Change (GCC), often characterized as "global warming," has become one of the emerging environmental issues of the new 21st century around the world. The basic premise of the issue is "that increased anthropogenic contributions of greenhouse gases are changing Earth's atmospheric composition to the point at which global systems stand to be noticeably altered" (Fortner et al., 2000). Peoples as a part of our environment are contributing to significant global climate changes on the Earth through our economic and technological activities. Therefore, it is very clear that people need to know about the emerging environmental issues for the new century.

Even though education about such a major issue is of considerable importance and significance, two new concerns have emerged in the recent research in environmental education, that is, the scientific uncertainty and the intangibility of the environmental issues. The first concern is 'scientific uncertainty' that may lead to misconception of the issues. Several studies of students' understanding of the issues (e.g., global warming) showed that students who hold more uncertain knowledge and informal information have misconceptions (Boyes and Stanisstreet, 1992, 1998; Stanisstreet and Boyes, 1996; Gowda et al., 1997). Scientific uncertainty about climate change has been a key barrier to establish a social consensus and policy on this issue compared to other environmental issues (Lee and Fortner, 2000).

According to Gallup (1997), public opinions from survey indicated that a majority of people believed that global warming poses a serious threat to their life or the next generation of Americans in their lifetime. In addition, about one-half of the people surveyed think that global warming has already

*Corresponding author: hlee@knu.ac.kr
Tel: 82-53-950-5917
Fax: 82-53-950-5946

begun to happen (41%). However, 38% of the public surveyed said they did not understand the global warming issue at all. This survey pointed out that even though people are very concerned about the global warming issue, they are not highly informed about it. In fact, scientific uncertainty about global warming is significant enough to warrant educating the public for understanding and responsible environmental behavior.

The other concern described in the literature is an intangibility of environmental issues. Mason and Santi (1998) described global warming as "a very large-scale effect whose nature is intangible; thus, the children could not have any empirical evidence of the phenomenon. In that way, they would face it only at a linguistic level". Every phenomenon involves a level of tangibility. However, this global climate change issue is difficult to be perceived by people's five senses. Boyes and Stanisstreet (1992) described that this issue is "imperceptible" to high school students, and therefore, "effectively abstract in nature".

The students of today not only face these emerging Earth systems and environmental issues, but they have a certain level of uncertainty and intangibility of those issues. Lee and Fortner (2000) attempted to compare and classify ten selected environmental issues by adults' perceptions of their concepts of certainty and tangibility. Their results indicated that the most uncertain issue was global warming, and the most certain issues were air pollution and acid rain. The most tangible issues were air pollution and El Niño, and the most intangible ones were ozone depletion and global warming. On the basis of their research ideas, this study is trying to classify the selected Earth systems and environmental topics by young students' perceptions of their concepts of certainty and tangibility.

This study is designed to explore elementary students' perceived certainty and tangibility, self-reported knowledge level, and perceived danger level of the selected 8 Earth systems and environmental issues, and their primary information source on these issues. The questions are as follows:

1. How well can Earth systems and environmental issues be understood by using the elementary students' perceived certainty and tangibility?
2. What are the elementary students' self-reported knowledge levels, perceived danger levels regarding the selected Earth systems and environmental issues?
3. How do elementary students' perceptions of the Earth Systems and environmental issues differ by gender?
4. What are the correlations among students' self-reported knowledge and perceived danger levels, perceived certainty and perceived tangibility toward environmental issues?
5. What is the information source about environmental issues mostly used by elementary students?

Definition of terms

The operational definitions shown here are meanings specific to this study.

Perceived Certainty: The perceived certainty can be defined as an observer's perception of the extent to which a thing or phenomenon can be described, predicted, and controlled based on empirical or experimental evidence. For instance, to accurately describe the movement of air appears more uncertain than to describe the movement of a train (Lee, 2000).

Perceived Tangibility: The perceived tangibility can be defined as an observer's perception of the extent to which a thing or phenomenon can be perceived by human sensory organs in daily life, i.e., see, feel, hear, etc. For instance, stones and trees can be perceived as more tangible than air and virus. But, when you can see a virus by using a microscope, the virus that was intangible to the naked eye becomes more tangible (Lee, 2000).

Method

Sample

Since this study was an exploratory study, we

were not attempting to generalize our findings of this study. Therefore, the sampling method used was one of convenience. The sample consisted of 94 elementary students, 11-12 years of age, drawn from one elementary school (Language Arts and Computer Magnet School) located in a large metropolitan area in the northeastern United States. This school provides computers with internet access and printers for student use and a resource library. The classrooms setting in which all instruction takes place is modern and well equipped. There were 46 male students (49%) and 48 female students (51%).

Instrument

The paper-and pencil questionnaire was developed and consisted of 8 Earth systems and environmental issues based on literature reviews: Acid rain, air pollution, El Niño, global warming, oil spills, ozone hole, trash disposal, and water pollution (Lee, 2000; Lee and Fortner, 2000; Riechard and McGarrity, 1994; Riechard and Peterson, 1998). The concepts of perceived certainty and tangibility were adopted from two previous studies (Lee, 2000; Lee and Fortner 2000). In order to establish content validity, the following approaches were applied in this survey. The instrument was reviewed and assessed by a small group of experts who consisted of two professors, five doctoral students, and one master student who are studying environmental education and communication. Specifically, review and assessment were performed with three elementary teachers both during and after the development of the instrument. For readability at the elementary level, they provided very useful suggestions and comments. All advice and comments were reflected in the content of the instruments.

A pilot test was administered to 20 fifth graders. The major observed problem was that the concept of certainty and tangibility was a little difficult to understand at the elementary level. Therefore, the following statements were used to explain terms (e.g., certainty and tangibility) and describe directions for students. During the second trial, we found that the students responded more clearly.

> For the next question, the words, **certainty** and **tangibility** are defined below. You may refer to these definitions for answering the questions on the next page.
>
> 1. **Certainty** means how well you understand something that can be described, predicted, and controlled. For example, you can be more certain about the movement of a train than about the movement of air. Certainty can change over time as we learn more about a subject or find ways to study it. Please, tell us ***how sure*** or ***how certain*** you are about understanding the environmental issues.
> 2. **Tangibility** means how well you understand something that can be perceived by the five senses, that is, **by seeing, hearing, smelling, tasting and touching**. For example, you can know about stones and trees because they can be understood using your five senses. They are items that are more **tangible** than items such as air or a virus. However, you can see a virus by using a microscope. Then the virus that was **intangible** to the naked eye becomes **tangible**. The **tangibility** of something also can change over time. Please, tell us ***how well you can sense*** the following environmental issues, that is, ***how tangible*** they are.

The questionnaire was divided into four sections. The first section of the questionnaire included a place for subjects to specify gender and favorite school subject. The second section included items that were intended to measure how certain elementary students were about their knowledge of the issues and the tangibility of the issues. For each item, there was a Likert-type rating scale of 1-6 (e.g., for tangibility section, 1 = very hard to sense it, 6 = very easy to sense it). The third section of the questionnaire consisted of items to assess the degree of a student's perceived knowledge and their perception of the amount of danger associated with 8 selected issues.

There was also the same rating scale of 1-6 (e.g., for danger section, 1 = very safe, 6 = very dangerous). The final section contained eight information sources to ascertain students' most available source on each of the Earth systems and environmental issues. Finally, Cronbach's alpha was used to determine the reliability of the instrument. Cronbach's alpha score (.87) addressed that the instrument obtained moderately high reliability.

Procedure

The questionnaires were distributed and the directions and terms were read aloud and explained for students. Students completed the questionnaires in their own classrooms (most students took between 15 and 20 min). Students were encouraged to ask questions about directions and words that they did not understand.

The computer program, Statistical Program for the Social Sciences (SPSS Ver. 11.5 for MS Windows) was utilized for statistical analyses. Descriptive statistics were first used to describe, analyze, and interpret the data that have been collected from the subjects in this survey. For the question 3, each student's response of each item was recorded, and the ratings were summed to four total mean scores on each section (e.g., self-reported knowledge, perceived danger, perceived certainty and tangibility).

Multivariate Analyses of Variance (MANOVA) was conducted for the following four sets derived from the survey: Perceived certainty, perceived tangibility, self-reported knowledge, and perceived danger levels. When MANOVA result was significant at a 95% confidence level, the follow-up t-tests were conducted to determine any significant differences in the four total mean scores toward the issues between males and females. Significance was determined at the 95% confidence level ($\alpha = 0.05$).

In addition, correlation tests (Pearson product-moment correlation technique = r, with at least 95% confidence level) were calculated among variables that were pertinent to the research question 4. Frequency and percentage distributions for the research question 5 were used to describe students' most frequent source of information on Earth systems and environmental issues.

Results

Question One: Perceived certainty and tangibility

As mentioned above, the perceived certainty and perceived tangibility were used to classify environmental issues in a previous study conducted by Lee and Fortner (2000). Their subjects were 90 college students (64 undergraduates and 26 graduates), whereas, this survey employed the perceived certainty and tangibility into elementary level students. The 8 Earth systems and environmental issues were classified using the perceived certainty and perceived tangibility mean scores (Fig. 1). According to Lee and Fortner (2000), environmental issues were classified into four groups: certain-tangible (**CT**) group, uncertain-tangible (**UT**) group, certain-intangible (**CI**) group and uncertain-intangible (**UI**) group. In contrast, all 8 issues in this study could be grouped into two categories: certain-tangible (**CT**) group and uncertain-intangible (**UI**) group (Fig. 1). For example, the right-upper quadrant of the chart represents the certain-tangible group. The left-lower quadrant means the uncertain-intangible group. Earth systems and environmental issues belonging to **CT** group were air pollution, endangered species, oil spills, trash disposal, and water pollution. In contrast, acid rain, El Niño, global warming, and ozone hole were classified into **UI** group.

More precisely, air pollution ($M = 4.77$, $SD = 1.32$), water pollution ($M = 4.67$, $SD = 1.35$), and trash disposal ($M = 4.59$, $SD = 1.40$) were perceived to be most certain (sure). However, the subjects perceived El Niño ($M = 2.83$, $SD = 1.79$), acid rain ($M = 2.93$, $SD = 1.57$), and ozone hole ($M = 3.31$, $SD = 1.62$) to be most uncertain (unsure).

With regard to the perceived tangibility, the subjects responded that trash disposal ($M = 4.73$, $SD = 1.37$), water pollution ($M = 4.63$, $SD = 1.33$), and oil spills

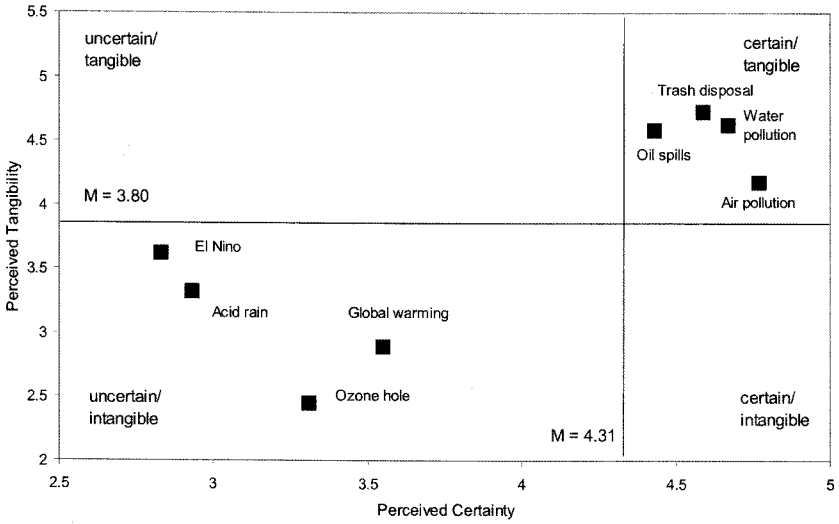

Fig. 1. Classification of eight environmental issues by perceived certainty and perceived tangibility.

(M = 4.59, SD = 1.46) were very easy to sense, whereas ozone hole (M = 2.45, SD = 1.48), global warming (M = 2.89, SD = 1.54), and acid rain (M = 4.18, SD = 1.57) were perceived to be most intangible by the elementary students.

As can be seen in Fig. 1, some interesting findings were observed in the elementary students' perceived certainty and tangibility. The students reported very low certainty and tangibility levels for global environmental issues related Earth systems and environmental issues (e.g., El Niño, global warming, and ozone hole). It appeared that the elementary students perceived themselves to be uncertain and intangible about the global environmental problems.

Question Two: Self-reported knowledge and Perceived danger levels

In the third section of the survey, items assess the degree of a student's self-reported knowledge and perceived danger level associated with the 8 selected Earth systems and environmental issues. In relation to students' self-reported knowledge level, the students reported themselves most knowledgeable of trash disposal (M = 4.89), air pollution (M = 4.78) and water pollution (M = 4.70). Acid rain (M = 2.74), and El Niño (M = 2.79) were perceived to be least familiar by the subjects.

From the subjects' point of view, the most dangerous environmental issues were water pollution (M = 5.04), and air pollution (M = 4.89). Least

Table 1. Mean score and standard deviation of students' self-reported knowledge and perceived danger levels toward the 8 issues

Rank order	Items of self-reported knowledge levels	M	SD	Items of perceived danger levels	M	SD
1	Trash Disposal	4.89+	1.29	Water Pollution	5.04++	1.01
2	Air Pollution	4.78	1.18	Air Pollution	4.89	1.04
3	Water Pollution	4.70	1.25	Ozone Hole	4.66	1.28
4	Oil Spills	4.39	1.30	Oil Spills	4.54	1.43
5	Global Warming	3.73	1.54	Acid Rain	4.16	1.29
6	Ozone Hole	3.38	1.44	Global Warming	3.94	1.27
7	El Niño	2.79	1.72	Trash Disposal	3.88	1.36
8	Acid Rain	2.74	1.37	El Niño	3.34	1.49

+: Scores were measured with a 6-point scale where 1 means not at all and 6 means very knowledgeable.
++: Scores were measured with a 6-point scale where 1 means very safe and 6 means very dangerous.

Table 2. Perceived certainty and tangibility, self-reported knowledge, and perceived danger levels of the 8 selected Earth systems and environmental issues between gender

	Gender		t-value
	Male Mean (SD)	Female Mean (SD)	
Perceived Certainty	4.13 (0.70)	4.45 (0.65)	- 2.29
Perceived Tangibility	3.80 (0.94)	3.78 (0.75)	0.09
Self-reported Knowledge	3.92 (0.83)	4.18 (0.70)	- 1.66
Perceived Danger	4.02 (0.69)	4.37 (0.68)	- 2.44*

*$p < .05$

dangerous problems were El Niño (M = 3.34) and trash disposal (M = 3.88), and Global warming (M = 3.94).

Question Three: Difference in self-reported knowledge, perceived danger, perceived certainty, and perceived tangibility scores by gender

This subsection relates to Research question 3: How do elementary students' perceptions of the Earth Systems and environmental issues differ by gender? The MANOVA was statistically significant (Wilks' lambda = 0.901, $F_{4,88} = 2.423$, $p = 0.05$) at $\alpha = .05$. Means, standard deviations and t values for the follow-up t-tests for difference in self-reported knowledge, perceived danger levels, perceived certainty and perceived tangibility scores between gender are presented in Table 2.

In relation to students' perceived certainty and tangibility, the perceived certainty score of female students was higher than that of for male students. The perceived tangibility score of male students was slightly higher than female students. However, the perceived certainty and tangibility scores were not significantly different at 95% confidence level or better between gender for the 8 selected Earth systems and environmental issues.

With regard to self-reported knowledge and perceived danger levels of students, the self-reported knowledge scores of female students (M = 4.18) was higher than male students (M = 3.92), and the perceived-danger level scores of female students (M = 4.37) was also higher than male students (M = 4.02). However, differences in the perceived danger by gender were only statistically significant at $\alpha < .05$ or better. In other words, t-tests revealed no significant differences between the summated mean scores of gender with perceived certainty, perceived tangibility, and self-reported knowledge toward the selected Earth systems and environmental issues except for the perceived danger level.

Question Four: Correlations among self-reported knowledge, perceived danger levels, perceived certainty and perceived tangibility

Correlations among self-reported knowledge, perceived danger levels, perceived certainty and perceived tangibility summated total scores were examined (Table 3). The results revealed that most pairs of scores were significantly correlated at a confidence level of 99% including between perceived certainty and tangibility ($r = .451$, $p < .01$), and between self-reported knowledge and perceived danger ($r = .343$, $p < .01$). More interesting, there is very high positive relationship between self-reported knowledge and perceived certainty ($r = .807$, $p < .01$).

Table 3. Correlations among independent variables and self-reported knowledge, perceived danger levels, perceived certainty and perceived tangibility scores

	Self-reported knowledge	Perceived danger	Perceived certainty	Perceived tangibility
Self-reported knowledge	1.0	.343**	.807**	.455**
Perceived danger	-	1.0	.316**	.382**
Perceived certainty	-	-	1.0	.451**
Perceived tangibility	-	-	-	1.0

**Correlation is significant at the 0.01 level (2-tailed)

Table 4. List of most frequent information source on the Earth systems and environmental issues

Issues (Total)		Most frequent source to get information on environmental issues		Second frequent source	
		Item[++]	%	Item	%
Acid Rain	94	School (33)	35.1	Don't know (32)	34.0
Air Pollution	94	School (60)	63.8	TV (13)	13.8
Water Pollution	93[+]	School (53)	57.0	TV (14)	15.1
Global Warming	94	School (46)	48.9	TV (14)	14.9
Oil Spills	94	School (28)	29.8	TV (27)	28.7
Ozone Hole	94	School (31)	33.0	Don't know (23)	23.5
Trash Disposal	94	School (55)	58.5	TV (12)	12.8
El Niño	94	TV (33)	35.1	Don't know (25)	26.6

[+]: The sum is not 94 due to one sample with missing value
[++]: 9 information sources are provided: School, parents, TV, Internet, newspaper, books, magazines, radio, and don't know

Question Five: Information source about Earth systems and environmental issues

As can be seen in Table 4, the subjects responded that their most frequent information source on environmental issues was from their school regarding air pollution (63.8%), global warming (48.9%), water pollution (57%), and trash disposal (58.5%). On the contrary, many students answered that they did not know about most frequent information source on the selected Earth systems and environmental issues. The subjects also answered that they obtained information about El Niño (35.1%), oil spills (28.7%), water pollution (15.1%), global warming (14.9%), air pollution (13.8%), and trash disposal (12.8%) from television.

Discussion and Conclusion

This exploratory study focuses on elementary students' perceived certainty, perceived tangibility, self-reported knowledge level, and perceived danger of eight selected Earth systems and environmental issues. When considering the degree of self-perception regarding the emerging issues, some important points can be made about the results of this study.

First, this study revealed that ozone hole, acid rain, El Niño, and global warming were identified by the elementary students as uncertain and intangible issues. As described in the preceding section, scientific uncertainty can be attributed to students' misconception of the issues. Numerous studies of students' understanding of environmental issues indicate that students can have misconceptions about more uncertain issues (e.g., global warming, and ozone depletion) compared to certain issues (Boyes & Stanisstreet, 1992, 1998; Fortner et al., 2000; Gowda et al., 1997; Rye et al., 1997). Khalid (2002) also stated that the presence of misconceptions could be lead to ineffective instructional activities in science classroom. Therefore, young students' alternative conceptions toward these uncertain and intangible issues can be a barrier and challenge in learning and understanding significant and important Earth systems and environmental issues. It is especially important to conduct more research and pay more attention to decrease uncertainty and intangibility about those global level issues.

In addition, several studies revealed that some of the similar misconceptions (e.g., global warming, ozone hole) were identified by various grade levels: 5th grade students (Francis, et al., 1993); 5th and 6th grade students (Christidou & Koulaidis, 1996); middle school students (Dorough, Rubba, & Rye, 1998); high school students (Gowda, Fox, & Magelky, 1997); and college & university students (Cheong, 2003; Lee & Fortner, 2000; Morgan & Moran, 1995; Khalid, 2002). How can these students' misconceptions hold unchanged up to the college level? Further studies need to take place for the purpose of looking for the potential reasons and

related factors of these students' alternative conceptions from both qualitative and quantitative inquiry.

Second, perceived certainty ($r = .807$, $p < .01$) and perceived tangibility ($r = .455$, $p < .01$) were highly positive correlated with self-reported knowledge compared to other relationships (Table 3). The results indicated that more knowledgeable issues were perceived as more certain and tangible issues by elementary students. According to Lee (2000), perceived certainty can change over time as students learn more about a subject or find ways to study it. Perceived tangibility also can change over time. Thus, how can we improve their content knowledge and change their perceptions? As shown in Table 4, the elementary students were more dependent on the two information sources for their environmental information: School and television.

In the United States school curriculum, one widespread approach for environmental education is to infuse it into various curricular areas (Disinger, 1987, 1993). Environmental education has taken place in many different forms as a part of school education. Science and environmental educators have developed various forms of programs (or activities) that are not only limited to single courses in the curriculum. Therefore, the findings of this study provide a significant implication for school science and environmental education because these contents have not received much attention as a core school curriculum for elementary school students. It is hoped that the environmental issues, including global level issues, should be extensively infused across the curriculum and/or integrated with school science education in order to help young students gain better understandings and content knowledge related to the Earth systems and environmental issues that are essential scientific literacy for the new globalization era.

Third, numerous studies indicate that the mass media influences public understandings, knowledge, and opinions related to environmental issues. Most of what Americans know about environmental knowledge, information and risks comes from the major mass media such as television and newspapers (Atwater, et al., 1985; Bowman, 1978; Bowman & Hanaford, 1977; Fortner & Lyon, 1985; Ostman & Parker, 1987; Salomone et al, 1990). However, our results showed that learning from school was the most frequent information source for environmental issues. The second most frequently used source of information was television among several mass media sources such as newspapers, books, magazines, radio, and Internet. Therefore, elementary level educators should keep in mind that school and television may be the most often used sources for the Earth systems and environmental issues. Young students' knowledge and perception could be greatly influenced by school-based education compared to adults and adolescents.

Fourth, the body of research on gender differences in perception of environmental risk indicated that females exhibit higher perceptions of risks than males (Burger et al, 1999; Flynn, Slovic, & Mertz, 1994; Ginsburg & Miller, 1982; Riechard & MaGarrity, 1994; Riechard & Peterson, 1998). As can be seen in Table 2, the results indicated that female subjects' perceived danger was significantly higher than male subjects ($t = -2.44$) at $\alpha < .05$ or better. When considering the gender differences regarding the issues, the study provided another evidence to support the previous studies regarding gender differences. Although it is difficult for teachers and curriculum developers, it is hoped that this result could influence teachers' understandings, instructional activities, and developing curriculum applied to these research findings.

Finally, our findings provide valuable criteria for elementary science and environmental education programs. As an elementary teacher or curriculum developer for an elementary level, "developing educational programs better matched to the learner's perception of an environmental issue may require efforts to decrease issue uncertainty through enhancing science knowledge, demonstrating ways to collect evidence for decisions, or establishing contact with credible sources of first hand information" (Fortner,

et al, 2000, pp. 138-139).

School science and environmental programs might not be playing enough of a role in providing knowledge and information about recent emerging environmental issues, even though awareness of the importance of science and environmental education has increased in recent decades. It is hoped that this study contributes to understanding the elementary students' perceptions toward the selected Earth systems and environmental issues.

Acknowledgments

This research was supported by Kyungpook National University Research Fund, 2004.

References

Atwater, T., Salwen, M.B., and Anderson, R.B., 1985, Media agenda-setting with environmental issues. Journalism Quarterly, 62 (2), 393-397.

Bentley, D., and Watts, M., 1994, Primary science and technology. Open University Press, Bristol, PA, USA, 221 p.

Bowman, J.S., 1978, American daily newspapers and the environment. The Journal of Environmental Education, 10 (1), 2-11.

Bowman, J.S., and Hanaford, K., 1977, Mass media and the environment since Earth Day. Journalism Quarterly, 55 (1), 160-165.

Boyes, E., and Stanisstreet, M., 1992, Students' perceptions of global warming. International Journal of Environmental Studies, 42, 287-300.

Boyes, E., and Stanisstreet, M., 1998, High school students' perception of how major global environmental effects might cause skin cancer. Journal of Environmental Education, 29 (2), 31-36.

Burger, J., Sanchez, J., Gibbons, J.W., Ondrof, J., Ramos, R., Mcmahon, M., Gaines, K. F., Lord, C., Fulmer, M., and Gochfeld, M., 1999, Attitudes and perceptions about ecological resources and hazards of people living around the Savannah river site. Environmental Monitoring and Assessment, 57, 195-211.

Cheong, C., 2003, The environmental perceptions of preservice secondary school teachers about the global environment. Journal of Korean Earth Science Society, 24 (4), 273-280.

Christidou, V., and Koulaidis, V., 1996, Children's models of the ozone layer and ozone depletion. Research in Science Education, 26, 421-436.

Disinger, J.F., 1987, Current practice: Environmental education in U.S. school curricula. In Disinger, J.F. (ed.), In trends and issues in environmental education: Environmental education in school curricula. ERIC/SMEAC, Columbus, OH, USA, 117-136.

Disinger, J.F., 1993, Environment in the K-12 curriculum: An overview. In Wilke, R.J. (ed.), Environmental education teacher resource handbook: A practical guide for K-12 environmental education. Kraus International Publications, Millwood, NY, USA: 117-136.

Flynn, J., Slovic, P., and Mertz, C., 1994, Gender, race, and perception of environmental health risks. Risk Analysis, 14, 1101-1108.

Fortner, R.W., Lee, J., Corney, J.R., Romanello, S., Bonnell, J., Luthy, B., Figuerido, C., and Ntsiko, N., 2000, Public understanding of climate change: Certainty and willingness to act. Environmental Education Research, 6 (2), 127-141.

Fortner, R.W., and Lyon, A.E., 1985, Effects of a Cousteau television special on viewer knowledge and attitudes. The Journal of Environmental Education, 16 (3), 12-20.

Francis, C., Boyes, E., Qualter, A., and Stanisstreet, M., 1993, Ideas of elementary students about reducing the "greenhouse effect." Science Education, 77, 375-392.

Gallup, 1997, Public concerned, not alarmed about global warming. [Online]. Available: http://www.gallup.com/poll/releases/pr971202.asp/ [2005, February 20].

Ginsburg, H., and Miller, S., 1982, Sex differences in children's risk-taking behavior. Child Development, 53, 426-428.

Gowda, M., Fox, J.C., and Magelky, R.D., 1997, Students' understanding of climate change: Insights for scientists and educators. Bulletin of The American Meteorological Society, 78 (10), 2232-2240.

Khalid, T., 2001, Pre-service teachers' misconceptions regarding three environmental issues. Canadian Journal of Environmental Education, 6, 102-120.

Lee, J., 2000, A cross-cultural investigation of college students' environmental decision-making behavior: Interaction among cultural, environmental, decisional, and personal factors. Unpublished Ph. D. dissertation, The Ohio State University, Columbus, USA, p. 188.

Lee, J., and Fortner, R. W., 2000, Classification of environmental issues by perceived certainty and tangibility. The International Journal of Environmental Education and Information, 19 (1), 11-20.

Morgan, M.D. and Moran, J.M., 1995, Understanding the greenhouse effect and the ozone shield: An index of scientific literacy among university students. Bulletin of American Meteorological Society, 76, 1185-1190.

Mason, L., and Santi, M., 1998, Discussing the green-

house effect: Children's collaborate discourse reasoning and conceptual change. Environmental Education Research, 4 (1), 67-85.

Ostman, R.E., and Parker, J.L., 1987, A public's environmental information sources and evaluations of mass media. Journal of Environmental Education, 18 (2), 9-17.

Riechard, D.E., and McGarrity, J., 1994, Early adolescents' perceptions of relative risk from 10 societal and environmental hazards. Journal of Environmental Education, 26 (1), 16-23.

Riechard, D.E., and Peterson, S.J., 1998, Perception of environmental risk related to gender, community socioeconomic setting, age, and locus of control. Journal of Environmental Education, 30 (1), 11-19.

Rye, J.A., Rubba, P.A., and Wiesenmayer, R.L., 1997, An investigation of middle school students' alternative conceptions of global warming. International Journal of Science Education, 19 (5), 527-551.

Salomone, K.L., Greenberg, M.R., Sandman, P.M., and Sachsman, D.B., 1990, A question of quality: How journalists and news sources evaluate coverage of environmental risk. Journal of Communication, 40 (4), 117-130.

Scruggs, T.E., and Mastropieri, M.A., 1994, The construction of scientific knowledge by students with mild disabilities. The Journal of Special Education, 28 (3), 307-321.

Watts, M., Jofili, Z., and Bezerra, R., 1997, A case for critical constructivism and critical thinking in science education. Research in Science Education, 27 (2), 309-322.

Stanisstreet, M. and Boyes, E., 1996, Young people's ideas about global environmental issues. In Harris, G., and Blackwell, C. (eds.), Monitoring change in education 2: Environmental issues in education. Ashgate Pub. Company, Aldershot, Hants, England, 186 p.

Watts, M., Jofili, Z., and Bezerra, R., 1997, A case for critical constructivism and critical thinking in science education. Research in Science Education, 27 (2), 309-322.

Manuscript received: 22 August 2006
Revised manuscript received: 9 October 2006
Manuscript accepted: 9 October 2006