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ORIGINAL ARTICLE

SDGs 연계 교육에서 예비 지구과학 교사들의 탄소 소양

김윤지
(대구대학교 조교수)

Carbon Literacy on Education in Connection with SDGs of the Pre-service Earth Science Teachers

Yunji Kim
(Daegu University)

ABSTRACT

This study is a basic research to apply ESD linked to SDGs to pre-service teachers majoring in earth science education. The purpose of this study is to evaluate carbon literacy by analyzing the awareness, attitude and knowledge, subjective norms, and behavioral control of the carbon footprint internalized by pre-service teachers. Pre-service teachers recognize the carbon footprint as their responsibility, but are not willing to pay the cost and accept inconveniences of the actions to reduce carbon footprint. They also support actions to reduce carbon footprint, but do not demand the actions from others. While they have sufficient knowledge about carbon mitigation actions, their conception of causes and effects of global warming is unstable. Pre-service teachers will go out to school sites and teach millions of students about global warming. It is essential to educate these teachers on the economic cost and social responsibility of reducing their carbon footprints. It is also important to find ways to bridge the gap between their thought and action. It is hoped that this study on pre-service teachers' carbon literacy will lead to realizing ESD.

Key words : carbon literacy, carbon footprint, global warming, education for sustainable development

Ⅰ. Introduction

One of the serious environmental problems facing the 21st century is climate change. In response to the worsening effect of global warming, the Intergovernmental Panel on Climate Change has publicized the fact that CO_2 is the most important anthropogenic greenhouses gas and that most of the average increase in the observed temperature globally caused by anthropogenic greenhouses gas(IPCC, 2007). Human activity has increased the concentration of CO_2 in the atmosphere by about 40% since 1750, and it is very likely that most of the observed temperature changes over the past 60 years have been caused by human activity(IPCC, 2013). Human activities are estimated

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***Corresponding author :** Yunji Kim, Daegu University, 201 Daegudaero, Jillyang, Gyeongsan, Gyeongbuk, 38453, Korea
E-mail : kimyunji@daegu.ac.kr
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to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate(IPCC, 2018). Since then, many reports and studies have urged people to recognize the importance of carbon reduction.

The term carbon literacy first emerged in the community of health professionals, who saw potential in merging a carbon conscious lifestyle with healthy choices. For example, biking or walking instead of driving is healthy and carbon reducing personal choices. Whitmarsh *et al.*(2009) defined as 'the ability to make informed judgements and to take effective decisions regarding the use and management of carbon, through both individual behavior change and collective action'. Howell(2018) bilds on this framework about carbon literacy in the context of personal choices, and defines carbon literacy as 'an individual's ability to obtain, understand and evaluate the relebant information necessary to make decisions with an awareness of the likely consequences regarding greenhouse gas emissons'. Dosa & Russ(2020) use the term carbon literacy to describe 'the knowledge, skills, attitudinal and motivational factors necessary to understand the importance, use and management of greenhouse gases'.

Carbon footprint is a currently popular term used to express the quantity of greenhouse gases emitted by a specific source. The word 'carbon' is used because the most important greenhouse gas is CO_2, and 'footprint' reminds us that the activity under consideration leaves an unintended mark on our planet. In its broadest definition, a carbon footprint is a measure of the total quantity of all greenhouse gases emitted by a specific entity or processor(Treptow, 2010). The amount of greenhouses gas, like CO_2, produced by a person's activities is defined as personal carbon footprint. To tame climate change, necessary changes to personal lifestyle must be made for carbon footprint reduction. Everyone has a unique carbon footprint and that no onesize-fits-all set of actions should be taken by all people. therefore, if people are aware of their personal carbon footprint and accordingly self-manage their behaviours, significant carbon reduction will be made(Lin, 2016).

In a study that investigated the perception of Korean college students about climate change, 103 out of 188 respondents, or 54.8%, answered 'serious'. In addition, 76 students (40.4%) expressed 'very serious' thoughts, and a total of 95.2% of college students are concerned about the seriousness of global warming(Choi, 2015). In the Korean curriculum, environmental education is integrated throughout educational activities as a cross-curricular theme. Therefore, the pre-service teachers enrolled in the College of Education will become the subject of education on global environmental issues, including climate change, when they go to the school site. In addition, the carbon literacy of pre-service teachers will have a direct or indirect effect on numerous students(Kim, 2021).

This study was designed as a basic study to apply ESD(Education for Sustainable Development) linked to SDGs(Sustainable Development Goals) to pre-service teachers majoring in earth science education. The purpose of this study was to analyze and evaluate the broad categories of carbon literacy internalized by pre-service teachers, that is, the awareness, attitude and knowledge of carbon footprint, and subjective norm and behavioral control. It will be able to contribute to fostering community capacity to actively participate in global development with the values and attitudes required of members of the global community.

Ⅱ. Method

This study was conducted at a college located in a small town near D Metropolitan City. The subjects of this study are pre-service teachers majoring in Science Education at the College of Education. In Earth Science Education curriculum at D University, "Earth Environmental Science" is a prerequisite course to acquire teacher qualifications. Earth Environmental Science is an introductory course for understanding and exploring the nature of the global environment. Students discuss recent trends on global issues such as glob-

al warming as well as issues of conflicting interests between countries and explore mitigation measures and actions to be taken. The students who participated in this study are currently taking or have already taken the Earth Environmental Science course. 27 students majoring in earth science education and 5 pre-service teachers double majoring earth science agreed to participate in the study. The subjects of this study were 9 female students and 4 male students in their second year, and 9 female students and 10 male students in their 3rd year, totaling 32 students. The gender makeup of the subjects was 18 female students (56%) and 14 male students (44%).

This research aims to apply ESD to pre-service teachers. ESD aims at developing competencies that empower individuals to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and a global perspective. Individuals should also be empowered to act in complex situations in a sustainable manner, which may require them to strike out in new directions; and to participate in socio-political processes, moving their societies towards sustainable development. International recognition of ESD as a key enabler for sustainable development has been growing steadily(UNESCO, 2019). The UN general assembly adopted the 2030 agenda for sustainable development. At the core of the 2030 agenda are 17 SDGs. The aim of the 17 SDGs is to secure a sustainable, peaceful, prosperous and equitable life on earth for everyone now and in the future. The goals cover global challenges that are crucial for the survival of humanity. The 13th goal of the SDGs is climate action; take urgent action to combat climate change and its impacts. This researcher has developed content to educate 17 SDGs, including the 13th goal, and runs a blog to share(blog.naver.com/sheistwinkle).

We reviewed studies on climate change education on the topic of carbon footprint. Lin(2016) studied an educational system that manages an individual's carbon footprint by applying the environmental behavior theory. While studying the system, the research subjects' awareness, attitude, and knowledge of carbon footprint were examined. Behavior control and subjective norms were also analyzed. This study adapted and revised some of Lin's precedent research to investigate the carbon literacy of pre-service teachers. The 19 test items were given in a 5-step Likert-scale survey, and some were presented in reverse items. 'Strongly agree' is calculated as 5 points, 'agree' is 4 points, 'undecided' is 3 points, 'disagree' is 2 points, 'strongly disagree' is 1 point, and reverse items are calculated as reverse-scored. Of the total of 25 questions, 6 were presented as open-ended questions. In Lin's study, 6 questions about the knowledge of carbon footprint were optional, but in this study, they were modified and added as open-ended questions. Some of the study subjects voluntarily participated in a one-on-one semi-structured interview with the researcher. This is also different from Lin's research method. The Likert-scale survey items from 1 to 19 were analyzed in a quantitative way by calculating each mean score. The remaining open-ended questions from 20 to 25 focused on qualitative analysis including interviews with the subjects. During the research, cross-check and validation of environmental education experts were conducted at the same time. The questions are as follows(Table 1).

Ⅲ. Results

1. Questions 1 to 19 : Likert-scale survey

Questions 1 to 7 of the carbon literacy questionnaire asked about the carbon footprint awareness of pre-service teachers(Table 2). Most respondents answered 'strongly agree' to question 1 "Global warming problems have consequences for my life." followed by 'agree' and then 'undecided'. The mean score was 4.2, indicating that pre-service teachers perceive global warming as affecting their lives. For question 2 "I worry about global warming problems.", 17 people, more than half of the subjects, answered 'agree'. In question 3 "I can see with my own eyes that the environment is deteriorating.", the number of respondents who answered 'agree' was the highest with 15. For question 4 "The attention given to the greenhouse effect is exaggerated.", there were 15 disagreements and 8

Table 1. Questionnaire of carbon literacy

1	Carbon footprint awareness	Global warming problems have consequences for my life.
2		I worry about global warming problems.
3		I can see with my own eyes that the environment is deteriorating.
4		® The attention given to the greenhouse effect is exaggerated.
5		® I am optimistic about the environmental quality in the future.
6		A better environment starts with me.
7		People who do not take the carbon footprint into account try to escape their responsibility.
8	Attitude towards carbon footprint	® Climate change is an unstoppable process, and we cannot do anything about it.
9		Reducing carbon footprint is beneficial to our living environment.
10		I am willing to sacrifice my convenience or to pay higher price in order to reduce my carbon footprint.
11	Perceived behavioral control	® There is very little I can do to save energy.
12		® There is very little I can do to save water.
13		For me to drink tap water instead of bottled water or drinks is easy.
14		® There is very little I can do to reduce waste.
15		I am confident that I can correctly separate and recycle garbage.
16		I am confident that I can choose the most environment-friendly transport for different travel purposes.
17	Subjective norm	Most people who are important to me have taken action to reduce their carbon footprints.
18		I feel pressure from people who are important to me to reduce my personal carbon footprint.
19		Most people who are important to me would approve of my carbon reduction behavior.
20	Carbon footprint knowledge (global warming, low-carbon behavior)	What is the major cause of global warming?
21		What is the environmental impact made by global warming?
22		Who do you think should take primary responsibility for the phenomenon of global warming?
23		What actions at home can help reduce carbon?
24		What transportation is helpful for carbon reduction?
25		What is the right consumption behavior to reduce carbon?

※ reverse-scored : ®

undecided. Since it was presented as reverse items, the mean score was calculated as reverse-scored and analyzed as 3.5. Question 5 “I am optimistic about the environmental quality in the future.” is also a reverse question, and the most respondents (14) answered ‘disagree’. There were 12 ‘agree’ responses to question 6 “A better environment starts with me.”, and the number of pre-service teachers who answered ‘strongly agree’ and ‘undecided’ were the same, each with 10. There were 16 ‘agrees’ to question 7 “People who do not take the carbon footprint into account try to escape their responsibility.”, which made up the majority, but there were also two ‘disagrees’. Therefore, it seems that many pre-service teachers are aware of their responsibility for their carbon footprint.

Table 2. Awareness analysis

Q	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Mean
1	13	11	8	0	0	4.2
2	8	17	6	1	0	4.0
3	11	15	4	2	0	4.1
4®	1	4	8	15	4	3.5
5®	1	3	10	14	4	3.5
6	10	12	10	0	0	4.0
7	6	16	8	2	0	3.8

※ reverse-scored : ®

Questions 8 to 10 of the questionnaire measure the attitudes towards carbon footprint of pre-service teachers(Table 3). Question 8 “Climate change is an unstoppable process, and we cannot do anything about it.” is a reverse item. The majority of people(17) answered ‘strongly disagree’,

followed by ‘disagree’ and ‘undecided’. The mean score was as high as 4.3, indicating that pre-service teachers have an attitude that there is something they can do to prevent climate change. In question 9 “Reducing carbon footprint is beneficial to our living environment.”, the largest number of responses was ‘agree’ with 15. In addition, 13 students answered ‘strongly agree’, the highest number, with the mean score of 4.3. In question 10 “I am willing to sacrifice my convenience or to pay higher price in order to reduce my carbon footprint.”, ‘undecided’ was selected the most with 12 responses and the mean score was 3.4. On this question, six pre-service teachers said they disagree with accepting inconvenience or paying for the cost.

Table 3. Attitude analysis

Q	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Mean
8®	0	1	5	9	17	4.3
9	13	15	4	0	0	4.3
10	4	10	12	6	0	3.4

※ reverse-scored : ®

Questions 11 to 16 of the questionnaire looked at the perceived behavioral control of pre-service teachers(Table 4). Item 11 “There is very little I can do to save energy.” presented as a reverse item received 15 ‘strongly disagree’ and 16 ‘disagree’. Item 12 “There is very little I can do to save water.” was also reverse-scored, with 15 responses each for ‘strongly disagree’ and ‘disagree’. The mean scores of 11 and 12 were the same (4.4), and most of the pre-service teachers showed the willingness to take actions to save energy and water. Contrary results were also found. To question 13 “For me to drink tap water instead of bottled water or drinks is easy.”, 19 people answered ‘strongly disagree’ and 9 people ‘disagree’. About 88% of pre-service teachers felt uncomfortable with drinking tap water, and only one answered ‘strongly agree’. The mean score was 1.6, which was the lowest score in this study. Reversed item 14 “There is very little I can do to reduce waste.” was answered by 18 ‘strongly disagree’ and 12 ‘disagree’. It had the highest mean score of 4.5 in this study. To question 15 “I am confident that I can correctly separate and recycle garbage.”, 17 responded with ‘strongly agree’ and 12 responded with ‘agree’. The mean score was as high as 4.4, and the pre-service teachers said that it was possible to control the behavior for separating waste for recycling. For question 16 “I am confident that I can choose the most environment-friendly transport for different travel purposes.”, 11 respondents answered ‘agree’ and 9 answered ‘strongly agree’. In addition, there were as high as 10 pre-service teachers who chose ‘undecided’ so the mean score for choosing an climate-friendly means of transportation for travel was 3.8, which is considered low.

Table 4. Behavioral control analysis

Q	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Mean
11®	0	1	0	16	15	4.4
12®	0	1	1	15	15	4.4
13	1	0	3	9	19	1.6
14®	0	0	2	12	18	4.5
15	17	12	2	1	0	4.4
16	9	11	10	1	1	3.8

※ reverse-scored : ®

Questions 17 to 19 of the questionnaire measured the subjective norm of pre-service teachers(Table 5). The most number of responses to question 17 “Most people who are important to me have taken action to reduce their carbon footprints.” was ‘undecided’, followed by ‘disagree’, and ‘agree’. The mean score was 2.8, which is lower than the median value, which shows that respondents have a slightly negative view on whether the people around them take actions to reduce their carbon footprint. For question 18 “I feel pressure from people who are important to me to reduce my personal carbon footprint.”, ‘disagree’ was the most answered by 15 people, and ‘undecided’ by 10. As for whether actions to reduce carbon footprint are required, a more negative point of view was expressed with the mean score at 2.4. On the other hand, for question 19 “Most people who are important to me would approve of my carbon reduction behavior.”, 15 respondents selected ‘agree’, which was

the highest. With a mean score of 3.5, the majority of pre-service teachers expressed a positive view as to whether they support actions to reduce carbon footprint.

Table 5. Subjective norm analysis

Q	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Mean
17	0	7	13	11	1	2.8
18	0	3	10	15	4	2.4
19	2	15	12	3	0	3.5

2. Questions 20 to 25 : Open-ended questions & interviews

Questions 20 to 25 of the questionnaire were presented in open-ended questions to examine the carbon footprint knowledge of pre-service teachers. Questions 20, 21, and 22 measured respondents' knowledge about global warming, and questions 23, 24, and 25 measured their knowledge about carbon mitigation actions. Qualitative analysis was used and the research results were obtained by transcribing semi-structured interview answers of some research subjects.

In question 20 "What is the major cause of global warming?", the most common answers included fossil fuels, greenhouse gases, and carbon emissions. In addition, a large number of pre-service teachers mentioned 'use of resources' and 'destroying the environment'. The following is from part of an interview with a pre-service teacher who answered that the main cause of global warming is 'wasting resources'.

> "The reason is… even when I look at our school, garbage is not put in the mandatory standard garbage bags, they don't separate to recycle plastic bottles and it seems like they just collect everything and throw it away without sorting for recycling. So, I think 'shouldn't we have to separate the garbage every time we throw it out?'. I feel guilty about it so I thought that this was the main cause. **Beverage bottles are thrown away with liquid in them, so I feel we are wasting the earth's resources too much**…"

A majority of pre-service teachers mentioned climate change when answering question 21 "What is the environmental impact made by global warming?". Specific words were used including global warming, temperature rise, extreme weather conditions, severe weather conditions, abnormal seasons, and abnormal climate. In addition, a large number of respondents answered that the ecosystem is being destroyed and changed due to global warming and also there are many answers mentioning a rise in sea level. Other opinions included ozone layer depletion and global pollution. The following is from part of an interview with a pre-service teacher who answered that the impact of global warming on the environment was 'rising temperature and abnormal climate'.

> "The thing that I can feel as an effect of global warming is the rising average temperature and abnormal climatic events we frequently observe recently. The weather suddenly became very cold and **in the summer it gets too hot than usual, so I can't live without the air conditioner on.** So the abnormal climate is due to some system on Earth... Even though some people say It's because of El Nino .. but actually many people think it's because of global warming..."

Twenty people, or 63% of the respondents, mentioned using words like 'I', 'human', or 'person' to question 22 "Who do you think should take primary responsibility for the phenomenon of global warming?". Also, there were three pre-service teachers who answered using the word 'us'. In less represented opinions, words such as companies or countries were also mentioned. The following is from part of an interview with a pre-service teacher who answered 'human' as mainly responsible for global warming.

> "At first, **I thought that the primary responsibility for global warming was on uh… humans.** Well... some argue that because of a certain period of the earth, global warming is not caused by human activities, but I still think that humans play a slightly catalytic role in..."

A variety of opinions were expressed for question 23

"What actions at home can help reduce carbon?". Many respondents mentioned actions to save electricity, energy, water, and resources as a way of reducing carbon footprint. In addition, some answered that the amount of waste should be reduced, recycled, and separated. There were answers as follows: reducing the use of single-use items, using eco-friendly products, and picking up food from restaurants instead of using delivery services. And there were also answers such as using less air conditioning, shutting off unnecessary electricity, and using high-energy-efficiency products. The following is from part of an interview with a pre-service teacher who said that the actions that can be taken at home to reduce carbon footprint are 'separating waste for recycling and limiting use of heating and cooling'.

> "Even just one person in the household trying to separate and dispose of garbage might help and uh… except when the weather is too hot, **I'm trying to use less air conditioning**. Well... rather than turning on the boiler, when I am alone at home, I only turn on the electric blanket which uses less electricity. this is how I try.."

Most of the pre-service teachers answered the question 24 "What transportation is helpful for carbon reduction?" picked public transportation. Specifically, 13 respondents mentioned bicycles, 6 the bus and 2 the subway. Six people mentioned walking. Some opinions were 'not driving old diesel vehicles' and 'riding a hydrogen car or electric vehicle'. The following is from part of an interview with a pre-service teacher who chose public and the bus as an effective means of reducing carbon emissions.

> "The reason is… **I saw the words written on the side of a bus. It said the bus is eco-friendly**…"

There were various answers to question 25 "What is the right consumption behavior to reduce carbon?". The majority of respondents answered that they should not use single-use products. Also other respondents mentioned avoiding using plastics, buying products that produce less waste, and using shopping bags from home instead of using plastic bags. In addition, there were answers including buying fewer products, recycling and using products for a long time. Some answered that they purchase high-energy-efficient products and eco-friendly products, and check their carbon footprint before purchasing. The following example is from part of an interview with a pre-service teacher who answered, 'purchasing a product with a low carbon footprint' as a correct consumption behavior for carbon reduction.

> "**I heard buying agricultural and seafood products with a low carbon footprint is advisable.** They are expensive though. I try to look for products indicated as having a low carbon footprint or anything like that. I think this effort might help …"

An additional question given to a pre-service teacher S, who participated in a one-on-one semi-structured interview with the researcher, was "What kind of action can you take in your daily life until you die?" Pre-service teacher said she is aware of the fact that waste sort and recycling is a serious and important matter but she said she feels she is not up to the task. S, who drank tea from her tumbler during the interview with the researcher, answered that she limits using plastic products. She also revealed that she carries her tumbler to hold water instead of buying bottled water.

Ⅳ. Discussion

This study shows that earth science pre-service teachers were concerned about the global warming problem affecting their lives. They think the warnings about the greenhouse effect are not exaggerated, and are not optimistic about the future of the environment. They think they are responsible for their car footprint and expressed awareness that they should start with themselves. Jho(2012) investigated the perceptions pre-primary teachers have on global warming. In this study, 18 out of 54 subjects, or one third of them had a cause-centered think-

ing and said that they did not recognize global warming as a serious problem. However, in this study, only 1 out of 32 subjects answered that they were not concerned about global warming. This difference can be explained by the change in the perception of the global warming problem over time about 10 years. It can be understood that the results of this study were similar to those of college students negatively aware of changes in the global environment to the future in the study of Cheong and Kim(2021).

Pre-service earth science teachers have shown a positive attitude about reducing our carbon footprint being beneficial to humans and believe that there is something they can do to combat climate change. On the other hand, when it comes to taking actions to reduce their carbon footprint, they show a different attitude when the actions cause inconvenience to them or cost a lot of money. Yoon *et al.*(2011), who studied global warming mitigation actions, discussed the attitude-behavior gap or value-action gap, referring to the complex factors between awareness of environmental issues and the implementation of pro-environmental behavior. Yoon's study shows that compared to students in Singapore, Korean students showed less willingness to act compared to their belief in environmental sustainability. Yoon's study can be used as a reference to explain the reasons why the respondents in our study show less willingness to take action to reduce their carbon footprint in the face of obstacles such as inconvenience and cost.

The pre-service teachers were positive about the behavioral control of saving energy and water. In addition, it was found that their willingness to take action to reduce waste and separate waste for recycling was also high. However, they reacted very negatively to the behavior of drinking tap water instead of drinking bottled water and beverages in plastic containers. The study of Kim (2021) can be used to evaluate the reason why pre-service teachers show more negative attitudes toward drinking tap water compared to their electricity use and waste seperation. Of course, there is a difference between the checklist of Kim's study and this study's question of whether drinking tap water is convenient. Nevertheless, these two studies are consistent in their discussion that it is necessary to correct the habit of unsustainable water use by reducing the gap between perception and practice.

The evaluation of the subjective norm of pre-service teachers showed low mean scores in general. They had a negative view on whether people around them are taking actions to reduce their carbon footprint. They also said they support actions to reduce other's carbon footprint but do not make demands on others to do that. In the study of Yoon *et al.*(2011), beliefs and willingness about taking actions for global warming mitigation differ in their manifested specific actions and countries. In addition, Yoon *et al.* found that many factors are intricately intertwined until the beliefs and willingness to act are translated into actual climate-friendly actions. This indicates that raising awareness and belief only through education may not be sufficient in inducing climate-friendly behavior, suggesting the need for an environmental policy as another external motivator. It seems that it is necessary to consider whether education can fill the gap between the perception and practice of pre-service teachers, which was identified from the results of this study.

Most of the pre-service teachers majoring in Earth science regard carbon emissions as a cause of global warming when they were asked about the knowledge of the carbon footprint. These results are consistent with the study of Jho(2012), who investigated the perceptions of global warming among pre-service elementary school teachers. However, unlike in Jho's study where elementary school teachers were found to recognize ozone layer depletion as a cause for global warming, this study found the teachers think ozone layer depletion is a result from global warming. In addition, some respondents said global warming pollutes the earth among its effects on the environment. These results are consistent with those of Lim *et al.*(2019)'s study on ozone layer depletion and environmental pollution where respondents showed misconceptions about global warming in that global warming leads to ozone layer depletion and environmental pollution. Lim *et al.* emphasized that a high level of awareness of global warming does not translate into a high level of understanding. We identified the need for

education and follow-up research to analyze and correct the conception about global warming for pre-service earth science teachers.

Ⅴ. Conclusions

The following conclusions can be drawn from this study investigating the carbon literacy of pre-service earth science teachers.

First, pre-service teachers are concerned about global warming and recognize the carbon footprint as their responsibility. However, they show a double attitude with less willingness when faced with the cost and inconvenience of reducing carbon footprint. It is known that more and more consumers are choosing to use expensive paper bags instead of cheaper plastic bags in a situation when they don't have eco-friendly bags. Education on economic costs and social responsibility to reduce their carbon footprint is essential.

Second, pre-service teachers are positive about behavioral control that saves energy and water, reduces waste, and separates waste for recycling. However, they are negative about drinking tap water instead of bottled water in plastic containers. They also support actions to reduce our carbon footprints, but do not demand the actions from others. It may not be enough just to form a consensus on the global warming issue through education. Compensation that can fill the gap between the perception and actions of pre-service teachers should be considered.

Third, while pre-service teachers have sufficient knowledge about carbon reduction actions, the conception about causes and consequences of global warming is ungrounded. Misconception, known through previous studies, was also confirmed in pre-service teachers majoring in Earth science, which was rather unexpected. In the near future, pre-service teachers will be teaching global warming issues to numerous students. There are good reasons to pay attention to their carbon literacy, including their conception about the issue.

국문요약

본 연구는 지구과학교육을 전공하는 예비교사들에게 SDGs(지속가능발전목표)와 연계된 ESD(지속가능발전교육)을 적용하기 위한 기초 연구이다. 연구의 목적은 예비교사가 내면화 하고 있는 탄소발자국에 대한 인식과 태도 및 지식, 주관적 규범 및 행동 통제를 분석하여 탄소 소양을 평가하는 것이다. 예비교사들은 탄소 발자국을 자신의 책임으로 인식하고 있지만, 비용을 지불하고 불편을 감수하는데 소극적인 이중적 태도를 갖고 있다. 또한 탄소 발자국을 줄이기 위한 행동을 지지하지만, 요구하지는 않는다. 탄소 저감 행동에 대한 상식은 충분한 반면, 지구 온난화의 원인과 결과에 대한 개념은 불안정하다. 예비교사들은 학교 현장으로 배출되어 수많은 학생들에게 지구 온난화 문제를 가르치게 될 것이다. 따라서 탄소 발자국을 줄이는 경제적 비용과 사회적 책임에 대한 소양 교육이 필수적이며, 생각과 행동 사이의 간극을 메울 수 있는 방법을 찾아야 할 것이다. 예비교사들의 탄소 소양(carbon literacy)에 대한 연구로부터 ESD로 이어지는 교육이 실현되기를 바란다.

주제어: 탄소 소양, 탄소 발자국, 지구 온난화, 지속가능발전교육

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