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RESEARCH ARTICLE

Korean Students' Environmental Perceptions: Focusing on comparative analysis with Canada and Singapore

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ABSTRACT

The purpose of this study is to investigate Korean students' perception of sustainable development. Using raw data on students' responses to the PISA 2018, this study analyzed Korean students' responses to items related to sustainable development and compared these results with those from Canada and Singapore. PISA 2018 student questionnaire's items related to sustainable development were reclassified into environmental awareness, self-efficacy, sense of purpose, and action. Results revealed that students' awareness of 'climate change and global warming' from all three countries was higher than that of 'global health', and their scores for environmental awareness were higher than their environmental self-efficacy. Regarding environmental self-efficacy and sense of purpose, Korea and Singapore showed a higher response than Canada. Among the three countries, Korea showed the highest participation rate in environmental actions due to Korea's socio-cultural and institutional characteristics. Students' perception of sustainable development showed a mostly positive correlation with science achievement, and economic, social, and cultural status (ESCS), and the correlation with science achievement was higher. These results highlight that it is possible to identify Korean students' perception of sustainable development and suggest implications for education in sustainable development.

Key words: Sustainable development, environmental awareness, environmental self-efficacy, environmental sense of pourpose, environmental action, science achievement, PISA, ESCS, Korea, Canada, Singapore

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Introduction

Given the links between the global climate crisis and humankind's potential for survival, environmental issues are reported in the media daily, thus evoking people's interest in the environment, raising their awareness of the crisis, and indirectly providing them with global citizenship education (MPDSI, 2022).

While environmental issues have emerged along with industrialization, the need for active global efforts to preserve the earth's ecosystem and reduce carbon emissions. As the world is

increasingly recognizing the fact that environmental problems are not simple nor spontaneously arising but are complex and caused by human activities, the need for education for sustainable development (ESD), that is, education that promotes the joint efforts of many countries worldwide and across various spheres such as politics, the economy, society, and culture, has come to light (WCED, 1987).

The term sustainable development (SD) was first used in the 1987 book Our Common Future. ESD refers to education that aims to impart values, behaviors, and ways of life that promote a sustainable future and social transformations 'to meet the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987). With the subsequent publication of the Rio Declaration on Environmental Development and the accompanying plan of action known as Agenda 21 in 1992, SD became a major policy issue for many nations. The importance of SD is now emphasised worldwide, and UNESCO has described ESD as 'global citizenship education'. Global citizenship education highlights the active role of learners, enabling them to become active contributors in shaping a sustainable world (UNESCO, 2014).

The Programme for International Student Assessment (PISA), an international comparative study that measures the literacy of 15-year-old students, formulates innovative topics every cycle that reflect the world's rapidly changing societies. The global competency was adopted as the innovative domain in PISA 2018 to measure students' competencies as global citizens (OECD, 2019b). Global competency supports the sustainable development goals (SDGs) adopted at the 70th UN General Assembly. In this regard, the PISA 2018 questionnaire on global competency deals with SD-related environmental, economic, and social issues (OECD, 2019a). In this study, the perceptions and practices of students with respect to SD-related environmental problems were investigated based on the results of the PISA 2018.

To analyze the responses of Korean students, two other countries were selected for comparison and the reasons are as follows: First, similar to Korea, Singapore and Canada present higher than the OECD average PISA performance, and these countries can be generally classified as countries with advanced education systems. Second, Canada has an advanced ESD system, so various projects and education policies related to ESD are being implemented in Canada (McKeown & Nolet, 2013). Third, driven by the goal of 'towards a model green city', Singapore's implementation of policies is based on a high degree of state control, and it has marked advantages in terms of its environmental policies (Neo, 2007) and includes education on global citizenship. These make it a good case for comparison with Korea.

The specific research questions that guided this study are as follows:

What are the Korean students' perception to environmental awareness, self-efficacy, sense of purpose, and action compared to Canada and Singapore?

How are students' environmental awareness, self-efficacy, sense of purpose, and action, science achievement, and PISA index of economic, social, and cultural status (ESCS) scores correlated?

Theoretical Background

Environmental Variables Consisting of Environmental Literacy

ESD is an approach to environmental issues that considers social, economic, and political dimensions, and

environmental education is a major component. The main goals of environmental education include improvement of students' knowledge about environmental problems, cultivation of their attitudes toward environmental problems, their ability to evaluate environmental problems in various ways, and their acquisition of the skills needed to participate in solving such problems (UNEP & UNESCO, 1976). The need for citizens to take responsibility for the environment through positive attitudes toward sustainability is being raised by scholars (Lee et al., 2013). Several studies reported environmental variables (Chen et al., 2011; Hassan et al., 2010; Tikka et al., 2000). Tikka et al. (2000) suggested that educational background affected environmental attitudes, activity levels, and knowledge. Also, attitudes, the quantity of activity, and knowledge about environmental issues correlated with one another. Chen et al. (2011) reported that respondents who were employed, holding leadership position, living in larger cities and single increased the odds of participating in pro-environmental behavior. Hassan et al. (2010) found that the level of environmental awareness on the concept of SD differed between two groups: 1) science STEAM versus art STEAM students; 2) urban school versus suburban school students.

From another perspective, studies have consistently reported that certain environmental variables are related to environmental behaviors. For example, a significant correlation was found between adolescents' demonstration of pro- environmental behavior and whether people close to them displayed such behavior (De Leeuw et al., 2015). Furthermore, multiple studies have highlighted that participation in environmental education increases the likelihood that students will engage in pro-environmental behaviors (Eppinga et al., 2019; Jorgenson et al., 2019). Eppinga et al. (2019) confirmed that students who took an environmental science program related to solving sustainability problems wherein they applied the concepts they were learning in a local context, showed positive changes in their willingness to engage in pro-environmental behavior and environmental awareness. As education can promote pro-environmental behavior in students but cannot necessarily induce them to internalise environmental concepts or persuade others to change their behavior, new forms of environmental education that create opportunities for students to interact and experiment with different types of actors are needed (Jorgenson et al., 2019).

These studies commonly expect students to be environmentally literate, which is the learning goal of ESD. An environmentally literate person shows a pro-environmental attitude based on higher environmental knowledge, and is likely to ultimately engage in pro-environmental behavior (De Young et al., 1993; Meinhold & Malkus, 2005).

ESD and Scientific Literacy

Science education aims to equip students with scientific literacy (AAAS, 1993; Bybee, 1997; MOE, 2015; Roberts, 2007). In general, scientific literacy refers to the ability to understand science and scientific processes, understand the relevance of science and technology to society, and make decisions and discuss issues based on an understanding of science and technology to solve problems related to science, technology, and society (Laugksch, 2000). Scientifically literate students are expected to scientifically identify issues around them that are relevant to themselves as citizens of the future, explain phenomena, and make claims based on scientific evidence (OECD, 2019a; Osborne et al., 2004).

This concept of scientific literacy is relevant to ESD. Recent developments in science are not made in isolation but are influenced by economic and technological developments and globalisation. Accordingly, science education not only

imparts scientific content knowledge to students but also enables them to make critical judgments about science related to the economy and society, and thus participate as decision-makers in the process of maintaining a sustainable world (Carter, 2008; Lee et al., 2013). The SDGs are related to the people, economies, and societies that must be developed, and to the natural environments, life support systems, and local communities that must be sustained (Parris & Kates, 2003). In teaching and learning from an environmental perspective, ESD in science subjects aims to include SDGs related to developmental issues such as climate change, disaster risk reduction, and biodiversity (Karaarslan & Teksöz, 2016).

Thus, ESD can be seen as an advancement of the cultivation of scientific literacy (Tsai, 2018) as it requires students to use competences related to critical thinking and collaborative decision-making in the context of sustainability issues (UNESCO, 2013). From PISA 2000, PISA science, which measures scientific literacy, has classified environmental issues as a part of scientific literacy and has dealt with relevant issues such as biodiversity, ecosystems, and the maintenance of species (OECD, 2019a).

ESD in Korea, Canada, and Singapore

Korea

In response to the World Summit on Sustainable Development designating 2005–2014 the 'UN Decade of ESD', the Korean government established strategies and plans to incorporate ESD in the curricula. With the enactment of the SD Framework Act in 2007, the Environmental Education Promotion Act in 2008, and the Low Carbon Green Growth Framework Act in 2009, ESD-related projects were implemented (Lee et al., 2014). The Korean government established the creation of a sustainable future through 'carbon-neutral as a principle' guiding its governance (Office of the President of the Republic of Korea, 2022). In the revised 2022 curriculum, the importance of leading learning experiences in which students generate and demonstrate knowledge through self-directed and sustainability learning is emphasised; this perspective assumes that competencies required of citizens in societies of the future can be developed by strengthening education that fosters community values and the ability to respond to sustainable development challenges (MOE, 2021).

Canada

Canada is known for having redefined its education system around sustainability and making great effort to promote ESD (McKeown & Nolet, 2013). Canada tends to be favourable to accepting government policies and social programs, and UN policies have been well received. The National Round Table (NRT), a semi-permanent roundtable conference on the environment and economy, was formed at government level, and in 1993, the Canadian Parliament set out the NRT's role in sustainable development in legislation which has lasted for approximately 20 years (Hopkins, 2013). In addition, Canadian universities have included SD in their teacher education programs and are actively conducting ESD-related research (Inwood et al, 2021; Robertson et al., 2020; White & Petry, 2011).

Singapore

Singapore achieved rapid economic growth through state-led industrialization; as resources were scarce in the country, it was inevitable that the state would lead the transformation (Neo, 2007). Simultaneously, the state did not

lose focus on protecting the environment in the process. At the 1992 United Nations Conference on Environment and Development held in Rio, which Singapore chaired, Singapore unveiled its Green Plan that defined the SD goals and strategies required to make its vision of becoming a 'model green city' a reality (Ministry of Environment, 1992). During the presentation, Singapore announced its goal of becoming an environmentally advanced nation by the year 2000 and its overall targets for green infrastructure, environmental governance, pollution monitoring and control, resource conservation, recycling, education, and technology (Goh, 2001). In 2014, Character and Citizenship Education, which is related to global citizenship education, was introduced in primary and secondary education curricula (Zguir et al, 2021). It is to be conducted for two hours per week, thus providing students with opportunities for ESD (MOE Singapore, 2022).

Research Methods

Sample and Data

The PISA study is based on sample data from each of the participating countries, and sampling is conducted according to standardised procedures for working with populations of students aged 15 years. All schools included in the sampling frame are classified according to school class, category, level of urbanisation, and school gender composition, and target schools are then sampled according to the probability proportional to size sampling method. Students participated in cognitive assessments and student questionnaires; the raw data on student responses to the relevant PISA 2018 items were analysed in this study. The raw data from responses to survey items by students in Korea, Canada, and Singapore were used together. Students from 79 countries participated in PISA 2018, including 6,876 students from Korea, 22,500 from Canada, and 6,676 from Singapore.

Questionnaire

In the PISA 2018 student questionnaire, SD-related items were selected such as students' awareness of global issues (six items), self-efficacy regarding global issues (six items), global mindedness (six items), and actions to address global issues (eight items) (OECD, 2019a). Items related to science education were selected from among these and reclassified into the following topics for this study: environmental awareness, self-efficacy, sense of purpose, and action.

Table 1. Details on PISA 2018 items analysed in the study

Subject (Item ID)	Items	Response scale
Environmental awareness (ST197)	How informed are you about the following topics? • Climate change and global warming • Global health (e.g. epidemics)	4 point Likert scale
Environmental self -efficacy (ST196)	How easy do you think it would be for you to perform the following tasks on your own? • Explain how carbon-dioxide emissions affect global climate change • Explain why some countries suffer more from global climate change than others • Discuss the consequences of economic development on the environment	4 point Likert scale
Environmental sense of purpose (ST219)	To what extent do you agree with the following statements? • Looking after the global environment is important to me.	4 point Likert scale
Environmental action (ST222)	Are you involved in the following activities? • I reduce the energy I use at home (e.g. by turning the heating down or turning the air conditioning up or down or by turning off the lights when leaving a room) to protect the environment. • I choose certain products for ethical or environmental reasons, even if they are a bit more expensive. • I sign environmental or social petitions online. • I boycott products or companies for political, ethical or environmental reasons. • I participate in activities in favour of environmental protection.	Binary scale

Data Analysis

To understand Korean students' responses to the PISA 2018 SD items, the frequency and percentage of their responses for each item were calculated, and were compared the averages of their scores with those of students from the other two countries. The positive responses of the Likert scale were coded so that the score increased, and the average was calculated.

To facilitate comparison between countries, a weighted variable was applied to set the number of students in each country to 5,000, and a one-way analysis of variance (ANOVA) was conducted for each item. When significant differences between countries were revealed in ANOVA, Scheffe's post-hoc test was conducted to confirm differences between specific groups. In addition, a correlation analysis was conducted to determine the relevance between survey topics and between survey topics and students' ESCS and scientific achievement scores. After calculating the average score for each domain by converting all items for each domain into variables, a correlation analysis was conducted with the variables, and the PISA indicators were used for ESCS and science achievement.

Results

Environmental Awareness

Students' awareness of 'Climate change and global warming, and global health (e.g., epidemics)' has been a major focus of research on environmental awareness. Table 2 presents the results of Korean students' responses.

Approximately 88.6% of students knew 'something about' or were 'familiar' with Item A: 'Climate change and global warming' and thought that they could explain it either at a 'general' level or 'well', while only 56.7% knew 'something about' or were 'familiar' with Item B: 'Global health (e.g., epidemics)'. This clearly suggests that Korean students' level of awareness of Item A was higher than their awareness of Item B. Higher average ESCS and science achievement scores were observed among students who perceived themselves as being generally or well aware of the issues and able

to explain them generally or well. The difference in the average science achievement scores of students who answered 'I have never heard of this' and 'I am familiar with this and I would be able to explain this well' was 184.198 for Item A and 92.494 for Item B. In contrast, the difference in ESCS scores was 0.5680 for Item A and 0.6749 for Item B.

Table 2. Results of Korean students' responses to items on 'environmental awareness'

Category		I have never heard of this	I have heard about this but I would not be able to explain what it is really about	I know so mething about this and could explain the general issue	I am familiar with this and I would be able to explain this well	Total
A. Climate change and global warming	Frequency (%)	55 (0.8)	699 (10.6)	3,829 (58.0)	2,016 (30.6)	6,599 (100.0)
	ESCS (SD)	-0.313 (0.856)	-0.276 (0.763)	0.047 (0.748)	0.255 (0.752)	0.072 (0.768)
	Science achievement (SD)	364.820 (74.511)	440.327 (91.605)	522.261 (91.474)	549.018 (95.163)	519 .889 (98.624)
B. Global health (e.g. epidemics)	Frequency (%)	159 (2.4)	2,691 (40.9)	3,031 (46.0)	705 (10.7)	6,586 (100.0)
	ESCS (SD)	-0.340 (0.717)	-0.030 (0.762)	0.124 (0.758)	0.335 (0.750)	0.072 (0.769)
	Science achievement (SD)	431.674 (95.969)	515.581 (96.996)	528.269 (97.336)	524.168 (95.929)	520.224 (98.195)

Note: SD=standard deviation

Table 3 shows the comparison results of the average responses of students in the three countries for the items on environmental awareness.

Table 3. One-way ANOVA results for 'environmental awareness'

Category	M (SD)				F	*p*	Scheffe
	CNA	KOR	SPG	Total			
A. Climate change and global warming	3.27 (0.73)	3.17 (0.65)	3.30 (0.68)	3.25 (0.67)	43.702	0.00	CNA, SPG > KOR
B. Global health (e.g. epidemics)	2.89 (0.76)	2.65 (0.70)	2.75 (0.77)	2.76 (0.75)	122.839	0.00	CNA > SPG > KOR

Note: M=mean, SD=standard deviation, CAN=Canada, KOR=Korea, SPG=Singapore

Awareness of Item A was higher than awareness of Item B among students in all countries. Specifically, the highest average awareness of Item A was found among students in Singapore (3.30), followed by students in Canada (3.27) and Korea (3.17); the difference in the mean values of the responses between Canadian and Singaporean students was not statistically significant. Average response for awareness of Item B was the highest for Canadian students (2.89), followed by Singaporean (2.75) and Korean (2.65) students. Korean students presented the lowest average awareness scores among the three countries for all items.

Environmental Self-efficacy

Self-efficacy refers to an individual's confidence in their ability to perform tasks and solve problems by planning and executing a series of actions (Bandura, 1994). The PISA 2018 questionnaire included three items on students' self-efficacy in performing actions related to SD and environmental issues. Table 4 presents the results of Korean students' responses.

Table 4. Results of Korean students' responses to items on 'environmental self-efficacy'

Category		I couldn't do this	I would struggle to do this on my own	I could do this with a bit of effort	I could do this easily	Total
A. Explain how carbon-dioxide emissions affect global climate change	Frequency (Percentage (%))	433 (6.6)	775 (11.8)	3,212 (48.7)	2,175 (33.0)	6,595 (100.0)
	ESCS (SD)	-0.240 (0.826)	-0.245 (0.783)	0.048 (0.743)	0.285 (0.721)	0.072 (0.769)
	Science achievement (SD)	450.150 (97.751)	460.119 (88.782)	514.257 (92.443)	564.888 (87.978)	520.028 (98.500)
B. Explain why some countries suffer more from global climate change than others	Frequency (Percentage (%))	466 (7.1)	918 (14.0)	3,219 (48.9)	1,975 (30.0)	6578 (100.0)
	ESCS (SD)	-0.198 (0.804)	-0.181 (0.777)	0.040 (0.748)	0.312 (0.715)	0.073 (0.768)
	Science achievement (SD)	457.360 (97.474)	478.691 (93.828)	516.247 (93.104)	561.311 (91.202)	520.092 (98.395)
C. Discuss the consequences of economic development on the environment	Frequency (Percentage (%))	559 (8.5)	1,172 (17.8)	3,084 (46.8)	1,780 (27.0)	6,595 (100.0)
	ESCS (SD)	-0.234 (0.798)	-0.141 (0.771)	0.064 (0.745)	0.328 (0.713)	0.072 (0.768)
	Science achievement (SD)	462.850 (95.142)	492.475 (95.157)	517.462 (95.201)	561.842 (90.256)	520.074 (98.491)

Note: SD=standard deviation

A total of 33.0% of respondents answered 'I could do this easily' for Item A: 'Explain how carbon-dioxide emissions affect global climate change', 30.0% answered 'I could do this easily' for Item B: 'Explain why some countries suffer more from global climate change than others', and 27.0% answered 'I could do this easily' for Item C: 'Discuss the consequences of economic development on the environment'. The highest percentage of 'I could do this easily' responses were for Item A, followed by items B and C. Analysis of the ESCS and science achievement averages for the 'environmental self-efficacy' items indicates that students who thought they could do well on the tasks had higher ESCS and science achievement scores. The difference between the average science achievement scores of students who answered 'I couldn't do this' and 'I could do this easily' was greatest for Item A (113.739), followed by Item B (103.951), and Item C (98.992). However, the difference between the average ESCS for students who answered 'I couldn't do this' and 'I could do this easily' was greater for Item C (0.5627) than for Item A (0.5255) or B (0.5104).

Table 5. One-way ANOVA results for 'environmental self-efficacy'

Category	M (SD)				F	*p*	Scheffe
	CNA	KOR	SPG	Total			
A. Explain how carbon-dioxide emissions affect global climate change	2.94 (0.93)	3.07 (0.85)	3.19 (0.77)	3.07 (0.85)	101.249	0.00	SPG > KOR > CNA
B. Explain why some countries suffer more from global climate change than others	3.06 (0.86)	3.01 (0.86)	3.05 (0.77)	3.04 (0.83)	4.559	0.01	CNA, SPG > KOR
C. Discuss the consequences of economic development on the environment	2.84 (0.91)	2.91 (0.89)	2.89 (0.81)	2.88 (0.87)	9.654	0.00	KOR, SPG > CNA

Note: M=mean, SD=standard deviation, CAN=Canada, KOR=Korea, SPG=Singapore

Self-efficacy was lowest for Item C for all countries. Specifically, students in Singapore presented the highest average self-efficacy for Item A (3.19), followed by students in Korea (3.07), and students in Canada (2.94). Average self-efficacy for Item B was the highest for students in Canada (3.06), followed by students in Singapore (3.05) and Korea (3.01). The difference between average self-efficacy for Canadian and Singaporean students was not statistically significant. For Item C, students in Korea (2.91) presented the highest average self-efficacy, followed by students in Singapore (2.88) and Canada (2.84); the difference between the average self-efficacy for Korean and Singaporean students was not statistically significant. Singaporean students presented higher averages for the three items on 'environmental self-efficacy' than did Korean or Canadian students.

Environmental Sense of Purpose

The item on environmental sense of purpose asks students to rate the importance of taking an interest in the global environment. Purpose can act as an internal guide when considering the direction one's life should take and whether or not to begin or continue to engage in activities that can have serious consequences for others (Moran, 2009). One's sense of purpose regarding the environment is an important topic to be dealt with in ESD as it involves one's will to participate in eco-friendly activities and the establishment of the importance of the environment in one's life. The results are presented in Table 6.

Table 6. Results on Korean students' 'environmental sense of purpose'

Category		Strongly disagree	Disagree	Agree	Strongly agree	Total
Looking after the global environment is important to me.	Frequency (%)	154 (2.3)	539 (8.2)	3,687 (56.0)	2,199 (33.4)	6,579 (100.0)
	ESCS (SD)	0.008 (0.808)	-0.041 (0.802)	0.008 (0.761)	0.213 (0.751)	0.072 (0.769)
	Science achievement (SD)	483.767 (108.221)	504.364 (106.041)	511.149 (97.746)	542.590 (92.298)	520.405 (98.279)

Note: SD=standard deviation

Most Korean students responded positively to the item on 'environmental sense of purpose', with 89.4% answering 'agree' or 'strongly agree'. Students' ESCS was not particularly correlated with 'environmental sense of purpose'. That said, the average ESCS for students who answered 'strongly agree' was significantly higher than for those who responded otherwise. Students who presented high levels of 'environmental sense of purpose' had higher science achievement scores.

Table 7. One-way ANOVA results on 'environmental sense of purpose'

Category	M (SD)				F	*p*	Scheffe
	CNA	KOR	SPG	Total			
Looking after the global environment is important to me.	2.97 (0.77)	3.20 (0.69)	3.07 (0.68)	3.08 (0.72)	129.528	0.00	KOR > SPG > CNA

Note: M=mean, SD=standard deviation, CAN=Canada, KOR=Korea, SPG=Singapore

In the results by country, Korean students presented the highest level of environmental purpose, with an average score of 3.20, followed by Singaporean and Canadian students (3.07 and 2.97, respectively). These items investigates their sense of purpose regarding the environment by asking whether they consider global environmental issues important in their lives.

Environmental Action

Tables 8 present Korean students' responses to items on their participation in pro-environmental activities.

Table 8. Results of Korean students' responses to 'environmental action'

Category		Yes	No	Total
A. I reduce the energy I use at home to protect the environment.	Frequency (%)	4,987 (73.7)	1,598 (24.3)	6,585 (100.0)
	ESCS (SD)	0.087 (0.762)	0.019 (0.786)	0.071 (0.769)
	Science achievement (SD)	520.682 (96.966)	519.045 (102.297)	520.282 (98.290)
B. I choose certain products for ethical or environmental reasons, even if they are a bit more expensive.	Frequency (%)	2,593 (39.4)	3,984 (60.6)	6,577 (100.0)
	ESCS (SD)	0.130 (0.782)	0.035 (0.758)	0.072 (0.769)
	Science achievement (SD)	509.330 (102 .564)	527.682 (94.707)	520.433 (98.286)
C. I sign environmental or social petitions online.	Frequency (%)	3,014 (45.3)	3,552 (53.4)	6,566 (100.0)
	ESCS (SD)	0.128 (0.762)	0.024 (0.771)	0.072 (0.769)
	Science achievement (SD)	514.834 (99.338)	525.626 (96.875)	520.682 (98.148)
D. I boycott products or companies for political, ethical or environmental reasons.	Frequency (%)	2,294 (34.9)	4,275 (65.1)	6,569 (100.0)
	ESCS (SD)	0.188 (0.764)	0.009 (0.763)	0.072 (0.768)
	Science achievement (SD)	522.749 (102.272)	519.421 (95.846)	520.581 (98.136)
E. I participate in activities in favour of environmental protection.	Frequency (%)	3,473 (52.9)	3,096 (47.1)	6,569 (100.0)
	ESCS (SD)	0.115 (0.771)	0.024 (0.764)	0.072 (0.769)
	Science achievement (SD)	519.725 (97.958)	521.728 (98.138)	520.669 (98.038)

Note: SD=standard deviation

The percentages of students who answered 'yes' were highest for Item A and Item E. The percentage of students who answered 'no' were highest for Item B, Item C, and Item D. The greatest difference between the percentages of 'yes' and 'no' answers was found for Item A (49.4%), followed by items D (30.2%), B (21.2%), C (8.1%), and E (5.8%). Approximately 73% of students reported reducing their energy use at home (Item A), a behavior that could be practiced relatively easily. Approximately 65.1% of students answered 'no' to Item D on participating in boycotts, and 60.6% answered 'no' to the item on prioritising eco-friendly products regardless of cost (Item B); the difference between the number of 'yes' and 'no' responses was the second greatest for this item after Item A. Korean students did not show a high rate of active pro-environment practice up to consumption level, such as boycotting or selecting products or based on environmental and ethical considerations. The percentages of students who answered 'no' for the items 'I sign environmental or social petitions online' and 'I participate in activities in favour of environmental protection' were slightly lower than the percentages of students who answered 'yes', but the differences were not large.

Students who reported participating in all five environmental action items had higher ESCS scores compared with students who did not participate or participated less. ESCS was higher for students who tended to take pro-environmental action. However, a consistent relationship was not found between taking environmental action and students' science achievement scores. Science achievement was high for students who took action as per Item A, but it was also high in students who did not take action as per items B, C, and E. In particular, differences of more than 10 points were found between the science achievement scores of students who answered 'yes' and those who answered 'no' for items B and C. For both of these items, students who reported not participating in those items had high science achievement scores.

Table 9. One-way ANOVA results for 'environmental action' behaviors

Category	M (SD)				F	*p*	Scheffe
	CNA	KOR	SPG	Total			
A. I reduce the energy I use at home [...] to protect the environment.	1.67 (0.47)	1.76 (0.43)	1.83 (0.38)	1.75 (0.43)	153.134	0.00	SPG > KOR > CNA
B. I choose certain products for ethical or environmental reasons, even if they are a bit more expensive.	1.42 (0.49)	1.39 (0.49)	1.48 (0.50)	1.43 (0.50)	34.391	0.00	SPG > CNA, KOR
C. I sign environmental or social petitions online.	1.19 (0.39)	1.46 (0.50)	1.21 (0.40)	1.29 (0.45)	570.888	0.00	KOR > CNA, SPG
D. I boycott products or companies for political, ethical or environmental reasons.	1.26 (0.44)	1.35 (0.48)	1.25 (0.43)	1.29 (0.45)	71.977	0.00	KOR > CNA, SPG
E. I participate in activities in favour of environmental protection.	1.36 (0.48)	1.53 (0.50)	1.42 (0.49)	1.44 (0.50)	146.812	0.00	KOR > SPG > CNA

Note: M: mean, SD: standard deviation, CNA: Canada, KOR: Korea, SPG: Singapore

For all three countries, more students took action for Item A than for the other items. Additionally, participation levels in behaviors related to Item D were generally low across the three countries. While Canadian and Singaporean students showed similar patterns in the ranking of environmental behavior items in which they primarily participated, Korean students consistently engaged the most in Item A and displayed different trends from the two countries in other environmental behavior items.

Correlation between Environmental Awareness, Self-efficacy, Sense of Purpose, Action, Science Achievement, and ESCS

Table 10. Correlation coefficient by variable for Korea, Canada, and Singapore

Country	Category	Awareness	Self-efficacy	Sense of purpose	Action	ESCS	Science achievement
KOR	Awareness	1					
	Self-efficacy	.483**	1				
	Sense of purpose	.217**	.256**	1			
	Action	.145**	.197**	.203**	1		
	ESCS	.255**	.210**	.110**	.101**	1	
	Science achievement	.331**	.227**	.154**	-.047**	.284**	1
CAN	Awareness	1					
	Self-efficacy	.473**	1				
	Sense of purpose	.249**	.170**	1			
	Action	-.167**	-.127**	-.256**	1		
	ESCS	.230**	.182**	.141**	-.111**	1	
	Science achievement	.320**	.113**	.162**	.040**	.259**	1
SPG	Awareness	1					
	Self-efficacy	.578**	1				
	Sense of purpose	.179**	.181**	1			
	Action	.127**	.144**	.212**	1		
	ESCS	.239**	.230**	.070**	.057**	1	
	Science achievement	.341**	.295**	.114**	-.078**	.398**	1

Note: ** p <.01, CNA: Canada, KOR: Korea, SPG: Singapore

For all three countries, the highest correlation was found between environmental awareness and self-efficacy. This may be because the survey items for 'environmental self-efficacy' asked about students' perceived ability to enact cognitive behaviors, such as explaining or discussing the environment based on scientific knowledge. The fact that self-efficacy for environmental action was not addressed in the questionnaire asking about environmental self-efficacy appears to be a limitation. The correlation between ESCS and science achievement was higher for the items on environmental awareness, self-efficacy, and sense of purpose than for items on environmental action. Korea and Singapore presented a low correlation coefficient for science achievement and environmental action, indicating a negative correlation, while Canada presented a positive correlation. Contrarily, Korea and Singapore presented low correlation coefficients for ESCS and environmental action, indicating a positive correlation, however, Canada presented a negative correlation between those items. In Canada, environmental action was negatively correlated with all of the environmental awareness, self-efficacy and sense of purpose items.

Table 11. One-way ANOVA results for 'environmental topics in the curriculum'

Is there any formal curriculum for the following topics in <national modal grade for 15-year-olds>?	M (SD)				F	p	Scheffe
	CNA	KOR	SPG	Total			
A. Climate change and global warming	1.11 (0.31)	1.01 (0.08)	1.05 (0.21)	1.05 (0.23)	264.426	0.00	CNA > SPG > KOR
B. Global health (e.g. epidemics)	2.89 (0.76)	2.65 (0.70)	2.75 (0.77)	2.76 (0.75)	307.337	0.00	CNA > SPG > KOR

Note: M: mean, SD: standard deviation, CNA: Canada, KOR: Korea, SPG: Singapore

As shown in Table 11, Canadian curricula for 15-year-olds included more environmental topics, followed by Singaporean and Korean curricula; this order coincides with the order of students' environmental awareness by country. Similarly, Hassan et al. (2010) found that secondary school students who scored higher in terms of environmental awareness and in-depth science knowledge participated more often in pro-environment activities compared with those who scored lower. These findings indicate the need to actively introduce ESD into curricula to prepare students for their future education. As the ability to make decisions and solve environmental problems, such as climate change, global warming, and the destruction of ecosystems, based on scientific knowledge, is fundamental, ESD taught in other subjects must be supplemented with a focus on science.

Discussion

The response of environmental awareness, self-efficacy, sense of purpose, and action, and the correlation between these subjects was investigated based on the PISA 2018 results from students in Korea, Canada, and Singapore for an in-depth discussion of the results.

Environmental Awareness, Self-Efficacy, and Sense of Purpose

Students from all three countries generally responded positively to items on environmental awareness, self-efficacy, and sense of purpose, though subtle differences emerged between countries depending on the items

First, students presented overall greater awareness of 'climate change and global warming' than of 'global health'. In Korea, climate change and global warming are covered as major concepts in the 'structure and circulation of the hydrosphere' and 'carbon cycle and climate change' units in middle and high school curricula (MEST, 2011). Moreover, they are frequently covered topics in the media. Conversely, as health problems and epidemics are rarely dealt with in the curriculum and students may not encounter them on a daily basis, they might consider them unfamiliar concepts. However, students were expected to have exhibited more awareness of those concepts in their responses to the PISA 2022 survey given the influence of the COVID-19 pandemic over the last three years.

Second, students from all three countries scored their 'environmental awareness' higher than their 'environmental self-efficacy'. Beyond gauging students' knowledge of topics like climate change and epidemics in the 'environmental awareness' items, items in the efficacy domain are intended to gauge students' perceptions of their ability to explain the relationship between carbon dioxide emissions and climate change, differences in climate change-related problems between countries, and the impact of economic development on the environment. In other words, the items in the efficacy domain go beyond enquiring into students' simple awareness; rather, they enquire into the epistemic practices that students can perform based on their knowledge, such as 'explaining' and 'discussing'. 'Explanation and argument' are considered major epistemic practices, the performance of which should be based on accurate scientific knowledge (Duschl, 2008; McNeill, 2011). A higher cognitive level and ability to apply knowledge are required to explain and discuss the issues than to merely understand them.

Third, the result of the response of 'environmental self-efficacy' seems to be related to a country's economic

development background. Korean and Singaporean students scored 'discuss the consequences of economic development on the environment' higher on average than Canadian students. Korea and Singapore are Asian countries that have achieved economic growth in a short period of time, and such growth has been backed by numerous SD-related social issues. Thus, Korean and Singaporean students have had many opportunities to learn about the environmental problems involved in their countries' economic growth through their school and the media.

Fourth, the fact that students in Korea and Singapore also presented greater 'environmental sense of purpose' than Canadian students can be seen as further evidence of the influence of the socio-economic situation on students' level of awareness of SD issues. A sense of purpose can be viewed as an intrinsic motivation to achieve a long-term life goal in accordance with one's values (Blattner *et al*., 2013). The greater a student's sense of purpose regarding the environment, the greater the possibility that they will engage in pro-environmental practice. This study found that the correlation between sense of purpose and environmental practice was relatively high for students in all three countries. As such, raising students' levels of environmental awareness through education is necessary to prepare a foundation for their environmental practice.

Environmental Action

Students in the three countries were most likely to take action to reduce energy use at home. However, social petitions and boycotts, which can be seen as more active forms of action, generally showed low participation rates Korea had a higher response rate to social petitions and boycotts than other countries, which may be due to the different social circumstances of the country. It was relatively easy for citizens to access social petitions through the e-People system. Also, Korean students are familiar with boycotts due to social issues resulting from historical relations with Japan. In addition to these social and historical circumstances, as interest in environmental change is increasing, each country needs to encourage students to participate more actively in protecting the environment.

However, with growing concerns about the climate change crisis, there is a need for more active participation in activities to protect the environment.

Correlation between Environmental Perceptions, Action, Science Achievement, and ESCS

A negative correlation, albeit a small one, was found between 'science achievement' and 'environmental action' among students in Korea and Singapore, which could indicate that science learning in school remains at the level of knowledge learning but does not extend to epistemic practices. This suggests that students should be encouraged to apply what they learn in science class to solve sustainability problems in daily life. School education in the future should be based on connecting learning with real life. Programs that integrate scientific theory and practical applications to address sustainability challenges not only enhance science learning but also promote students' future roles as agents of change (Ballantyne & Packer, 2005; Eppinga et al, 2019).

As is being done in Canada, continuous efforts are needed to move toward an increased statistical correlation between attitudes and action. For 'environmental action' to emerge from environmental awareness and pro-environmental attitudes, students must experience the climate crisis first-hand or participate in a region-based program. Students must

realize that they are members of a community that must take the initiative to solve problems collectively(Barry, 1976). This is also related to students' 'agency', through which they become the subjects of their own action and lead their lives and learn according to their own values, goals, and ways of finding happiness; their 'co-agency', through which they learn together in cooperation with others; and their 'transformative competencies', through which they develop abilities to create new value, resolve dilemmas, and act responsibly, as highlighted by the OECD (2019c). 'Real experience, trying to change social norms, and working together for the benefit of the community' are key to the continuous practice of environmental action (Quimby & Angelique, 2011). Thus, Korea's efforts to induce active environmental awareness and practice by introducing ecological conversion education in the 2022 revised curriculum (MOE, 2021) is expected to have a positive impact by increasing students' agency in the context of science and enhancing their transformative competencies.

Conclusion and Implications

In this study, we analyzed Korean students' awareness, self-efficacy, sense of purpose, and actions of environmental issues based on the results of the PISA 2018, by comparing them with those of students from Singapore and Canada. The research findings are as follows:

First, students from all three countries exhibited positive perceptions of environmental awareness, self-efficacy, and sense of purpose. The variations in students' responses are likely influenced by each country's unique social and historical context. In nations like Korea and Singapore, which have experienced rapid economic growth, students may be more exposed to both direct and indirect experiences concerning the environmental impacts of economic development. Additionally, environmental practices are influenced by each country's social situation and its relationships with neighboring countries.

Second, the importance of ESD can be argued through an examination of students' environmental awareness, self-efficacy, and sense of purpose, and the correlations between these factors and students' science achievements and ESCS. All three domains were more highly correlated with science achievement than with ESCS. While informal education, such as home education, can improve students' sensitivity to SD or values, this finding suggests that school education has a greater influence. When examining the negative correlation found between 'scientific achievement' and 'environmental action,' it is evident that it is necessary to include this topic in the national curriculum. This inclusion will enable students to apply what they have learned in social practice.

As environmental problems, such as desertification, artificial rainfall, and increased carbon emissions, are often common problems, they are characteristically global and must be viewed from a global perspective. ESD emphasises ways to solve environmental problems in an integrated manner across economic, social, environmental, and cultural spheres, among others, during the process. Ultimately, ESD aims to lead students, as present and future members of society, to enact pro-environmental behaviors by cultivating their attitudes toward the environment and presenting them with environmental issues from multiple perspectives.

In the future, sustainability issues will impact our lives even more seriously than at present. For a sustainable future, students should be aware of and concerned about current environmental problems, develop the will to design solutions

to such problems, and implement such solutions in practice. Further analysis in a future study of the PISA 2022 data on students who experienced the global pandemic and natural disasters caused by global climate change could provide the basis for more in-depth discussions of ESD.

Conflicts of Interest

The author(s) declared no conflicts of interest.

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