Analysis of Emotions of High School Students Participating in a School SS1 Club Project Related to Climate Change

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Abstract

This study explored types and intensities of students' emotions related to participation in school-based SS1 club project related to climate change (CE). Ten high school students participated twice a week for 7 weeks in club activities to model causes/impacts of CE, explore local problems related to CE, and plan and participate in social action. Researchers used the control-value theory to analyze how students' emotions changed over time and found that while some initially reported negative emotions persisted after the club activities concluded (anxiety, fear, guilt, and despair), students also reported more positive emotions (sense of accomplishment, confidence) than before. Students' emotions became more positive when planning and participating in social action and some emotions (guilt, anxiety, and expectation) helped to drive students to action. We discuss implications for club activities as a way to educate students about CE and we raise questions for future research.

Keywords

Climate change – SSI education – emotions – club activity – control-value theory

본 연구의 목적은 기후변화 SSI 동아리 프로젝트 참여한 학생들의 기후변화에 대한 감정의 유형과 수준을 탐색하는 것이다. 10명의 고등학생들이 연구에 참여하였으며, 동아리활동은 7주 동안 14차시로 진행되었다. 동아리활동은 기후변화에 대한 지식 이해 활동, 기후변화 문제 조사 활동, 사회적 실천 활동으로 구성되었다. 활동이 진행되면서 탐색한 학생들의 감정 변화를 분석하기 위해 통제-가치 이론을 활용하였다. 연구 결과, 동아리활동 전과 후 모두에서 학생들은 기후변화에 대해 걱정, 죄책감, 절망감, 막막함, 혼란, 두려움, 불안함 등의 부정적인 감정을 강하게 느꼈다. 그러나 학생들의 주요 감정 중 성취감, 자신감과 같은 일부 긍정적 감정은 세기가 증가하였다. 학생들의 감정은 사회적 실천 활동에 참여하면서 긍정적으로 변화되었고, 죄책감, 불안함, 기대감은 학생들의 실천을 동기화하였다.

1 Introduction

Ulrich Beck (1986) referred to modern society as a risk society that produces risks such as climate change, financial crises, and nuclear crises. Such risks seem to be irreversible, global, uncertain, socially out of control, and threatening the existence of life on Earth. Beck (1999) suggested that risks are caused by modernization and industrialization and are an important aspect of modern society, which has relied on heavy use of fossil fuels. The International Panel on Climate Change (IPCC, 2014) warned that modern human activities have had a serious impact on the earth's processes, including the climate system.

To address the risks of climate change, efforts have been made at various levels. At the international level, for example, the United Nations Framework Convention on Climate Change (UNFCCC) adopted limiting global average temperature rises to below 2°C and further to 1.5°C above pre-industrial levels at the Conference of the Parties. Participating countries set nationally determined contributions and cooperate to reduce greenhouse gases (UNFCCC, 2015). However, domestic and international efforts alone cannot address climate change risks, and citizen support and practice in the formulation and implementation of policies are essential (IPCC, 2014).

Citizens' engagement and action related to climate change risk response should be based on understanding and awareness of climate change, so systematic education on this theme is very important (Yun, 2009). In Korea, the Ministry of Environment (MOE, 2008) reported that 90.5% of citizens were aware of the seriousness of climate change. By contrast, they were passive as

far as actual action and had a lack of willingness to participate in solving it (Jung et al., 2007). These findings suggest that the education to cultivate willingness and competencies for climate change action is urgently needed, and science education for social change should be at the center (Hodson, 2010).

Socio-scientific issues (SSI) education, a major research flow in transformative science education, including climate change education, emphasizes individuals' psychological, moral, and emotional development as well as cognitive development (Zeidler, 2014). In SSI education, reasoning and decision-making about SSI are based on informal reasoning that consists of rationalism, emotion, and intuition (Sadler & Zeidler, 2005). Emotions are regarded an important area to be fostered in reasoning and decision making about SSI.

Despite the importance of emotions for education, research on emotions in education has been slow to emerge. From 2000s, the number of studies focusing on emotions in education has gradually increased (Pekrun & Linnenbrink-Garcia, 2014). Research on emotions in education has mostly focused on the achievement emotions experienced by students in academic tasks. However, emotions related to the content of learning, to the process of constructing knowledge, and to social interactions in the classroom are recognized as important, suggesting that there are three more distinct groups of emotions in addition to achievement emotions: topic emotions, epistemic emotions, and social emotions. Achievement emotions are emotions that are directly related to an activity or outcome and topic emotions are simply caused by learning subjects (Pekrun & Linnenbrink, 2014). For understanding achievement emotions, Pekrun (2006) proposed a new comprehensive conceptual system for emotion, the control-value theory, by integrating the main theories on emotions, such as the expectancy-value approach to emotions and attributional theory. This theory suggests that emotions are influenced by value and control appraisals of outcomes and activities and shows the relationship among them.

Because of the complexity and urgency of the climate change issue, students may have mixed emotions about the content of climate change and may experience complicated emotions during learning. The importance of emotions to the issue of climate change and climate change education has been emphasized. Roeser (2012) stated that emotions are essential in understanding the impacts of climate change risks, making practical and moral decisions, and encouraging actions. As a motivation for action, Brown and Pickerill (2009) suggest that cultivating the ability to reflect emotions can sustain activism. However, there have only been a few studies on emotions about climate change and even fewer on the subject in East Asia, and previous studies have dealt only with some elements of emotions (Lombardi & Sinatra, 2012; Meijnders,

2001; Nabi, 2018; Roeser, 2012; Weber, 2006). As emotions are known to vary in different subjects and cultures (Song & Choi, 2011), understanding emotions about climate change in each cultural setting is important.

The major goals of this study are to use the control-value theory to explore Korean high school students' emotions about climate change before and after an SSI school club project (Pekrun, 2006; Pekrun et al., 2007) and to investigate students' emotions about climate change experienced during the club project activities. To achieve these major goals, three research questions were developed.

1. What are students' topic emotions about climate change before participating in school SSI club activities?
2. What are students' dominant emotions about climate change and how do they change during school SSI club activities?
3. How are students' topic and achievement emotions about climate change different after participating in school SSI club activities?

2 Theoretical Framework

2.1 *SSI Education and Action*

Roberts (2011) suggested the concepts of scientific literacy in terms of Vision I and Vision II. Vision I emphasizes learning about "science itself," in which students acquire the knowledge and skills to solve and access problems as scientists do. Vision II, on the other hand, refers to the ability of students to understand the nature of science, to use science, and to make informed decisions in science-related situations that may be faced as citizens (Roberts, 2011). Recently, Sjöström and Eilks (2018) proposed Vision III of scientific literacy, which emphasizes action and participation. Vision III aims at fostering the education of citizens who can do socio-political actions in science education (Sjöström & Eilks, 2018). The direction of SSI education is well aligned to Vision III, which not only considers the individual's psychological, moral, emotional development, and social context in the classroom (Zeidler et al., 2005), but also enables students to participate in SSI reasoning and action to solve problems (Zeidler, 2014).

The need for SSI education is emerging in a modern society with many risks, and research and program development in SSI education are being actively conducted worldwide (Zeidler & Nichols, 2009). SSI is a social, political, ethical, moral, and environmental issue caused by the development of science and technology. SSI education initially developed with an interest in the moral, ethical, and social contexts that influence individual reasoning or decision making (Zeidler et al., 2005). But at the very least, it aims to show

sustainability on ecological themes and get involved in civic science and activism (Zeidler, 2014). Examples of SS1 education programs include Scientific Literacy Education Program for 21 Century Global Citizens (SLEP 21) in Korea, Promoting Attainment of Responsible Research and Innovation in Science Education (PARRISE), Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments (IRRESISTIBLE) project in Europe, and Science and Technology Education Promoting Wellbeing for Individuals, Societies, and Environment (STEPWISE) in Canada. For example, STEPWISE in Canada, which puts activism as the theoretical core, implemented the research-informed and negotiated action (RiNA) project in which students lead the way in exploring SS1, solving problem, and putting the solutions into action (Bencze, 2017).

2.2 *Emotions*

Emotions of different types and intensities are experienced by all participants while engaging in learning tasks within the educational environment. They are also closely related to student achievement, goal achievement, and self-regulation (Song & Choi, 2011), are used as a tool for academic achievement and personal growth, and play an important role for both teachers and students in the classroom (Pekrun & Linnenbrink, 2014). Thus, in order to understand the nature of what a student experiences in a learning situation, consideration of emotions is essential (Sansone & Thoman, 2005; Song & Choi, 2011).

While affects, emotions, and moods are distinguished by a researcher's theoretical and methodological background, but some descriptions are commonly used (Linnenbrink, 2006). In particular, Linnenbrink (2006) found that many studies on affects, emotions, and moods use the definitions suggested by Rosenberg (1998). Rosenberg (1998) divided them into affective traits and affective states. Affective traits are stable certain forms of emotional reactions, usually long lasting, less changeable and affecting affective states. Affective states are defined, as things that vary from situation to situation, are less stable with time, and are divided into emotions and moods. Moods are affective states located between affective traits and emotions that are less intense than emotions but have a longer duration. Emotions are stronger than moods: short-lived, acute, and strong mental changes resulting from reactions to meaningful situations within an individual's environment. Individuals often remember the triggering event in which emotions are experienced (Rosenberg, 1998).

Definitions of emotions also vary among researchers, but many researchers commonly state that emotions are formed by multi-dimensional elements that include cognitive, physiological, behavioral, and motivational factors (Linnenbrink, 2006). According to Pekrun (2006), especially in science

education, emotions are “seen as multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes” (Pekrun, 2006, p. 316).

Among the dimensions of emotions, the most basic is valence, which indicates the value or expected consequence of a specific piece of information (Barrett, 2006; Morris et al., 2019). It is divided into positive emotions and negative emotions. It is also expressed in pleasant and unpleasant emotions. Examples of positive emotions are hope and joy, and examples of negative emotions are sadness and anger.

In order to explain functions of emotions interacting with various educational elements, such as learning content, knowledge generation processes, and social interaction in the classroom, emotions are categorized into achievement emotions, epistemic emotions, topic emotions, and social emotions according to the object focus (Pekrun & Linnenbrink, 2014). Achievement emotions are emotions that are directly related to an activity or outcome. Epistemic emotions are generated by the quality of task information and processing. Topic emotions are simply caused by learning subjects. Social emotions are emotions associated with interactions with teachers, students, and others (Pekrun & Linnenbrink, 2014).

3 The Control-Value Theory

The studies on emotions adopt different perspectives and methods and are relatively isolated from each other (Pekrun et al., 2007). The control-value theory is a relatively new conceptual system of achievement emotions that integrates several theories (Pekrun, 2006), and many studies on emotions use the control-value theory as a theoretical background (Linnenbrink, 2006).

The core of the control-value theory is appraisals of activities and outcomes. Prior to the appraisals, environments, achievement goals, beliefs, gender, and so on may affect emotions, but appraisals act as a more direct factor than others (Pekrun et al., 2007). Appraisals are divided into value appraisals and control appraisals. Value appraisals are the determination of how valuable you are to an activity and outcome. It is either positive or negative. However, control appraisals are the determination of controllability of activities and outcomes. The form of appraising an outcome is divided into prospective and retrospective. Control appraisals in the prospective form imply causal expectations, and in the retrospective form link the causes for a given outcome (Pekrun et al., 2007).

Pekrun et al. (2007) divided achievement emotions into outcome/prospective emotions, outcome/retrospective emotions, and activity emotions according to the object focus and suggested achievement emotions based

on appraisals (Table 1). If the object focus is on outcome/prospective, the value appraisals are success (positive) and failure (negative) for the expected outcomes, and the control appraisals ask how much control you have when achieving those outcomes. For example, consider when the value appraisal is negative and the control appraisal is high. Even if the outcomes are predicted to be negative, the student experiences anticipatory relief because they feel they have worked hard and contributed a lot.

When the object focus is on outcome/retrospective, the value appraisals are the success (positive) and failure (negative) of the outcomes, and the control appraisals are retrospective determination of the causes of the outcome. For example, if the value appraisal is positive and the control appraisal is other, the students may feel gratitude. Finally, when the object focus is on activity, the value and control appraisal are made on the activity. For example, if the value appraisal does not exist (none), students will experience boredom in the activity regardless of the control appraisal (positive/negative).

TABLE 1 Achievement emotions by value and control appraisals (Pekrun et al., 2007)

Object Focus	Appraisals		Emotion
	Value	Control	
Outcome/ Prospective	Positive (Success)	High	Anticipatory joy
		Medium	Hope
		Low	Hopelessness
	Negative (Failure)	High	Anticipatory relief
		Medium	Anxiety
		Low	Hopelessness
Outcome/ Retrospective	Positive (Success)	Irrelevant	Joy
		Self	Pride
		Other	Gratitude
	Negative (Failure)	Irrelevant	Sadness
		Self	Shame
		Other	Anger
Activity	Positive	High	Enjoyment
	Negative	High	Anger
	Positive/Negative	Low	Frustration
	None	High/Low	Boredom

FIGURE 1 Outline of the study

4 Method

The goals of this study were to explore high school students’ emotions about climate change before and after an ssi school club project related to climate change using the control-value theory and to investigate students’ emotions about climate change during the club project. The outline of the study is presented in Figure 1. Students’ emotions about climate change were investigated before, during, and after the ssi school club project using pre-, in-activity, and post-questionnaires, respectively. In-depth interviews and data analysis followed the club activities.

4.1 Research Context and Participants

This study is part of the Action-Oriented ssi (Socio-Scientific Issues) School Club Activity project (Park, 2020) conducted with the support of the Ministry of Education in Korea. The participants were comprised of 10 volunteer students who attended G High School located in Gimpo, Korea. They participated in an ssi school club project for 7 weeks. The club project was conducted for 2 hours every week. The club project undertaken in this study focused on climate change and set three steps of activities goals. The first step was designed to invite students to understand the causes and effects of climate change through scientific modeling. The second step included the exploring local problems and solutions related to climate change at the individual, regional, and international levels. The third step aimed to involve students in planning and engaging in social action based on the knowledge and information dealt with in Steps 1 and 2 (Figure 2).

FIGURE 2
Procedures of SSI school club project

4.2 Data Collection

In order to explore the high school students’ emotions about climate change, we relied on a self-report methodology, collecting data through pre-, in-activity, and post-questionnaires during the program and afterwards performed in-depth interviews. According to Kim and Yang (2011), the emotions suggested by Pekrun et al. (2007) for Western students might not be the same as the emotions experienced by Korean students due to the cultural specificity of emotions.

An initial questionnaire for the pre- and post-surveys was developed based on emotions among Korean students (Kim & Yang, 2011). Three science education experts reviewed the content validity and adequacy. Each expert independently judged whether the items of the questionnaire had proper content and expressions, and then all experts gathered together to discuss and revise items where there was disagreement. Throughout this process, the initial questionnaire was revised and then a pilot test was conducted to 15 students in a high school near G High School to check the quality of the questionnaire items. As a result, a questionnaire with 49 items was finalized, and the structure of questionnaire is summarized in Table 2.

The first five question items required students’ background knowledge and perceptions of climate change. Students’ responses on these items were

TABLE 2 Structure of the questionnaire

#	Subject of questions
1–5	Background knowledge and perception of climate change
6–7	Value appraisal
8–9	Control appraisal
9–48	Emotions on climate change
49	Emotions other than the 39 emotions in the previous questions

TABLE 3 Survey questions about value and control appraisals of outcome/prospective emotions

#	Survey question	Survey content
6	Can the climate change problem be solved?	Value appraisal
7	Please tell why you answered Question 6 as you did.	
8	If I try to solve the climate change problem, this effort will be very helpful in solving the problem.	
9	Please tell why you answered Question 8 as you did.	

used to confirm the validity of the value and control appraisals of students about climate change. Question items from 6 to 9 collected data on students' value and control appraisals of outcome/prospective emotions about climate change. Table 3 shows the survey questions on value and control appraisals of outcome/prospective emotions. Items 6 and 8 used a 5-point Likert scale and 7 and 9 asked for open-ended responses.

Items from 9 to 48 required students to respond with their emotions about climate change (Table 4). Lastly, item 49 asked students to report any emotions, if they had, other than 39 emotions previously responded. In the case of outcome/retrospective emotions, the value appraisals were 'negative.' The control appraisals were qualitatively analyzed based on the students' responses of 9 to 49 and in-depth interview data. This is because when each student thinks about the causes of climate change retrospectively, they can think of the causes as diverse as themselves, humanity, ancestors and so on, and experience different emotions accordingly.

Also, in order to investigate students' emotions about climate change during the course of the club activities, we developed an in-activity questionnaire. In-activity questionnaire asked participants select the three strongest

TABLE 4 Examples of survey question about emotions about climate change

Emotions	Intensity of emotion					Write down the reasons for this feeling
	Not at all				Very much	
Fear	1	2	3	4	5	
Anxiety	1	2	3	4	5	
Hope	1	2	3	4	5	

emotions they experienced during the activities in each week and write the reasons why they thought they had experienced them. Lastly, in-depth interviews were conducted in an open format to understand and supplement participants' ambiguous responses to the questionnaires. They were conducted at the school after all club activities were completed. In-depth interviews usually took 20–30 minutes per participants. All in-depth interviews were audio-recorded and transcribed for further analysis.

4.3 Data Analysis

The results of pre-, post-, and in-activity questionnaires were used as primary data, and in-depth interview data were used to supplement the analysis. The data analysis process is shown in Figure 3. First, in the pre-survey analysis, we examined students' topic emotions about climate change. Topic emotions with an average of less than two points in the Likert scale were excluded from the analysis, because they generally meant that students hardly experienced the emotions. The topic emotions were basically related to climate change outcomes. Emotions in climate change outcomes are those that come from each student's perception on the current status of climate change. In general, control-value theory has been used for the analysis of achievement emotions. However, because of the temporal, urgent and critical nature of climate change crisis, the theory could provide deeper understanding on topic emotions about climate change. Participants' topic emotions were categorized into outcome/prospective emotions and outcome/retrospective emotions depending on

FIGURE 3 Data analysis process

their temporal directions. For example, if a student felt “overwhelmedness” and answered, “I think there will be problems in living due to climate change,” then the emotion comes from predicting the outcomes of climate change. So it is classified in outcome/prospective emotions. In this process, students’ responses on surveys and in-depth interview results were used together. Students’ value and control appraisals of outcome/prospective emotions were classified according to their level.

However, if a student’s value appraisals of emotion were found to be negative because the impact of climate change might be perceived as having negative consequences, then it was categorized as outcome/retrospective. Students’ control appraisals of outcome/retrospective emotions were also qualitatively analyzed based on the 39 emotion survey responses and in-depth interview data.

Second, we conducted an in-activity survey every week. Students were asked to select the three strongest emotions experienced during each activity and to provide the reasons for them. Based on the results of the students’ responses, all emotions that appeared were counted and arranged by incidence, and the patterns of changes in emotions as the course of club activity progressed were summarized.

Last, in the post-survey analysis, the process of analysis was similar to that of the pre-survey. Activity emotions were identified and described to identify the effects of climate change club activities on emotions. For example, a student’s confidence emotion could be recognized from this reply in the post-survey: “Joining this project made me more confident that I could understand climate change.”

After analyzing the emotions about climate change through the pre-, post-, and in-activity questionnaires, ambiguous content of the analysis was explored and supplemented using the transcriptions of the in-depth interviews. Also, the reliability and validity of students’ emotions investigated were improved by crosschecking the analyzed emotions by peer examination of the results at least three times during data analysis. Three science teachers with master’s degrees in science education participated in the peer examination.

5 Results

The results of this study are described according to the sequence of data collection: participants’ emotions before club activity, during club activity, and after club activity. In each section, the participants’ emotions identified were reported. Also, in the pre- and post-surveys, we analyzed emotions using the control-value theory.

FIGURE 4 Topic emotions about climate change before the ss1 school club project (emotions with an average over 3 points)

5.1 *Topic Emotions about Climate Change before the ss1 School Club Project*

The topic emotions about climate change of high school students were explored before the ss1 school club project. Emotions with average of 4 or higher were anxiety (4.3), guilt (4.2), and overwhelmedness (4.1). Emotions with relatively high points (less than 4 but higher than 3) were heaviness (3.9), confusion (3.8), fear (3.4), nervousness (3.2), and shame (3.0) (Figure 4). Among negative emotions, timidity (2.0), displeasure (2.0), melancholy (2.0), annoyance (1.9), irritation (1.9), distress (1.9), sense of defeat (1.6), boredom (1.5), and envy (1.3) were 2.0 or less points in average. All positive emotions did not exceed three on average. Only two emotions, interest (2.7) and hope (2.1) received above 2 points. The other 10 emotions such as expectation (2.0), confidence (1.5), pride (1.5), sense of accomplishment (1.4), joy (1.3), self-esteem (1.2), satisfaction (1.2), fun (1.2), peacefulness (1.2), and relief (1.1) were 2 or below. This means that participants had mostly negative emotions about climate change.

Participants' topic emotions about climate change were further analyzed based on the control-value theory (Table 5). In the right column of Table 5, A refers to the emotions shared by all participants in the same row of the table and the number refers to the number of participants who shared the emotions belonging to the specific value and control appraisal. All the emotions the student(s) reported were listed. For example, when the value and control appraisals of outcome/prospective were negative and low respectively, three participants felt anxiety, nervousness, and overwhelmedness. However, in the

TABLE 5 Analysis of topic emotions about climate change before the SSI club project

Object focus	Appraisals		Emotions (A*, n**)
	Value	Control (number of students)	
Outcome/ prospective	Positive (Success)	High (1)	A: Futility, confusion, expectation, anxiety, nervousness, pressure, fear, helplessness, hope, tension, embarrassment
		Mixed (Success/ Failure)	A: Expectation, anxiety, nervousness, tension, fear, helplessness, confusion, overwhelmedness, hope, annoyance
		Medium (1)	A: Anxiety, nervousness, overwhelmedness
		Low (1)	A: Nervousness, confusion, pride, anxiety, fear, overwhelmedness, sense of accomplishment
	Negative (Failure)	High (2)	A: Confusion, anxiety, tension, fear, sadness, overwhelmedness 1: Pressure, embarrassment, distress, hope, nervousness, anger
		Medium (1)	A: Confusion, anxiety, fear, interest
		Low (3)	A: Anxiety, nervousness, overwhelmedness 2: Confusion, fear, annoyance 1: Despair, helplessness, sadness, tension, heaviness, melancholy

TABLE 5 Analysis of topic emotions about climate change before the SSI club (*cont.*)

Object focus	Appraisals		Emotions (A*, n**)
	Value	Control (number of students)	
Outcome/ retrospective	Negative (Failure)	All	4: Shame 2: Guilt 1: Heaviness, anger, pressure, sadness, embarrassment, futility, melancholy, overwhelmedness
		Self	8: Guilt 2: Shame 1: Timidness
		Other	5: Heaviness 3: Resentment 2: Dissatisfaction, anger, irritation 1: Embarrassment, displeasure, shame, futility, overwhelmedness
		Topic emotion (Not related to outcome)	5: Interest

NOTES: *A refers to the emotions shared by all participants in the same row of the table. ** n = refers to the number of participants who shared the emotions belonging to the specific value and control appraisal.

outcome/retrospective, we did not indicate the number of students in the control of appraisals because each student can be counted more than once.

The findings are as follows. First, in outcome/prospective, emotions such as, anxiety (10 students) and confusion, nervousness, fear, and overwhelmedness (8 students) were found in most students regardless of value and control appraisals. This may be related to students' perceptions of the seriousness of climate change at present regardless their anticipation of the future. For example, during an in-depth interview, Suni, who had a negative value appraisal and low appraisal, felt anxiety and was worried about the warming weather. However, Jaeil, who had positive value appraisal and high control appraisal also felt anxiety about a disaster approaching:

Suni: Im so anxious that the weather is getting hotter.

Jaeil: I am anxious about what to do when a movie-like disaster comes.

Value appraisals of outcome/prospective emotions were found to be divided into three levels: positive, mixed, and negative. This is different from the value appraisals presented in the control-value theory (Pekrun et al., 2007), which has two distinct levels: positive and negative. As climate change is a theme involving uncertainties about the future, the new value appraisal, mixed, seems to have appeared in this study. The control appraisals of outcome/prospective emotions were divided into the same form as the control-value theory: high, medium, and low.

The control appraisals of outcome/retrospective emotions were divided into three levels, all, self, and other, which were different from the existing ones, I, other, and irrelevant. The reason for this difference may come from students thinking of climate change as a human-related problem. So, irrelevant was not found in this study. In addition, some students responded that the cause of climate change was all of humanity. Therefore, a control appraisal all that was distinct from I and other was added. For example, Jayoung said, "Climate change is rapidly becoming a problem due to human beings of the present age, so I felt embarrassment." We categorized embarrassment as outcome/retrospective emotion because she pointed out the causes of climate change retrospectively. Because she put the cause of climate change as human beings, control appraisal belongs to "all."

Students whose value appraisals of outcome/prospective emotions were positive or mixed felt hope, expectation, sense of accomplishment, and pride. Other students whose value appraisals were negative had no positive emotions about climate change. This can be understood as meaning that positive emotions about climate change could be supported by positive value judgments about solutions to climate change.

Chanmi, who had a mixed value appraisal, noted,

If climate change is resolved, I think I will feel sense of accomplishment.

Last, in outcome/retrospective emotions, guilt was found in all students. Students felt guilt when judging the causes of climate change as all or self. The number of students with a control appraisal of all was greater than those with self. In addition, students who felt that the causes of climate change was all also felt shame, while those who responded the causes of climate change as other felt heaviness and resentment.

5.2 *Dominant Emotions about Climate Change during the ss1 School Club Project*

The ss1 school club project related to climate change was conducted in 14 sessions over 7 weeks. One week's activity consisted of two sessions, and a survey was conducted after each activity to examine the emotions about climate change immediately after the activity. The results of the survey are shown in Figure 5. Students' dominant emotions in each week are shown using the size of the word and the number of students who felt that emotion is in parentheses. Positive emotions are written in red while negative emotions in black.

Negative emotions were mainly experienced when learning about the causes and effects of climate change. At the beginning of the project, in Step 1, emotions such as fear, anxiety, overwhelmedness, and guilt appeared among participants. By contrast, positive emotions were mainly involved in Step 2, group activities, and Step 3, social practices. As the project progressed, more students had positive emotions such as interest, expectation, and joy. Particularly when preparing for social practice, all showed positive emotions except fear of experiencing social practice for the first time. As the project progressed, the students' emotions about addressing climate change changed from overwhelmedness to expectation. In the early weeks of the project, many students felt overwhelmedness and thought that solving climate change was too difficult and in the distant future.

Week & Content	Number of students	Emotions
1. Impacts of climate change	10	Fear (5), anxiety (5), overwhelmedness (4), guilt (3) Anger (2), despair (1), sadness (1), futility (1), interest (1) , pressure (2), hope (1) , embarrassment (1), tension (1)
2. Causes of climate change	10	Overwhelmedness (6), guilt (4) Embarrassment (2), anxiety (2), timidity (1), shame (2), despair (1), helplessness (1), pressure (1), heaviness (1), self-esteem (2) , fear (1), hope (1) , fun (1), annoyance (1), joy (1) , nervousness (1), sense of accomplishment (1)
3. Planning group activity	10	Expectation (7), overwhelmedness (4), interest (3) Hope (1) , uncomfortable (1), heaviness (1), self-esteem (1) , anxiety (2), guilt (2), tension (2), joy (1) , sense of accomplishment (1) , envy (1), fun (1)
4. Presentation of group activity results	9	Surprised (3) Confusion (2), overwhelmedness (2), disappointment (2), fun (3), sense of accomplishment (2) , futility (1), curiosity (1) , confidence (1), self-esteem (2) , hope (2) , interest (1) , pressure (1), heaviness (1), regret (1), expectation (1)
5. Planning social action	7	Expectation (4) Confidence (1), interest (1) , hope (2) , sense of accomplishment (2) , guilt (3), surprised (1), envy (1), overwhelmedness (1), fear (1), self-esteem (1) , futility (1), anxiety (1), shame (1)
6. Preparing social action	7	Expectation (7), fun (3) Curiosity (1) , self-esteem (2) , hope (2) , interest (1) , sense of accomplishment (1) , fear (1)
7. Social action (Emotions that lead to action)	10	Guilt (4), anxiety (3), expectation (3) Sadness (1), pressure (1), interest (2) , sense of accomplishment (1) , embarrassment (1), self-esteem (1) , envy (1), pride (2) , fear (2), shame (2), hope (1) , confidence (1), joy (1) , heaviness (1), responsibility (1)

FIGURE 5 Emotions about climate change during the ss1 club project.
NOTES: Students' dominant emotions in each week are shown. Black type denotes negative emotions and red denotes positive emotions. Larger type indicates this emotion was reported by more participants.

Over time, however, they discovered some ways to help overcome the climate change crisis by means of their own efforts, and they felt some expectation towards their own practice. For example, Nayeon, who felt overwhelmedness during Week 1 activities noted,

I don't know how to try to stop climate change.

However, as the project progressed, she felt expectation during Week 6 when she came to realize some ways to overcome the climate change:

There are more things we can do to help address climate change, and if we do it well, we will be able to inform others about the severity of climate change and help improve awareness.

Expectation seems to be one of the main emotions that led to the practice. In order to foster students' actions for climate change mitigation, first-hand experience of taking action and practice is necessary during student activities.

Last, after the social action sessions, we investigated the emotions that motivate students towards practice. Even though the emotions that led to practice were quite different for each student, guilt, anxiety, and expectation were the most common emotions. Students answered that such emotions about climate change were strengthened and formed in their mind during while learning the causes and effects of climate change and doing action to protect the Earth. For example, Dongil reported feeling guilt and replied as follows:

It seems that my unintended actions have negatively affected the environment. From now on, I will be interested in the issues of climate change and practice small things first.

Aran reported feeling expectation:

As I worked hard on the project, I thought that many people were still ignorant about climate change. When I was making a poster with the message that the earth was in danger, I worked harder with the expectation that viewers might even think about climate change and the environment and change their attitude.

5.3 *Changes in Emotions about Climate Change after ssi School Club Project*

After the club activities, students' emotions that were reported with an average of three or more were anxiety (4.3), guilt (3.8), confusion (3.7), heaviness (3.4),

FIGURE 6 Topic emotions about climate change before and after the SSI school club project

fear (3.3), sadness (3.3), and shame (3.2). Of the 39 emotions, those with a large change compared to the pre-survey and those with higher than three points are shown in Figure 6. Because the number of participants was small, the statistics were used as indicators to identify overall trends in change. In general, the difference in points for each emotion between the pre- and post-surveys was moderate. However, some emotions received higher points after the club activities: sense of defeat, futility, sense of accomplishment, relief, sadness, and peacefulness. Some other emotions received lower points: guilt, nervousness, overwhelmedness, heaviness, melancholy, embarrassment, interest, and dissatisfaction. Overall, students tended to have more positive emotions after the club activities than before.

Like the pre-survey analysis, the control-value theory was used to analyze these emotions further. From the data analysis, the value appraisals of outcome/prospective emotions were divided into three levels, positive, mixed, and negative (Table 6), and the control appraisals of outcome/retrospective emotions were divided into three levels: all, self, and other.

Although students' value and control appraisals of climate change were influenced and changed by the SSI school club activities, they showed similar emotional tendencies depending on the appraisal. Among the outcome/prospective emotions, most students felt anxiety, confusion, nervousness, fear, and overwhelmedness regardless of the students' value and control appraisals.

TABLE 6 Analysis of topic and achievement emotions about climate change after the ssi club project

Type of emotion	Object focus	Appraisals		Emotions (A*, n**)
		Value	Control (number of students)	
Topic emotion	Outcome/ prospective	Positive (Success)	High (2)	A: Expectation, hope, anxiety 1: Pressure, tension, fear, pride, confusion, confidence, pressure, nervousness, overwhelmedness, sadness
		Mixed (Success/ failure)	High (1)	A: Futility, confusion, pressure, fear, sadness
			Low (1)	A: Futility, anxiety, expectation, confusion, nervousness, pressure, hope, fear, tension, interest, pride, overwhelmedness, sense of defeat,
		Negative (Failure)	High (2)	A: Anxiety, futility, nervousness, overwhelmedness 1: Pressure, tension, fear, despair, Sadness, annoyance, anger interest
			Medium (1)	A: Anxiety, futility, despair, nervousness, overwhelmedness, helplessness
			Low (3)	A: Anxiety, fear 2: Confusion, tension, sadness, overwhelmedness, 1: Relief, nervousness, peacefulness, boredom, annoyance

TABLE 6 Analysis of topic and achievement emotions about climate change (*cont.*)

Type of emotion	Object focus	Appraisals		Emotions (A*, n**)
		Value	Control (number of students)	
Achievement emotion	Outcome/ retrospective	Negative (Failure)	All	3: Guilt 2: Shame, sadness, confusion 1: Helplessness, sadness, distress, heaviness, displeasure
			Self	6: Guilt 4: Shame 1: Timidness, helplessness
			Other	7: Heaviness 3: Resentment 2: Anger, irritation 1: Dissatisfaction, futility, envy
				2: Interest
				1: Sense of accomplishment, confidence, confusion

NOTES: *A refers to the emotions shared by all participants in the same row of the table. ** n = refers to the number of participants who shared the emotions belonging to the specific value and control appraisal.

These emotions might be experienced due to the global, irreversible, and uncertain nature of climate change. The negative natures of climate change appear to have strongly influenced students' emotions even if they had made positive judgments about climate change or had thought that their efforts contributed greatly to the resolution of climate change. Students whose value appraisals of outcome/prospective emotions were mixed or positive felt expectation and hope about mitigating climate change. Also, guilt was mostly found among students, and when their control appraisals were other than guilt, they reported feeling a sense of heaviness and resentment.

As students participated school ssi club activities, activity emotions appeared: Two students felt interest, and one student felt sense of accomplishment, confidence, and confusion. Most of activity emotions tended to be positive. Additionally, we found that students who had negative value

appraisals and low control appraisals in the outcome/prospective emotions felt relief, peacefulness, and boredom. If the appraisals of the outcome/prospective emotions after the project were negative, the participants tended to lose interest in climate change and were more focused on the present.

6 Conclusions and Discussion

This study explores students' emotions about climate change before and after SSI school club activities related to climate change and qualitatively analyzes them using the control-value theory. We also examined the changes of emotions during club activities and we found that students tended to have negative topic emotions about climate change such as anxiety, guilt, overwhelmedness, heaviness, confusion, fear, and nervousness before participating in the club activity on climate change. Some students experienced a mixed value appraisal and felt confusion, anxiety, nervousness, fear, and overwhelmedness regardless of value and control appraisals. The global, accelerating, and uncertain nature of climate change may contribute to this. Also, students who anticipated that climate change problems could be solved felt greater expectations and interest.

During the club activity, students' dominant emotions showed some changes depending on the nature of the activity. Most students tended to have negative emotions during the first step activity, understanding activities on causes of climate change. However, they tended to have more positive emotions during second step activity, identifying climate changes issues in the community, and during the third step activity, social action planning and participation. Overwhelmedness prevailed in knowledge understanding activities, but turned into expectation during the community issues investigation and social action planning and participation activities. Last, some emotions, such as guilt, anxiety, and expectation, seemed to be associated with the causes, effects, and resolutions of climate change, respectively.

After the club activities, students still tended to show negative emotions: anxiety, guilt, confusion, heaviness, and fear. However, students also tended to have more positive emotions, such as sense of accomplishment, relief, and peacefulness, and less negative emotions such as guilt, nervousness, overwhelmedness, heaviness, melancholy, embarrassment, and dissatisfaction. However, among a small number of students, activity-related emotions such as interest, sense of accomplishment, confidence, and confusion appeared. Students with negative value appraisals and low control appraisals feel emotions of relief, peacefulness, and boredom.

This study examines and describes high school students' emotions about climate change in various contexts of a club activity. Trends in the changes in

students' emotions before, during, and after the club activity are identified. The application of the control-value theory to the analysis provides a deeper understanding of the students' appraisals about the theme, self, and controllability, and their relationship to the emotions. With these findings, students' emotions could be related to future learning and action.

During the analysis, new classification categories were reported in this study. For example, Pekrun et al. (2007) classified outcome/prospective object focuses into positive and negative value appraisals (Tables 5 and 6). However, in this study, in addition to these two categories, mixed value was identified. In the control-value theory, the successes and failures of activities are very distinct. However, because climate change is a theme involving uncertainty, a new value appraisal of mixed may appear. In control appraisals of outcome/retrospective emotions, three sub-levels, all, self, and other, were reported in this study, which are different from the existing sub-levels of one, self, other, and irrelevant. Students may feel that climate change is closely related to them; therefore, irrelevant was not found. In addition, students thought that the causes of climate change belong to all of humanity; therefore, the control appraisal all was added. This suggests that the classification scheme of the control-value theory may depend on the theme.

Based on these conclusions, there are two suggestions to foster the education of active citizens who can make informed decisions and act on climate change. First, emotional aspects should be considered along with cognitive, affective, and practical aspects when developing and implementing ss1 education programs that include climate change education. In this research, students experienced various emotions while participating in climate change activities, and some emotions such as hope and interest were found to have a certain relationship with value appraisals and control appraisals of climate change. Also, some emotions motivate students towards action. Therefore, planning and implementing activities that take into account emotional aspects in order to regulate value and control appraisals and drive emotions that lead to action can help foster the creation of activists who are fully functional.

In order to induce students' actions to address climate change, knowledge-understanding activities and investigation and taking-action activities in the program need to be balanced. In this research, when students tried to address climate change, both negative and positive emotions led to action. The dominant emotions that led to action were guilt, anxiety, and expectation. These emotions were deeply related not only to knowledge-understanding activities but also to investigation and taking-action activities. However, especially in Korea, Park (2019) suggests that climate change education programs in Korea tend to have a high degree of reflection of knowledge areas, but lack reflection of values, attitudes, participation, and action. Considered with the results

of this study that students felt negative emotions during understanding climate change and felt positive emotions during investigation and taking-action activities, students would be expected to have negative emotions mainly about climate change after domestic climate change activities. Indeed, students felt negative emotions when they learned about climate change, such as anxiety, guilt, overwhelmedness, heaviness, confusion, fear, and nervousness. Therefore, SSI programs should provide students with concrete and realistic information on the causes and effects of climate change and the message should be conveyed that the problem of climate change can be solved and that individual efforts can be help greatly by doing investigation and taking-action activities.

Since up to the present there has been a lack of discussion on emotions related to climate change, it is meaningful that this study comprehensively explores emotions about climate change and the effects of an SSI program. We hope that the information discussed in this study will be useful in developing future programs and analyzing programs related to climate change.

Abbreviations

IRRESISTIBLE	Including Responsible Research and innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments
IPCC	International Panel on Climate Change
MOE	Ministry of Environment
PARRISE	Promoting Attainment of Responsible Research & Innovation in Science Education
RiNA	Research-informed & Negotiated Action
STEPWISE	Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environment
SLEP 21	Scientific Literacy Education Program for 21st Century Global Citizens
SSI	Socio-Scientific Issue
UNFCCC	United Nations Framework Convention on Climate Change

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Ethical Considerations

Approval to conduct this study was granted by the Seoul National University Ethics Review Board. The data collected from this project has obtained the necessary clearance from the school, guardians and the students involved in the study. The names of the school and participants used in this study are all pseudonyms.

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