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Determination of Preservice Chemistry Teachers' Cognitive Structures via Flow Map Method and Their Knowledge Level on "Greenhouse Gases and Their Effects" Topic

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Abstract

The purpose of the current study was three-fold. The first purpose was to examine preservice chemistry teachers' cognitive structures in order to define their conceptual understanding and misconceptions of "greenhouse gases and their effects." The second purpose was to determine their knowledge level regarding this topic by means of different kinds of concept tests. The third purpose was to analyze the correlation between the preservice chemistry teachers' success on the tests and their conceptual understanding. Thirty preservice chemistry teachers from Hacettepe University participated in the study. To define their cognitive structures relevant to the topic, the flow map method was used. Multiple Choice Concept Test, Correct Concept Test, and Incorrect Concept Test were used to determine their knowledge level of "greenhouse gases and their effects". The analysis on the flow maps showed that they do not have enriched cognitive structures and lack knowledge. Also we observed that they have some misconceptions. It was determined that there is a significant, positive correlation between their success on the Correct Concept Test scores. However, their scores on the Multiple Choice Concept Test and Incorrect Concept Test were insignificant when assessed in relation to conceptual understandings.

Keywords: Cognitive Structure, Concept Test, Conceptual Understanding, Flow Map, Misconception

Introduction

The greenhouse effect and global warming rank first among environmental problems. The greenhouse effect is a dangerous threat to the future of our global environment (Baranzini, Chesney & Morisset, 2003). Events resulting from global warming such as climate changes, melting glaciers and drought will threaten our planet in the near future (Yıldız, Sipahioğlu & Yılmaz, 2000). So the public must be informed about the serious consequences of global warming (Daniel, Stanisstreet & Boyes, 2004).

In this point, it is very important for students to learn about the environment and environmental problems. In the formulation of their environmental awareness, it is very important to be well-informed about these problems and free of misconceptions about these issues. Because of the complexity of these environmental problems leads to misunderstandings among students as well as the general public (Groves & Pugh, 1999). A better understanding of students' ideas about the environment can lead to better instruction methods and potential improvements in the public understanding of science (Cordero, 2001).

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For science teachers and educators, determination of students' cognitive structures is vital for the examination of their knowledge, conceptual understandings and misconceptions about various issues. Cognitive structure represents the organization and relationships of concepts in a students' long term memory (Tsai, 2001). Educators can understand the students' misconceptions, help them engage in metacognitive learning and thus enhance their learning outcomes through analyses of the students' cognitive structures. Students' cognitive structures potentially display how they relate learned concepts to life experiences and can allow students more flexibility in expressing their ideas (Tsai & Huang, 2002).

For representing students' cognitive structures, a flow map method is used. The sequential and network linkages in respondents' recall are displayed by a flow map (Anderson & Demetrius, 1993). The flow map analyses provide evidence of the amount of knowledge and its organization in memory (Yang, 2004).

It is an analysis of the sequential linkage and crosslinkage of ideation in the respondents' recorded narrative. The map is not produced by the respondents (Dhindsa & Anderson, 2004). Linkages among respondents' statements are examined by recall narrative, either in written or recorded oral communications (Anderson, 2009). There are two types of arrows used in the flow map diagram. While linear arrows indicate the sequential flow of how the respondent expresses his/her own ideas, recurrent arrows indicate the connections among relational statements, such as the associations between the occurrences of revisited ideas (Tsai, 2001).

The flow map can also be used to analyze students' misconceptions. Students' misconceptions that are itemized and recognized in the flow map represent part of their cognitive structures. The numbers of misconceptions in the flow map display the accuracy of the conceptual frameworks (Tsai, 2001).

Misconceptions are conceptual and propositional knowledge that is inconsistent with or different from the commonly accepted scientific consensus (Sanger & Greenbowe, 2000). Students develop these misconceptions as a result of personal experience, misinformation from other people or through the media (Ausubel, 1968 and Driver et al., 1985 as cited in Khalid, 2003). Sometimes students have strong misconceptions that even after learning the correct concepts in the classrooms, they resist modifying their pre-existing ideas. Instead they use their misconceptions in interpreting the new acquired knowledge (Driver et al. as cited in Khalid, 2003).

Results of some studies show that preservice teachers and students have misconceptions about issues such as the greenhouse effect, global warming and ozone depletion (Arsal, 2010; Bahar & Aydın, 2002; Bal, 2004; Boyes, Chamber & Stanisstreet, 1995; Boyes, Stanisstreet, 1998; Boyes, Stanisstreet & Papatoniou, 1999, Cordero, 2001; Groves & Pugh, 1999; Kalıpcı, Yener & Özkadif, 2009; Khalid, 2001 and 2003; Summeers, Kruger & Childs, 2001). These are abstract, complex environmental issues (Boyes, Chamber & Stanisstreet, 1995). Many students have only partial understanding of these concepts because they frequently fail to comprehend the processes that cause these problems, their effects on human beings and on the planet. As a result, they develop a conception that is incompatible with scientific explanations (Soyibo, 1995 as cited in Khalid, 2003).

For an effective, accurate and efficient learning to be realized, misconceptions of pre-service teachers forge in their minds are to be revealed (Kalıpcı, Yener & Özkadif, 2009). Since teachers having misconceptions is one of the possible reasons of students misconceptions, especially it is important to prevent pre-service teachers' misconceptions about issues such as the greenhouse effect, global warming during their undergraduate education. Therefore, research is needed to determine preservice teachers' misconceptions about these issues (Arsal, 2010).

Also different types of tests are used to explore the students' knowledge about environmental issues. In educational practice, testing has been primarily considered as an evaluation tool (McDaniel, Anderson, Derbish & Morisette, 2007). But recent studies demonstrated that taking a test on studied material promotes learning and conceptual understanding (Cranney et al., 2009; Roediger & Marsh, 2005; Tulving, 1967). Reading the choices in a test or retrieving information by cues might activate relative memory, modify the memory trace of target items and increase the probability of a successful retrieval later (Kang, McDermott & Roediger, 2007). Testing effect comes into stage while students try to select one response among several. Factors like distraction and the correctness of response descriptions may influence their construction of new positive and negative outcomes when they are unfamiliar with a question. In their study Chang, Yeh and Barufaldi (2010) investigated the testing effect. They used three types of tests: multiple choice, correct concept test and incorrect concept test. They found that traditional tests can affect learners' long term memory; students develop more correct concepts when true descriptions are given in tests and they develop more misconceptions when more incorrect concepts are provided. McDaniel et al. (2007) concluded that classroom testing can be used to promote learning. They investigated the testing effect in a college course. Students took weekly quizzes including multiple choice or short answer questions. In other weeks, students sat for additional reading. They found that quizzing, not additional reading, improved students' learning, and short answer quizzes yielded greater benefit.

As far as the studies concerned, the sources of students' misconceptions and information are absolutely critical (Arsal, 2010; Kalıpçı, Yener & Özkadif, 2009; Khalid, 2003). Preservice teachers can equip their students with true knowledge and proper orientation only if they have received correct information during their own educational life. So it is critically important to analyze the cognitive structures of preservice teachers so as to define their knowledge, conceptual understandings and misconceptions regarding "greenhouse gases and their effects".

Aim of the study

The study aimed to:

(1) Identify the preservice chemistry teachers' cognitive structures in order to define their conceptual understanding and misconceptions regarding "greenhouse gases and their effects",

(2) Determine their knowledge level on "greenhouse gases and their effects" by means of different kinds of concept tests,

(3) Analyze the relationship between their success on different types of tests and their conceptual understanding.

In this aspect, the present study focused on the following research questions:

(1) What is the level of the preservice chemistry teachers' cognitive structure relevant to "greenhouse gases and their effects"?

(2) What is the knowledge level of the preservice chemistry teachers as demonstrated by different types of concept tests?

(3) Is there a relationship between the preservice chemistry teachers' scores on different types of tests and their conceptual understanding?

Methodology

Sample

30 preservice chemistry teachers (5th grade) from the Department of Chemistry Education, Faculty of Education, Hacettepe University participated in this study during the 2009–2010 academic year. In this study the preservice chemistry teachers have been divided into 3 groups randomly, each consisting of 10 undergraduates.

Instruments

The data collected from students included four kinds:

(1) The Multiple Choice Concept Test (MCCT)
(2) The Correct Concept Test (CCT)
(3) Incorrect Concept Test (ICT)
(4) The Flow Maps

Multiple Choice Concept Test (MCCT): The Multiple Choice Concept Test was developed by the researchers of the present study. It consists of 22 multiple choice items related to the "greenhouse gases and their effects". Five experts in the field of chemistry education reviewed an initial version of the test regarding: (a) the adequacy of the test's chemistry content with respect to students' developmental appropriateness, and (b) clarification and comprehensibility of the statements. Cronbach Alpha validity of this test was computed as 0,76.

Correct Concept Test (CCT): The Correct Concept Test was developed by the researchers of the present study. It consists of 22 correct scientific statements. The choices (correct and incorrect ones) in the multiple–choice test are used while preparing CCT. The students are requested to answer the test items as "true" or "false". Cronbach Alpha validity of this test was computed as 0,83.

Incorrect Concept Test (ICT): The Incorrect Concept Test was developed by the researchers of the present study. It consists of 22 incorrect scientific items. The choices (correct and incorrect ones) in the multiple–choice test are used while preparing ICT. The students are requested to answer the test items as "true" or "false". Cronbach Alpha validity of this test was computed as 0,70.

The maximum score for each test is 22. The content validity of the tests has been approved by the five experts in the field of chemistry education. Examples of items from the three tests are shown in Appendix 1

Flow maps: In this study, the flow map method was used to analyze the preservice chemistry teachers' cognitive structures relevant to "greenhouse gases and their effects". In this process firstly preservice chemistry teachers were requested to give written answers to two open-ended questions. These questions are: What are greenhouse gases and their sources? and Explain the reasons and implications of increasing greenhouse gases in the atmosphere and their impacts on the environment and humanity. Each preservice chemistry teachers' answers to these questions were gathered and the researchers designed a flow map for each of them in line with the procedure developed by Anderson and Demetrius (1993). The linear and recurrent linkage numbers in these flow maps were calculated. These linkage numbers constituted the flow map score for each preservice chemistry teacher and were regarded as the indication of their conceptual understanding. A sample of flow map is showed in Appendix 2.

Moreover, the researchers also formulated a sample flow map to calculate to be formulated maximum linear and recurrent linkages. According to this flow map, the applicable maximum score in the flow map is 33 for linear linkage and 23 for recurrent linkage (each linkage was estimated 1 point).

Reliability of the flow map method: The reliability of the flow map method was determined by a second independent researcher to code conceptions from the preservice chemistry teachers' narratives. The Pearson correlation coefficient (r) for each preservice chemistry teacher for linear linkages ranged from 0.85 to 0.95.

The implementation steps of the study

This study was conducted during five weeks with the participation of 30 preservice chemistry teachers (5^{th} grade) from the Department of Chemistry Education in the 2009–2010 academic year. “The greenhouse gases and their effects” was chosen as the topic because it is an actual topic and it is presented in high school chemistry textbooks, general chemistry textbooks and general biology textbooks as well as homework and projects prepared by preservice chemistry teachers in training.

(1) Firstly, the aims of the study were made clear to the preservice chemistry teachers.

(2) The preservice chemistry teachers were randomly divided into three groups, each consisting of 10 preservice chemistry teachers.

(3) In order to assess their cognitive structures on “greenhouse gases and their effects”, they were asked two open-ended questions.

(4) Two weeks later, the researchers administered three types of concept tests to the preservice chemistry teachers. Group I was given CCT, Group II ICT and Group III MCCT.

(5) After that the researchers formulated a flow map for each preservice chemistry teacher by means of their written answers to two open-ended questions. Totally 30 flow maps were formulated. The conceptual understanding and misconceptions of the preservice chemistry teachers were assessed through these formulated flow maps and analysed with regard to the scope, richness and accuracy of the defined cognitive structures.

Statistical Analysis

In this study, the data analysis was carried through descriptive statistics (frequency and percentage distribution). Also Pearson correlation coefficient was used to evaluate the correlation between success on the tests and conceptual understanding.

Results

The results were examined in line with the study's research questions. With regard to the first research question, the preservice chemistry teachers' cognitive structures were examined in order to define their conceptual understanding and misconceptions regarding “greenhouse gases and their effects”. To this aim, the researchers individually analyzed the flow maps for formulated each preservice chemistry teacher. The analysis of these flow maps revealed that the preservice chemistry teachers establish only linear linkage on “the greenhouse gases and their effects”. Therefore, only linear linkage average was used during the analysis. Table 1 shows the average linear linkage number calculated by means of flow maps.

Table 1. Descriptive statistics for each group with flow maps

Groups	N	Min	Max	Mean	Std. Dev.
Group I	10	3.00	12.00	8.90	3.1429
Group II	10	5.00	11.00	7.70	1.9465
Group III	10	4.00	12.00	7.40	2.5906

As Table 1 shows, the mean linear linkage number is $\overline{X}$=8.9 in the flow maps formulated for the preservice chemistry teachers in Group I; it is $\overline{X}$=7.7 for Group II and $\overline{X}$=7.4 for Group III. It has been determined that the linear linkage number developed by the preservice chemistry teachers is minimum 3 and maximum 12. Therefore, we observed that the preservice chemistry teachers have confined knowledge and conceptual understanding of "greenhouse gases and their effects" and so poor cognitive structures. Also they put the relevant statements in a linear order. With regard to the flow maps formulated:

The preservice chemistry teachers stated that CO_2, NO_2, CH_4 and CFCs are greenhouse gases. We also ascertained that there are some preservice chemistry teachers who have misconceptions indicating that CO, SO_2, SO_3, $H_2O_{(g)}$, NH_3, CCl_4, He, Ar are greenhouse gases. None of them mentioned O_3, CH_3Br and CH_3Cl as greenhouse gases.

48 % of the preservice chemistry teachers cited fossil fuel, unfiltered factory chimneys, car exhaust, perfume, deodorant and garbage dump as the source of greenhouse gases. The remaining of them did not mention sources for greenhouse gases. 98% of the preservice chemistry teachers never cited the sources of greenhouse gases CH_4 and NO_2.

The preservice chemistry teachers listed the reasons of greenhouse gas increase in the atmosphere as follows: unconscious industrialization, unconscious consumption, unconscious spray and deodorant use, increased vehicle use, non-filtered factory chimneys, deforestation, population growth, fossil fuel use and non-use of renewable energy sources.

20% of the preservice chemistry teachers stated that increased greenhouse gas in the atmosphere caused the greenhouse effect and subsequent global warming. 83% of the preservice chemistry students mentioned that the greater greenhouse gas content in the atmosphere caused only global warming. However, 76% of them have not explained this process and its relationship to the greenhouse effect.

The preservice chemistry teachers stated that global warming led to glaciers melting, exhaustion of water sources, some types of strain and animal extinctinction, rising temperatures, rising sea level, climate change, desertification, flooding, spate and drought. They recognized that all these factors threaten our future.

The preservice chemistry teachers never mentioned CO_2 circulation in nature, especially photosynthesis and respiration events.

They found no correlation between ozone depletion and the greenhouse effect. Only two of them cited that the ozone was depleted due to CFC increase in the atmosphere. The fact that 93% of the preservice chemistry teachers rated all the greenhouse gases as ozone-depleting gases shows that they do not know which the ozone-depleting gases are.

Also in regard to the first research question, while we were formulating the flow maps for each preservice chemistry teacher, we examined their answers to two open-ended questions. Meanwhile we detected that the preservice chemistry teachers have some misconceptions concerning “greenhouse gases and their effects”. Table 2 shows these misconceptions and their distribution.

Table 2. The preservice chemistry teachers’ misconceptions regarding “greenhouse gases and their effects” and related frequency and percentage distribution

Misconceptions	f	%
SO_2, CO are greenhouse gases.	3	10.0
SO_2 is a greenhouse gas.	5	16.6
SO_2 and $H_2O_{(g)}$ are greenhouse gases.	4	13.3
SO_2, SO_3, CO are greenhouse gases.	5	16.6
SO_2, SO_3, $H_2O_{(g)}$ are greenhouse gases.	5	16.6
SO_x, CCl_4 are greenhouse gases.	1	3.3
SO_x are greenhouse gases.	4	13.3
He, Ar are greenhouse gases.	1	3.3
S compounds are greenhouse gases.	1	3.3
SO_2, CO, NH_3 are greenhouse gases.	1	3.3
CO is a greenhouse gas.	1	3.3
SO_2, CO, $H_2O_{(g)}$ are greenhouse gases.	1	3.3
The greenhouse gas increase in the atmosphere causes global warming.	19	63.3
Greenhouse gases cause acid rain.	7	23.3
S compounds cause greenhouse effects.	1	3.3
SO_2 causes greenhouse effects.	1	3.3
Acid rains cause increased greenhouse effects in the atmosphere.	1	3.3
Global warming leads to acid rains.	1	3.3

In the analysis of flow maps, 18 misconceptions have been defined. The preservice chemistry teachers have listed SO_2, SO_3, S compounds, CO, NH_3, CCl_4, $H_2O_{(g)}$ as greenhouse gases. 63.3% of them stated that the greenhouse gas increase in the atmosphere causes ozone depletion. Another 23.3% thought that greenhouse gases caused acid rains. On the other hand, 3.3% of them identified acid rains as one of the reasons for the greenhouse effect in the atmosphere, also stating that “global warming caused acid rains”, “SO_2 caused greenhouse effects“.

In terms of the second research question, different types of concept tests were prepared in order to determine the preservice chemistry teachers’ knowledge level of “greenhouse gases and their effects”. Group I was given CCT, Group II ICT and Group III MCCT. Related percentage distributions are shown in Table 3.

Table 3 shows that the success level of Group I perservice chemistry teachers are the lowest for statements 3 and 11. 40% of the preservice chemistry teachers marked statement 3 (“the water vapour both exacerbates and alleviates the global warming”) correctly while 30% of them marked statement 11 (“water vapour is not a greenhouse gas”) correctly.

The Group II preservice chemistry teachers demonstrated a low success level on ICT for the statements 2, 6, 7, 18, and 19. They answered statement 2 incorrectly, stating that “CO_2, CH_3Cl, CH_3Br, CFC are both ozone depleting and sera gases”, whereas 80% of them incorrectly answered statement 6 (“CO/CO_2 is one of the pollutants that cause ozone layer depletion”) and statement 18 (“Various human actions affect global warming as follows, from the most to the least: industrialization, energy use, deforestation, agriculture"). All of them gave an incorrect answer for statement 19 ("CFCs are used in coolers and artificial fertilizers. They are only greenhouse gases") and statement 7 ("CO_2 has increased in the atmosphere in recent years. Ecologists consider it as a result of inappropriate maintenance of solid and nuclear waste").

Table 3. Percentage of distribution regarding success level of Group I, II and III preservice chemistry teachers on the tests

Item No	Group I (CCT)		Group II (ICT)		Group III (MCCT)	
	Right Answer %	Wrong Answer %	Right Answer %	Wrong Answer %	Right Answer %	Wrong Answer %
1	70	30	80	20	90	10
2	100	0	0	100	20	80
3	40	60	90	10	10	90
4	70	30	90	10	90	10
5	90	10	40	60	90	10
6	100	0	20	80	100	0
7	100	0	0	100	100	0
8	100	0	50	50	90	10
9	100	0	60	40	90	10
10	90	10	30	70	70	30
11	30	70	80	20	40	60
12	100	0	80	20	100	0
13	100	0	70	30	90	10
14	100	0	70	30	90	10
15	90	10	70	30	100	0
16	80	20	100	0	90	10
17	60	40	100	0	70	30
18	90	10	20	80	20	80
19	100	0	0	100	100	0
20	70	30	80	20	100	0
21	100	0	60	40	100	0
22	100	0	90	10	50	50

The Group III preservice chemistry teachers had a low success level on MCCT for statements 2, 3, 11 and 18. 80% of them gave a incorrect answer to question 2 ("Which of the following is both a greenhouse gas and ozone-depleting gas?"); 90% incorrectly answered question 3 ("Which of the following statements about water vapor is true?"). While 60% of the preservice chemistry teachers incorrectly answered question 11, ("Which of the following is not a greenhouse gas?"), the other 80% gave a incorrect answer to question 18 ("Which of the following are various human actions that affect global warming from the most to the least effective?").

Considering the study's third research question, a simple correlation analysis was carried out in order to investigate the relationship between the preservice teachers' test scores and their conceptual understanding. Pearson correlation coefficient was estimated. The findings are shown in Table 4.

Table 4. Results of Correlations

Conceptual understanding of groups	Pearson Correlation	p
Conceptual understanding (flow map scores) of Group I-CCT	0.862**	0.001
Conceptual understanding (flow map scores) of Group II -ICT	0.427	0.219
Conceptual understanding (flow map scores) of Group III-MCCT	0.129	0.723

**Correlation is significant at the 0.01 level.

Table 4 reveals that there is a high level, positive and significant relationship between the Group I preservice chemistry teachers' scores in CCT and their conceptual understanding ($r=0.862$, $p<0.01$). There was no significant relationship between Group II preservice chemistry teachers' ICT scores and their conceptual understanding ($r=0.427$, $p>0.01$), and Group III preservice chemistry teachers' MCCT scores and their conceptual understanding ($r=0.129$, $p>0.01$).

Discussion

In line with the first research question, we analyzed 30 flow maps that we formulated by using the preservice chemistry teachers' answers to two open ended questions regarding "greenhouse gases and their effects" and that aimed to discover their relevant cognitive structures. It was determined that the preservice chemistry teachers develop only linear linkages and the number of linear linkage developed by them is 3 at minimum and 12 at maximum. These values are considered to be extremely low. Assessment of the flow maps formulated by the researchers revealed that the linear linkage is 23 and recurrent linkage is 33. Accordingly, it has been concluded that the preservice chemistry teachers have poor cognitive structures. These findings are consistent with the results of a previous study by Selvi and Yakışan (2005). Selvi and Yakışan (2005) aimed to discover the preservice biology teachers' cognitive structures relating to "carbon cycle", a part of the ecological cycle. The flow maps charting the preservice teachers' cognitive structures showed that the number, organization, order of ideas, number of the linear linkage (a determiner of the recalled information) and number of the recurrent linkage that indicates the richness of the knowledge nets in preservice teachers' cognitive structures were less than expected.

The result of the analysis formulated from 30 flow maps confirms that the preservice chemistry teachers have misconceptions regarding "greenhouse gases and their effects". The preservice chemistry teachers listed $H_2O_{(g)}$, CO, SO_2 and SO_3 as greenhouse gases. In their research including higher education students, Oluk and Oluk (2007) pointed out that some students considered the elements such as C, N, Pb, H, S to cause the greenhouse effect. This showed that they have incorrect information about greenhouse gases. Futhermore, Bahar and Aydın (2002) concluded that the preservice classroom teachers have insufficient background about greenhouse gases and global warming and suffer misconceptions of greenhouse gases and global warming.

Of the preservice chemistry teachers, 23.3% stated that greenhouse gases caused acid rains. This statement showed that the preservice chemistry teachers erroneously considered that all greenhouse gases cause acid rains. In fact only N_2O contributes to acid rains accompanied by its greenhouse effects and ozone depletion (Gündüz, 2008).

We noted that 3.3% of the preservice chemistry teachers misconceive acid rains as one of the reasons for the greenhouse gas increase in the atmosphere. However, the greenhouse effect is not among the results of acid rains. Groves and Pugh (1999) showed in their study of preservice elementary school teachers' misconceptions that the preservice teachers incorrectly cited acid rains as produced by the greenhouse effect. Some 3.3 % of the preservice chemistry teachers stated that global warming causes acid rains, which also showed that they hold relevant misconceptions. Kahraman et al. (2008) have concluded that most preservice classroom teachers have insufficient and incorrect information about global warming.

Of the preservice chemistry teachers 63.3% stated that "the greenhouse gas increase in the atmosphere caused ozone depletion". The preservice chemistry teachers had erroneous ideas considering that all greenhouse gases contribute to ozone layer depletion. Scientific evidence confirms that CFC, NO, CH_3Cl and CH_3Br are the greenhouse gases that cause ozone layer depletion (Gündüz, 2008).

Of the preservice chemistry teachers 3.3% mistakenly expressed that "SO_2 has greenhouse effect". SO_2 is a pollutant gas causing acid rains. Unlike other pollutant gases, SO_2 impedes temperature increases because SO_2 is oxidized to H_2SO_4 in the air. H_2SO_4 can absorb and reflect the sunbeams coming to the surface (Gündüz, 2008).

The preservice chemistry teachers have construed a false correlation among global warming, ozone-layer depletion and the greenhouse effect. These findings are consistent with the results of studies by Kalıpçı, Yener and Özkadif (2009) focusing on preservice biology, science and elementary teachers. Research results show that preservice teachers have certain misconceptions about reasons and results of the greenhouse effect. Arsal (2010) concluded that the preservice science and classroom teachers are confused about the reasons, effects and prevention of the greenhouse effect. In his study aiming at defining 27 preservice science teachers' misconceptions regarding the greenhouse effect, ozone layer depletion and acid rains, Khalid (2003) found out that the preservice teachers hold a number of false conceptions on the given issues. The idea that ozone layer depletion contributed to the greenhouse effect, or that increased greenhouse effect caused ozone layer depletion were among these mistakes. The study by Pekel and Özay (2005) aimed to assess high school students' ideas about the ozone layer, reasons and results of ozone depletion. Their research showed that most students have an idea about the ozone layer as well as misconceptions regarding the reasons and results of ozone layer depletion. For example, nearly half of the students stated that the greenhouse effect and acid rains caused ozone layer depletion, and again nearly half of them regarded ozone layer depletion as the reason behind the greenhouse effect.

With regard to the second research question of our study, we attempted to determine the preservice chemistry teachers' knowledge level on "greenhouse gases and their effects" through different types of concept tests. To this end we estimated the percentage distribution of the preservice chemistry teachers' answers.

To assess the percentage distribution of the Group I preservice chemistry teachers with regard to their answers on CCT test, they can be considered successful in a general sense. The underlying reason for the preservice chemistry teachers' lowest success level for statements 3 and 11 was that they considered $H_2O_{(g)}$ as a greenhouse gas. But as mentioned by Gündüz (2008), $H_2O_{(g)}$ is not a greenhouse gas. In relationship with the ICT answers given by Group II preservice chemistry teachers, they were found to have a low success level for statements 2 and 6. They stated that all of the greenhouse gases caused ozone depletion and CO is a greenhouse gas. These answers showed that they have misconceptions that explain their lower success level. The fact that the preservice chemistry teachers have misconceptions regarding greenhouse gases that cause ozone layer depletion supported their idea that CFC gases are only greenhouse gases. Therefore, all of the preservice chemistry teachers gave a incorrect answer for statement 19. To analyze the percentage distribution of the Group III preservice chemistry teachers' answers in MCCT, they were found successful in a general sense. They had a lower success level for statements 2, 3, 11, and 18. In terms of preservice chemistry teachers' misconceptions, they listed all the greenhouse gases as ozone-depleting gases and $H_2O_{(g)}$ as a greenhouse gas. This error resulted in a lower success level on their side. Moreover, most of them answered question 18 incorrectly both on ICT and MCCT, thus exposing that they misunderstand the existence of global warming.

Considering our third research question, a simple correlation analysis was carried out in order to investigate the relationship between the preservice chemistry teachers' success level and their conceptual understanding. Pearson correlation coefficient was estimated. There was a significant, positive and high-level relationship between the Groups I preservice chemistry teachers' CCT scores and their conceptual understanding. No significant relationship was detected between Group II preservice chemistry teachers' ICT scores and their conceptual understanding and Group III preservice chemistry teachers' MCCT scores and their conceptual understanding. As the result of an overall analysis regarding preservice chemistry teachers' success level in different types of tests, they have shown a better performance on CCT and MCCT compared with ICT. The preservice teachers have had the highest success level on CCT and lowest success level on ICT. The test types have influenced the preservice chemistry teachers' success levels. As mentioned in the study of Chang, Yeh and Barufaldi (2010), the different types of tests had the negative and positive effects on the preservice chemistry teachers' conceptual understanding. CCT affected preservice chemistry teachers' success positively with true statements vice versa, ICT affected preservice chemistry teachers' success negatively with incorrect statements. On the other hand MCCT made it easy for them to remember related information by giving many more clues. But the distractor choices on this test led them to perceive false information as true. Roediger and Karpicke (2006) believe that tests are accepted as evaluation tools in the educational environment. However, a test is a sound method not only to assess but also to contribute to the learning process. According to Rodieger and Marsh (2005) the multiple choice tests are generally used without considering their effects on the students' knowledge. These tests have two effects on learning. They create a positive effect by making it easy for students to recall background information and find the right answer by eliminating the alternatives. On the other hand, these tests create negative effect because they have distractor choices that cause students to attain incorrect information by the end of the test.

Conclusions and Recommendations

Our assessment is as follows:

Since preservice chemistry teachers are accountable for training the next generations, applications could be done to be intended to determine their knowledge level and possible misconceptions related to environment-environmental problems and prevent to these misconceptions.

Exploring of the preservice chemistry teachers' cognitive structures would contribute to a more effective, qualified training and educational process by identifying their mental structures and the inter-knowledge they develop. Also, within this study we observed that flow map method is an effective method for exploring cognitive structures. Such alternative methods can be investigated and used.

With the understanding that tests are known to contribute to learning and conceptual understanding as well as functioning as assessment and evaluation tools, test items should be prepared with due care and contribute to the improvement of preservice teachers.

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Appendix 1. Selected items of MCCT, CCT and ICT

MCCT Items
2. Which of the following is both a greenhouse gas and ozone-depleting gas? a) Nitrogen monoxide (NO), methyl bromide (CH_3Br), methyl chloride (CH_3Cl), chlorofluorocarbons (CFCs). b) Carbon dioxide (CO_2), methyl chloride (CH_3Cl), methyl bromide (CH_3Br), chlorofluorocarbons (CFCs). c) Methane (CH_4), sulphur dioxide (SO_2), carbon dioxide (CO_2).
3. Which of the following statements about the water vapor is correct? a) Water vapor ($H_2O_{(g)}$) exacerbates global warming. b) Water vapor ($H_2O_{(g)}$) both exacerbates and alleviates global warming. c) Water vapor ($H_2O_{(g)}$) has no effect on global warming.
6. Which of the following is one among the pollutants that cause ozone layer depletion? a) Carbon monoxide (CO) /carbon dioxide (CO_2). b) Sulphur dioxide (SO_2). c) Chlorofluorocarbons (CFCs).
11. Which of the following is not a greenhouse gas? a) Methane (CH_4). b) Methyl bromide (CH_3Br). c) Water vapor ($H_2O_{(g)}$)
12. Which of the following is the result of ozone layer depletion? a) Asthma b) Skin cancer c) Ulcer
CCT Items
2. Nitrogen monoxide (NO), methyl bromide (CH_3Br), methyl chloride (CH_3Cl), chlorofluorocarbons (CFCs) are both greenhouse and ozone-depleting gases. True /False.
3. Water vapor ($H_2O_{(g)}$) both exacerbates and alleviates global warming. True /False.
6. Chlorofluorocarbons (CFCs) are one among the pollutants that cause ozone layer depletion. True /False.
11. Water vapor ($H_2O_{(g)}$) is not a greenhouse gas. True /False.
12. Skin cancer is the result of ozone layer depletion? True /False.
ICT Items
2. Carbon dioxide (CO_2), methyl chloride (CH_3Cl), methyl bromide (CH_3Br), chlorofluorocarbons (CFCs) are both greenhouse and ozone-depleting gases. True /False.
3. Water vapor ($H_2O_{(g)}$) has no effect on global warming. True /False.
6. Carbon monoxide (CO) /carbon dioxide (CO_2) is one among the pollutants that cause ozone layer depletion. True /False.
11. Methyl bromide (CH_3Br) is not a greenhouse gas. True /False.
12. Skin cancer is the result of ozone layer depletion? True /False.

Appendix 2: The flow map which was designed for a preservice chemistry teacher

1. Carbon dioxide (CO_2), methane (CH_4), nitrogen oxide (NO_x) are greenhouse gases.

↓

2. Unconscious manuring is the source of nitrogen oxide (NO_x)

↓

3. Agricultural activities and dump sites are the source of methane (CH_4).

↓

4. Fossil fuels, vehicles, factories are the source of Carbon dioxide (CO_2).

→

5. Greenhouse gases cause to greenhouse effect.

↓

6. Crust of the earth heats as a result of greenhouse effect.

↓

7. Increment of amount of greenhouse gases cause to climate changes.

↓

8. Increment of amount of greenhouse gases cause to extreme drought.

↓

9. Increment of amount of greenhouse gases cause to desertification

↓

10. Increment of amount of greenhouse gases cause to flood catastrophe.

↓

11. Increment of amount of greenhouse gases affects human health.

↓

12. Increment of amount of greenhouse gases occur loss of vegetation.

↓ Linear linkage (each linkage was estimated 1 point).