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Article

Effect of Domestic and Global Environmental Events on Environmental Concern and Environmental Responsibility among University Students

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Abstract: Recently, both global and domestic environmental events have been occurring more frequently, bringing catastrophic consequences to humans and the environment. These adverse events have caused widespread concern among the general public. In positive terms, these devastating events could potentially enhance people's environmental awareness, which, in turn, could instill a greater sense of environmental responsibility. This study aims to investigate how university students concern themselves with global and domestic catastrophic environmental events and to examine how global and domestic environmental concerns mediate the effect of environmental knowledge and attitudes on university students' environmental responsibility. Students of King Mongkut's University of Technology Thonburi in Bangkok, Thailand were selected as the participants. A simple random technique was applied to select the research participants. Questionnaire surveys with 863 students were carried out during September–October 2019. A path analysis was performed to test how global and local environmental concerns mediate the effect of environmental knowledge and attitudes on university students' environmental responsibility. The results demonstrated that domestic environmental concerns, taken alone, contributed less to the students' sense of environmental responsibility. Domestic environmental concerns had a stronger effect on environmental responsibility when taken together with global environmental concerns. In addition, both domestic and global environmental concerns could help transform environmental knowledge and attitudes into environmental responsibility. Only environmental attitudes had no direct effect on responsibility. These results show that domestic and global catastrophic environmental events could raise students' levels of concern for the environment, and, ultimately, enhance their sense of responsibility to protect the environment.

Keywords: global environmental concerns; domestic environmental concerns; environmental attitudes; environmental responsibility

1. Introduction

Recently, the general public has experienced several catastrophic environmental events, including both domestic and global events. In Thailand, Bangkok's particulate matter (PM2.5) concentration crisis from November 2018 until January 2019 and in September 2019 caused health concerns and health impacts, not only among vulnerable groups (e.g., elderly people and the poor), but also among the general public. PM2.5 refers to particulate matter with diameters of 2.5 micrometers (μm) or less. A high concentration of PM2.5 in a particular area potentially causes toxic health effects. The Pollution Control Department of Thailand reported that the concentration of PM2.5 in many areas was higher than the air quality index (AQI) which indicates an acceptable range of air quality [1]. In Thailand, the annual standard for PM2.5 concentrations is set at 25 μg/m3 and

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the daily standard is set at 50 μg/m3 [1]. Public concern about PM2.5 concentrations led to the urgent need for government action to manage the problem.

In addition, the Thai public noticed the shorter winter season, and scholars also found that the number of cold days (temperature < 16 °C) during the winter season was decreasing in the north and northeast [2]. Limsakul et al. [2] also demonstrated that many parts of Thailand will experience rising average temperatures, particularly during the summer season. Obviously, there will be more warm days (> 35 °C daily mean temperature) per year, particularly in the Chao Phraya River basin, the central plain and the lower northern regions. Consequently, there will be an extension of the summer period (with maximum daily temperature > 35 °C) for 2–3 months on average.

More recently, extreme floods influenced by Tropical Depression Podul on August 29, 2019 and Tropical Depression Kajiki on September 3, 2019 occurred in the northeastern region of Thailand. They caused devastating damage to many local communities. In September 2019, there were flash floods that remained for several weeks. The most affected provinces included Ubon Ratchathani, Yasothon, Roi Et and Sri Saket. Up to 20,000 people were affected in Ubon Ratchathani and Sri Saket alone [3].

On a global scale, many other catastrophic events have recently occurred in several parts of the world. Those events reflect a global environmental crisis that is having serious impacts on both ecosystems and human well-being. During 2018–2019, there were fires in many parts of the Amazon rainforest. In 2019, the National Institute for Space Research (INPE) reported that more than 80,000 fires occurred across Brazil [4]. Losses of 906,000 hectares (2.24×106 acres; 9,060 km2; 3,500 sq mi) of forest within the Amazon biome were estimated [4]. The Amazon rainforest contains almost three million plant and animal species, and there are about one million indigenous people, or 350 groups, living there. It also contains the world's largest river system. Because of its diversity and the existence of various ecosystems, the Amazon rainforest provides ecological services, not only for locals, but also for the entire world population [5]. For instance, the Amazon rainforests potentially absorb millions of tons of carbon dioxide every year [6], which helps mitigate global warming. Other global environmental problems that have contributed widely to public concerns include the deaths of aquatic animals due to waste in the oceans, changes in global average temperature, the decline of polar bears at the North Pole and rising sea levels (details explained in Table 1). All of these problems have been highlighted in both national and international public media.

Table 1. Catastrophic Environmental Events Occurring in Thailand and Other Countries.

	Catastrophic Environmental Events	Situations
Domestic	$PM_{2.5}$ concentration in Bangkok	During November 2018–January 2019 and in September 2019, Bangkok's atmosphere was full of particulate matter ($PM_{2.5}$), with concentrations higher than the air quality index in many areas. For instance, on December 21, 2018, the Pollution Control Department of Thailand reported that the concentration of $PM_{2.5}$ along Dingdang Road was 100 μg/m^3, which was two times higher than the air quality index (50 μg/m^3) [1].
	Shorter winter period in Thailand	Thailand has been facing shorter winter periods. According to Limsakul et al. [2], it is expected that the duration of the cold period (with cold days, temperature < 16 °C) in the northern and northeastern parts of Thailand could shorten after mid-century from 2–2.5 months to 1–2.5 months.
	Rising temperatures in Bangkok during summer	The Thailand Meteorological Department [7] reported that from 1995–2009, the average annual temperatures had significantly risen by about 0.95 °C. This was higher than the average world temperature increase of 0.69 °C [8]. Limsakul et al. [2] also found that the number of warm days (> 35 °C daily mean temperature) per year was expected to increase, particularly in the Chao Phraya River basin, the central plain and the lower northern regions. The increase in the number of warm days constitutes an extension of the summer period (with maximum daily temperature > 35 °C) by 2–3 months on average. Consequently, the northeastern, central

	Catastrophic Environmental Events	Situations
		and southern parts of Thailand are expected to have hot periods extended to 5–6 months by the end of the century.
	Heavy floods in northeastern Thailand	Limsakul and Singhruck [9] found that central and eastern Thailand would face decreases in total rainfall, whereas the northeast, the Gulf regions and Bangkok, would experience increasing rainfall. The Thailand Meteorological Department [7] also reported that Thailand would face more intense tropical storms during the change of seasons (from rainy to winter and winter to summer). On August 29, 2019, Tropical Storm Podul passed through Thailand, followed by Tropical Depression Kajiki on September 3, 2019, which enhanced the southwest monsoon. Heavy floods occurred in many provinces across Thailand, particularly in the northeastern regions, including the Ubon Ratchathani, Yasothon, Roi Et and Sri Saket provinces. More than 20,000 people from Ubon Ratchathani and Sri Saket evacuated to 49 evacuation centers [3].
Global	Fires in the Amazon rainforest	The Amazon basin contains almost three million species of plants and animals [5], and 350 groups of about one million indigenous people [6]. The Amazon rainforests provide ecological services for the world's population by absorbing millions of tons of carbon every year [6]. When large numbers of trees are cut or burned, the carbon stored in those trees is released into the atmosphere. From January 1 until August 29, 2019, the INPE reported more than 80,000 fires across Brazil [4]. It was estimated that more than 906,000 hectares (2.24×106 acres; 9,060 km2; 3,500 sq mi) of Amazon forest have been lost due to fires in 2019. These fires raised environmental concerns, not only in Brazil, but around the world due to the excess carbon dioxide and carbon monoxide in the fires' emissions.
	Death of aquatic animals due to waste in the oceans	According to the report "Marine Debris: Understanding, Preventing and Mitigating the Significant Adverse Impacts on Marine and Coastal Biodiversity" [10], approximately 663 to 817 species worldwide have been affected by marine debris since 2012, and about 80% of marine litter is plastic. Various types of aquatic animals, such as fish, seabirds, sea turtles and marine mammals, can become entangled in, or ingest, plastic debris, causing suffocation, starvation and drowning. Many studies have found that micro- and nano-plastics in oceans have caused ecological impacts on flora and fauna, such as dolphins, whales, sea turtles, sea lions and seals [11]. The effects of plastic pollution on marine life have been highlighted in the public media, both domestically and internationally. This media attention can raise people's level of concern about this problem.
	Changes in global average temperature	According to the NOAA 2018 Global Climate Summary, the combination of land and ocean temperature has increased at an average rate of 0.07 °C per decade since 1880. Since 1981, the average rate of increase has been 0.17 °C, which is more than double the prior rate. These projections also show that global surface temperatures will be more than 0.5 °C warmer than the 1986–2005 average by 2020 [12]. Many regions in the world, including New Zealand, the Middle East, Europe and the Mediterranean Sea, experienced record warm years. Additionally, some parts of Asia, the Atlantic Ocean and the western Pacific Ocean were also record warm. In contrast, some regions, such as Canada and the north-central United States were cooler than average [12].
	Decline of polar bears at the North Pole	Naturally, the polar bear or *Ursus maritimus* relies on sea ice for feeding, breeding and movement. They mostly live in Arctic areas where the land is covered by ice for almost the whole year. Their preferred habitat is the continental shelf where they can easily access prey, including ringed seals and bearded seals [13]. The reduction of sea ice and longer ice-free periods during the summer can reduce foraging success and cause nutritional stress [14]. Hunter et al. [15] found that global warming caused significant reductions of sea ice in Arctic areas; thus, they predicted that there would be rapid decreases in the polar bear population by the end of the 21st century. As a result, the polar bear is listed as a threatened species under the U.S. Endangered

Catastrophic Environmental Events	Situations
	Species Act. According to Bromaghin et al. [16], northeastern Alaska and the Northwest Territories faced a 40% loss of polar bear populations (from 1,500 to 900 bears) from 2001–2010.
Sea level rise	Sea level rise is one of the adverse consequences of climate change [17]. There are several reasons that a warming climate could potentially cause rising sea levels, including the melting of marine ice-sheets and thermal expansion of sea water. Many previous studies have analyzed sea level rise as a consequence of climate warming. It has been estimated that sea levels rose globally by about 15–20 cm in the past century [18], and it will continue to increase in the 21st century [19].

Although these catastrophic environmental events cause diverse negative impacts on human well-being and natural ecosystems, both domestically and internationally, these events could help raise the level of environmental concern among people, and ultimately, lead to a greater individual sense of environmental responsibility. Many previous studies have investigated the role of environmental knowledge and environmental attitudes in promoting an individual sense of environmental responsibility and pro-environmental behaviors [20, 21]. Some studies have also investigated the roles of environmental concerns in predicting individuals' environmentally-related behaviors [22–24], as well as the relationship between environmental attitudes and environmental concerns [25]. However, the influence of global and domestic environmental concerns, generated from the recent occurrence of catastrophic environmental events, on the relationship between knowledge/attitudes and a sense of environmental responsibility has never been investigated. Understanding the associations among environmental knowledge, attitudes, domestic and global environmental concerns, and a sense of environmental responsibility could have implications for the development of better communication regarding the consequences of current catastrophic environmental events. Such effective communication could help promote citizen participation in pro-environmental behaviors.

This study aims to investigate university students' concerns about global and domestic catastrophic environmental events and to examine how global and domestic environmental concerns mediate the effect of environmental knowledge and attitudes on university students' sense of environmental responsibility. The participants of this study were university students of King Mongkut's University of Technology Thonburi in Bangkok, Thailand. The results of this study may provide strategies for communicating with or educating university students about the consequences of global and domestic catastrophic environmental events and relevant environmental issues in order to enhance their sense of environmental responsibility.

2. Literature Review

2.1. Environmental Responsibility

In this study, environmental responsibility (ER) refers to a sense of personal obligation towards the environment or feelings of responsibility to take action to avoid negative impacts on the environment. Regarding the value-belief-norm theory (VBN), environmental responsibility is the only one variable that has a direct path towards an individual's decision to engage in pro-environmental behaviors (PEBs) [26]. ER is therefore considered important to promote PEBs. Many scholars also contend that ER significantly contributes to an individual's readiness to engage in PEBs [27–29]. Clark et al. [25], for instance, stated that ER enables individuals to act for environmental protection. Similarly, Zhu et al. [30] demonstrated that different levels of perceived responsibility contribute to an individual's conservation intentions. ER potentially persuades both individuals and institutions to accept responsibility for causing environmental problems due to their behaviors and to alter their daily practices to minimize negative consequences [31]. ER is greatly related to personal

norms, which could be generated from both feelings of moral obligations towards societies and/or nature and personal feelings of obligation due to social pressures [32, 33]. This study emphasizes the role of personal feelings of moral obligations towards societies and/or nature in creating ER. Thus, variables related to environmental knowledge, environmental attitudes, and global and domestic environmental concerns were selected to investigate their influence on ER.

2.2. Environmental Attitude

Environmental attitude (EA) refers to individuals' attitudes towards the environment. Schultz et al. [34] conceptualized EA as an individual's beliefs, affects and behavioral intentions related to environmentally-related issues. EA can be measured based on people's beliefs about the natural environment, which beliefs could be positive or negative [35]. Lee and Hae [36] conceptualized EA into three aspects, including 1) environmental beliefs that refer to people's notions about the relationship between humans and the natural environment, 2) environmental value, which refers to people's perceptions of environmental values and relevant environmental problems (these perceptions can regulate environmentally-related behaviors), and 3) environmental sensitivity, which refers to people's recognition of the seriousness of environmental problems and notions about the influence of human activities on environmentally-related problems. Many studies have shown that positive environmental attitudes are significantly correlated with PEBs [37, 38]. However, some studies also found a weak correlation between positive environmental attitudes and PEBs [39, 40], and Vermeir and Verbeke [41] demonstrated that the single variable of environmental attitudes was too weak to predict PEBs.

According to the VBN theory, by having positive environmental attitudes, people will be able to recognize the negative consequences of certain behaviors for the environment, and this recognition can finally create a sense of personal obligation to act in an environment-friendly manner. To measure people's environmental attitudes, the new environmental paradigm (NEP) scale, as proposed by Dunlap and Van Liere [42], has been widely used [43, 44]. For instance, Arcury [45] measured individuals' environmental attitudes using the NEP scale and found a significant relationship between environmental knowledge and attitudes. The new NEP scale consists of 15 items and has five sub-scales. Those scales and items aim to measure people's perceptions of issues related to the interconnection between humans and the environment, such as limits to growth, anti-anthropocentrism, the fragility of nature's balance, the rejection of exemptionalism and the possibility of an eco-crisis [46]. The reliability of the NEP scale has been tested in many studies and has been proved as a valid tool to measure people's perceptions of environmental values [39, 47]. Halkos and Matsiori [48] also applied the NEP scale to measure environmental attitudes.

2.3. Environmental Knowledge

Environmental knowledge (EK) refers to an individual's ability to identify the symbols, concepts and behavior patterns related to the protection and conservation of the environment according to received environmental information [49]. Chan [50] defined EK as an individual's understanding of knowledge of the environment and relevant issues, such as current environmental situations, the causes of environmental problems and possible impacts. Previous studies have shown that EK could enhance environmental concerns and awareness for environmental problems [21, 51]. For instance, Lee [52], Mostafa [53] and Oguz et al. [54] demonstrated that by having greater knowledge of environmental problems or issues, people were more likely to behave in a more environmentally-friendly manner. Similarly, Flamm [55] showed that households reporting their engagement in purchasing energy-efficient cars had relatively higher levels of EK. However, some studies found that fostering singular knowledge tended to have a low impact on people's engagement in environmental behaviors [56, 57]. EK may contribute to individuals' positive attitudes towards pro-environmental behaviors, which may ultimately encourage participation in environmentally-friendly behaviors. Mostafa [58] also showed that EK has a positive impact on consumers' attitudes towards

green products. Similarly, Sang [59] found a significant effect of EK on attitudes towards green purchasing behaviors.

2.4. Environmental Concern

Environmental concern (EC) refers to the degree to which people are concerned about environmental problems and dangers to the earth's ecosystems and to natural sustainability [60, 61]. Similarly, Singh and Bansal [62] viewed EC as people's consciousness toward environmental and ecological problems and their perceptions of the necessity of environmental problem-solving actions. In other words, EC is related to people's awareness of environmental problems, which can be indicated in several ways, including attitude, recognition and personal response towards environmental issues [63]. Abdul-Muhmin [64] stated that the occurrence of environmental events that posed a threat to nature and interrupted the balance between humans and nature, on both the regional and international levels, appeared to positively affect the levels of ecological and environmental concern. Wu et al. [65] demonstrated that EC played an important role in predicting behavioral intentions to accept autonomous electric vehicles.

Currently, there are many global environmental issues that may contribute to individuals' levels of concern, including climate change, loss of biodiversity and natural disasters. Climate change is one of the hot issues that concerns many scholars and the general public as it could potentially change global ecological and social systems [66]. The impacts of climate change can cause catastrophic environmental events, both on the regional and global levels, such as tropical storms, a rise in average global temperatures, sea level rise and coastal erosion. In addition to global environmental issues, local and regional environmental issues could also concern many people as they could obviously generate negative effects for people living in the problem areas. Local environmental issues are related to domestic environmental events, such as air pollution, waste water pollution and solid waste problems. Both global and domestic environmental events could positively contribute to people's environmental concerns, which could ultimately lead to a sense of environmental responsibility to protect the environment. However, the potential influence on individuals' environmental responsibility has never been empirically tested.

3. Conceptual Idea of the Study

This study aims to investigate the roles of global and domestic environmental concerns in mediating the effect of environmental knowledge and environmental attitudes on people's sense of environmental responsibility. The proposed conceptual framework for this study can be seen in Figure 1.

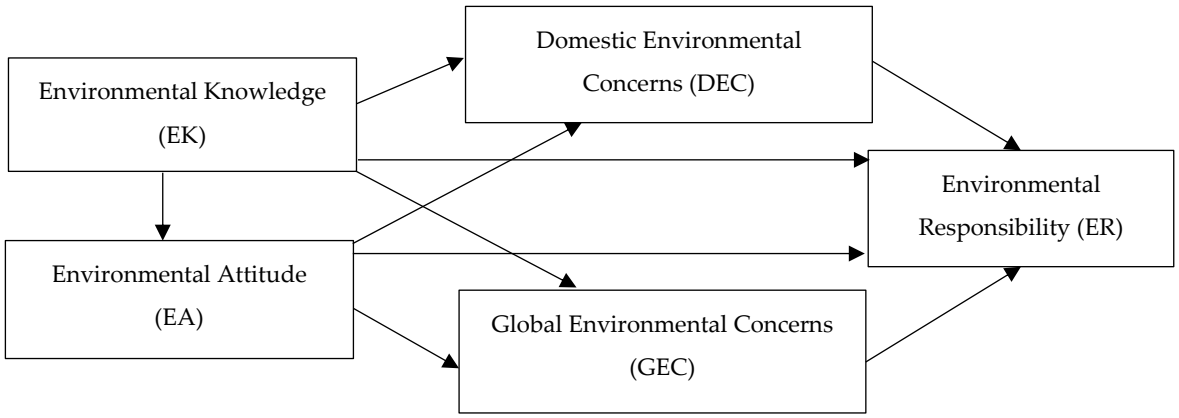

Figure 1. Conceptual Idea of the Study

Overall, environmental knowledge (EK) and environmental attitude (EA) are assumed to have a direct effect on environmental responsibility (ER) and to have indirect effects on ER through both

domestic environmental concerns (DEC) and global environmental concerns (GEC). By having a certain level of EK and a positive EA, people can construct appropriate levels of concern about environmental issues related to global and domestic environmental events, which, in turn, affect ER. As stated in the VBN theory [26], having a positive EA could contribute to a moral responsibility to protect the environment, which, in turn, could affect behavioral intentions to engage in pro-environmental behaviors. It can be also assumed that people with a positive EA may construct appropriate levels of EC, including both DEC and GEC. Widegren [67] showed that people acquired their EA over time and that a positive EA could help increase EC.

In addition, EK can also positively and directly contribute to EA. Namely, individuals with appropriate environmental knowledge could have a positive attitude towards the environment. For instance, Bradley et al. [68] found a significant link between the EK and EA of students. EA can also positively and directly affect EC. As stated by Ünal, Steg and Gorsira [51], EK can enhance individuals' concerns and awareness of environmental problems. Wurzinger and Johansson [69] also found that tourists with more EK reported a relatively greater EC for the environmental issues related to tourism destinations. Moreover, it also can be assumed that EK could have a significant effect on EC through EA. Hunter and Rinner [70] reported that EK could contribute to EC with the support of EA, regarding people's participation in species preservation behaviors. Finally, when having a certain level of EC, people are expected to construct a sense of ER. As found by Wu et al. [65], Lin and Huang [71], and Prakash and Pathak, [72], EC expressed as individuals' environmental awareness can strengthen their sense of ER and guide them to act in an environmentally-friendly manner.

The novelty of this study is that EC is divided into DEC and GEC, which are related to individual awareness on current environmental situations. Both DEC and GEC could have different degrees of effect on ER and could have different levels of power in mediating the effect of EK and EA on ER. Thus, the results will have implications for strategic communication of catastrophic environmental consequences with the purpose of enhancing an individual sense of ER.

4. Research Methods

4.1. Participants and Ethical Issues

Participants of this study were undergraduate students (18–23 years old) enrolled in King Mongkut's University of Technology Thonburi (KMUTT), Bangkok, Thailand. In the 2019 academic year, there were 11,858 students. This study employed a simple random sampling method to select participants. The size of the sampling population was calculated based on the Yamane formula [73] with a 96.0% confidence level. The results showed that 594 participants were required. However, in the data collection, questionnaire sheets with consent forms were distributed to 1,000 students, and 863 students decided to engage in the survey (86.3% response rate). This research project was also approved by the Research Ethics Committee of the School of Liberal Arts, KMUTT.

4.2. Instruments

A questionnaire was developed and was inspected for its validity by measuring its face validity, and the questionnaire was tested with 30 undergraduate students to confirm the reliability of the questionnaire items. The internal consistency of the scales, which were developed for measuring levels of EK, EA, DEC, GEC and ER, were tested by calculating Cronbach's alpha. The results showed that the values of Cronbach's alpha calculated for each variable were all above 0.70, thus the items and scales developed for measuring each variable were reliable [74]. All questionnaire items are shown in Table 2.

In measuring environmental knowledge (EK), this study measured participants' perceived EK (subjective knowledge) by employing self-reporting techniques. The five-item EK scale was developed based on the application of the EK scale established by Zhu [75]. Zhu's EK scale [75] was also used by Pan et al. [76]. For this study, a questionnaire item related to local EK was also added.

For measurement of environmental attitude (EA), this study measured EA based on direct self-reporting techniques by applying the new environmental paradigm (NEP) scale [46]. Many previous

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studies also relied on self-reporting techniques [77] and the NEP scale to measure EA [78]. The NEP scale aims to measure people's perception of, or belief about, the relationship between humans and the environment [46]. The revised NEP scale contains 15 items. For this study, only six items were selected based on the consideration of students' capabilities to understand meanings and contexts related to each question. This change ensured the reliability of the collected data.

Regarding environmental concern (EC), EC was divided into domestic environmental concern (DEC) and global environmental concern (GEC). DEC refers to individuals' concerns about catastrophic environmental problems occurring in Thailand during the past decade. These include PM2.5 concentrations in Bangkok during 2018–2019, shorter winter periods, rising temperatures in Bangkok during the summer season and heavy floods occurring in the northeastern part of Thailand during August and September 2019. GEC refers to individuals' concerns about environmental problems occurring in other countries or another part of the world. These problems reflect adverse impacts on the world's macro environmental and ecological systems. These problems include fires in the Amazon rainforest, the death of aquatic animals due to waste in the oceans, rising global average temperatures, a dramatic decline in the polar bear population at the North Pole and sea level rise. For the measurement of DEC and GEC, a five-point Likert scale, ranging from 1 (not at all) to 5 (very much concerned), was developed based on the application of a Gallup Poll environmental concern question [79]. Participants were asked to indicate how concerned they were about relevant environmental events.

In measuring environmental responsibility (ER), this study measured participants' feelings of responsibility towards the environment. A five-point Likert scale with responses ranging from 1 (completely disagree) to 5 (completely agree) was developed based on the application of questions developed by Kaiser and Shimoda [32].

Table 2. Variables, Explanations and Questions for Data Collection.

Variables	Questions	Response Category
Environmental Knowledge (EK)	How much do you know about climate change situations?	1 = Not at all 5 = Very well
	How much do you know about causes of global warming?	
	How much do you know about impacts of global warming?	
	How much do you know about characteristics of ecosystems and natural resources?	
	How much do you know about causes of temperature rise in Bangkok city?	
Domestic Environmental Concerns (DEC)	How concerned are you about $PM_{2.5}$ concentrations in Bangkok city?	1 = Not at all 5 = Very much concerned
	How concerned are you about the shorter winter period in Thailand?	
	How concerned are you about rising temperatures in Bangkok city in summer?	
	How concerned are you about heavy floods occurring in the northeastern part of Thailand?	
Global Environmental Concerns (GEC)	How concerned are you about fires in the Amazon rainforest?	1 = Not at all 5 = Very much concerned
	How concerned are you about the death of aquatic animals due to waste in the oceans?	
	How concerned are you about rising global average temperatures?	
	How concerned are you about the dramatic decline of polar bears at the North Pole?	
	How concerned are you about sea level rise?	
Environmental Responsibility (ER)	I am aware of environmental impacts before deciding to do something.	1 = Completely disagree 5 = Completely agree
	I am willing to purchase green products even though I have to pay more.	
	I am willing to act environmentally even though I do not feel comfortable, such as using public transportation, using stairs instead of an elevator, etc.	

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Variables	Questions	Response Category
	It is my responsibility to protect the environment.	
	I have tried to use things more efficiently in order to save natural resources, such as energy saving behaviors, reuse and recycling behaviors, etc.	
Environmental Attitudes (EA)	Ecosystems are vulnerable, and they can be easily deteriorated.	1 = Completely disagree 5 = Completely agree
	Nature is strong, and it can cope with consequences of human development activities.	1 = Completely agree 5 = Completely disagree
	Naturally, the existence of plants and animals is for human's utilization.	
	The earth is like a spaceship with finite room and resources.	1 = Completely disagree 5 = Completely agree
	If things continue on their present course, we will soon experience a major ecological catastrophe.	1 = Completely agree 5 = Completely disagree
	Humans have the right to modify the natural environment to suit their needs.	

4.3. Data Collection and Analysis Environmental Responsibility

Data collection by questionnaire surveys was carried out during September and October 2019 at King Mongkut's University of Technology Thonburi in Bangkok, Thailand. All corrected data were inspected before being used for statistical analysis. For the data analysis, a path analysis was carried out to test the proposed conceptual model in Figure 1. Undergraduate students' ER was defined as an endogenous variable that might be influenced by GEC and DEC, which were defined as exogenous variables. Moreover, both GEC and DEC were also defined as endogenous variables that might be influenced by two exogenous variables, including EA and EK. The variable of EA was also an endogenous variable that might be affected by EK. The proposed path model is shown in Figure 1. The model's fit was evaluated based on the following indexes: $\chi 2$ test, root mean square error of approximation (RMSEA), comparative fit index (CFI), goodness-of-fit indexes (GFIs), chi square/degree of freedom ratio (CMIN/DF) and incremental fit index (IFI). The statistical software Analysis of Moment Structure (AMOS) version 21 was used to carry out the analysis.

5. Research Methods

5.1. Characteristics of Participants and Variable Scores

Table 3 presents the characteristics of the participants and the participants' reported scores of variables, including EK, DEC, GEC, ER and EA. The proportion of female participants was slightly higher than male participants, with 52% and 48%, respectively. There were 373 participants studying in their 4th year, which accounted for the highest proportion at 43.20%. There were 130 participants, or 15.10%, studying in their 1st year, which was the smallest group. Participants in their 2nd and 3rd years numbered 190 (22%) and 170 (19.70%), respectively. Considering participants' fields of study, the results showed that 41.6%, or 359 students, were studying engineering, and 29.5%, or 255 participants, were studying science and technology. The proportion of participants in information technology was the smallest, with only 4.6%. The average GPA reported by all participants was M = 2.70, SD = 0.494.

Table 4 shows the average scores of EK, DEC, GEC, ER and EA reported by participants. Compared with other variables, the participants reported the highest average scores for GEC (M = 4.17, SD = 0.75) and DEC (M = 4.01, SD = 0.69). EA had the lowest score (M = 3.55, SD = 0.56). ER had an average score of 3.82 with a standard deviation of 0.53, and EK had an average score of 3.69 with a standard deviation of 0.56. Regarding GED, it was found that participants reported the highest concern about the death of aquatic animals due to waste in the oceans (M = 4.29, SD = 0.75), whereas they reported the lowest concern about the dramatic decline of polar bears at the North Pole (M = 4.05, SD = 0.62). For DEC, participants reported the highest concern about rising temperatures in Bangkok in the summer (M = 4.15, SD = 0.70) and heavy floods occurring in the northeastern part of

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Thailand (M = 4.15, SD = 0.72). Participants reported the lowest concern about the shorter winter period in Thailand (M = 3.74, SD = 0.65).

Table 3. Characteristics of the survey participants.

Items		n	Percent
Gender	Male	414	48%
	Female	449	52%
School Year	First Year	130	15.10%
	Second Year	190	22%
	Third Year	170	19.70%
	Fourth year	373	43.20%
Fields of Study	Engineering	359	41.6
	Science and Technology	255	29.5
	Information Technology	40	4.6
	Industrial Education	137	15.9
	Arts and Media	72	8.3
GPA	M = 2.7, ±0.494		

Table 4. Levels of environmental knowledge, local environmental concerns, global environmental concerns, environmental responsibility, and environmental attitude.

Variables	Mean	SD	Cronbach's α
Environmental Knowledge (EK)	**3.69**	**0.56**	0.798
How much do you know about climate change situations?	3.69	0.45	
How much do you about causes of global warming?	3.97	0.50	
How much do you know about impacts of global warming?	4.01	0.65	
How much do you know about characteristics of ecosystems and natural resources?	3.26	0.50	
How much do you know about causes of temperature rising in Bangkok city?	3.53	0.70	
Domestic Environmental Concerns (DEC)	**4.01**	**0.69**	0.731
How concerned are you about $PM_{2.5}$ concentrations in Bangkok city?	4.01	0.67	
How concerned are you about the shorter winter period in Thailand?	3.74	0.65	
How concerned are you about rising temperatures in Bangkok city in summer?	4.15	0.70	
How concerned are you about heavy floods occurring in the northeastern part of Thailand?	4.15	0.72	
Global Environmental Concerns (GEC)	**4.17**	**0.75**	0.871
How concerned are you about fires in the Amazon rainforest?	4.24	0.80	
How concerned are you about the death of aquatic animals due to waste in the oceans?	4.29	0.75	
How concerned are you about rising global average temperatures?	4.16	0.85	
How concerned are you about the dramatic decline of polar bears at the North Pole?	4.05	0.62	
How concerned are you about sea level rise?	4.13	0.75	
Environmental Responsibility (ER)	**3.82**	**0.53**	0.740
I am aware of environmental impacts before deciding to do something.	3.73	0.58	
I am willing to purchase greening products though I have to pay more.	3.48	0.55	
I am willing to act environmentally though I do not feel comfortable such as using public transportation, using stairs instead of elevator, etc.	3.69	0.50	
It is my responsibility to protect the environment.	4.10	0.50	

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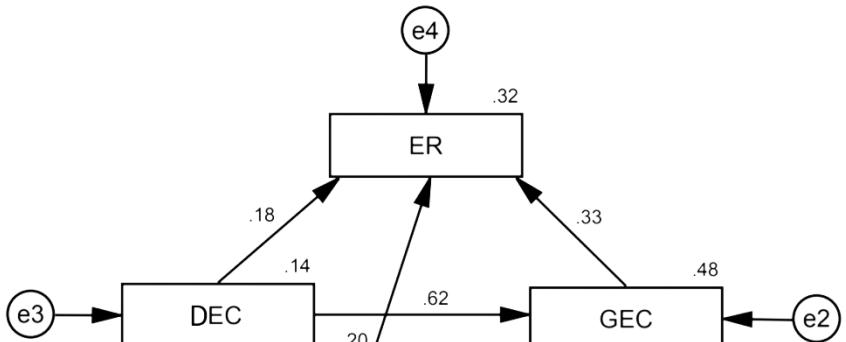
Variables	Mean	SD	Cronbach's α
I have tried to use things more efficiently in order to save natural resources such as energy saving behaviours, reuse and recycling behaviours, etc.	4.10	0.54	
Environmental Attitude (EA)	**3.55**	**0.56**	0.700
Ecosystems are vulnerable, and they can be easily deteriorated.	3.93	0.70	
The nature is strong, and it can cope with consequences of human development activities.	3.57	0.50	
Naturally, existence of plants and animals is for human's utilization.	3.55	0.50	
The earth is like a spaceship with finite room and resources.	4.07	0.58	
If things continue on their present course, we will soon experience a major ecological catastrophe.	2.84	0.55	
Humans have the right to modify the natural environment to suit their needs.	3.31	0.55	

Note: n = 863

5.2. Path Analysis

The proposed conceptual model (see Figure 1) was tested by performing a path analysis using IBM SPSS Amos 21. First, regarding the model assessment, the results suggested that there was no significant direct effect from environmental attitude (EA) on environmental responsibility (ER); therefore, the path from EA to ER was eliminated in order to achieve acceptability of the model. After eliminating the path from EA to ER, the results showed that the overall fit of the model to the data was acceptable (see Figure 2 and Table 5). The $\chi 2$ value was not significant ($\chi 2 = 1.991$, df = 2, probability level = 0.158). Therefore, there was a close fit between the model and the observed data. All other indexes presented in Table 4 were also statistically accepted. For example, the GFI value must be greater than 0.90 to indicate a close fit between the data and the proposed model. The results of the model assessment showed an acceptable GFI value of 0.999. The root mean square error of approximation (RMSEA) had a value of 0.034, which is less than 0.08; therefore, we can conclude that the model is a reasonable approximation of the data. Brown and Cudeck [80] suggested a suitable value of RMSEA, which can reveal reasonable errors of approximation should they be lower than 0.08. The results also showed a statistically acceptable value for the comparative fit index (CFI), which is used to indicate the discrepancy function adjusted for sample size. The value was 0.999, which indicates a close model fit. Hu and Bentler [81] proposed that an acceptable model fit should have a CFI value of 0.90 or greater. Additionally, the incremental fit index (IFI), used to indicate the possibility of having the worst model, had a value of 0.999, which is greater than 0.900, thus indicating the acceptability of the model. Another important index is the CMIN/DF, which indicates how well the data fits the model after dropping one or more paths. The results showed a CMIN/DF value of 1.991, which is considered acceptable [82]. Overall, it can be concluded that the data fits the model perfectly, and the proposed model is acceptable after eliminating the path from EA to ER.



(1)

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Figure 2. Estimated path analysis model of the effect of environmental knowledge, environmental attitude, and domestic and global environmental on environmental responsibility

Table 5. Goodness-of-Fit Indices.

Indices	Statistics	Accepted Value
GFI	0.999	>0.900
CFI	0.999	≥0.900
RMSEA	0.034	<0.08
CMIN/DF	1.991	<3
IFI	0.999	>0.900

Considering the effect of all variables on ER (see Table 6), the analysis results demonstrated a multiple correlations value of 0.32. This indicates that approximately 32% of the variance in ER can be accounted for by the linear combination of those variables. The results of the path analysis also showed that the predicted path from EK and EA to DEC and GEC, and from DEC and GEC to ER, was statistically significant. Among all variables, the standardized direct effect of GEC on ER was the largest at 0.328. The standardized direct effect of DEC on ER was 0.181, and the standardized direct effect of EA on ER was 0.161. The predicted path from EK to EA was also statistically significant, and the standardized direct effect was very small at 0.087. The predicted path from EK to DEC was statistically significant, and the standardized direct effect was 0.271. The predicted path from EK to GEC was statistically significant, and the standardized direct effect was 0.076. The effect of DEC on GEC was the strongest (0.618), compared to all paths.

Additionally, both DEC and GEC mediated the effect of EA on ER, and the effect of EK on ER. EK had the standardized indirect effect value of 0.141; whereas, EA had a value of 0.133. Considering the total indirect effect of EA on ER, it was found that the greatest value was generated from the indirect effect of EA on ER through DEC and GEC. Similarly, for the indirect effect of EK on ER, the greatest value was generated from the indirect effect of EA on ER through DEC and GEC. Most importantly, GEC mediated the effect of DEC on ER, and the standardized indirect effect value was the strongest at 0.203.

In total, it can be concluded that DEC had the highest total effect on ER, followed by EK, GEC and EA, respectively. However, GEC had the strongest direct effect on ER, and it also mediated the effect of DEC on ER, which had the highest value of indirect effect. EA had the least effect on ER, and no direct effect was found. EK was still found to be important as it had both a strong direct effect on ER, and it also had indirect effects on ER through DEC, GEC and EA (see Table 7).

Table 6. Parameter estimates path analysis.

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Paths			Estimate	S.E.	C.R.	β
Environmental Attitude	<---	Environmental Knowledge	.086	.034	2.572	.087*
Domestic Environmental Concerns	<---	Environmental Knowledge	.332	.039	8.554	.271**
Domestic Environmental Concerns	<---	Environmental Attitude	.289	.039	7.358	.233**
Global Environmental Concerns	<---	Environmental Attitude	.179	.034	5.196	.133**
Global Environmental Concerns	<---	Domestic Environmental Concerns	.675	.029	23.278	.618**
Global Environmental Concerns	<---	Environmental Knowledge	.101	.034	2.934	.076*
Environmental Responsibility	<---	Domestic Environmental Concerns	.138	.029	4.702	.181**
Environmental Responsibility	<---	Global Environmental Concerns	.229	.027	8.590	.328**
Environmental Responsibility	<---	Environmental Knowledge	.191	.027	6.929	.204**

* $p < 0.01$, ** $p < 0.001$

Table 7. Direct, indirect and total effects of exogenous variables on endogenous variables.

Exogenous Variables	Endogenous Variable	Direct Effect	Indirect Effect	Total Effect
Environmental Knowledge	Environmental Responsibility	0.204	0.141	0.345
Environmental Attitude	Environmental Responsibility	0.000	0.133	0.133
Domestic Environmental Concerns	Environmental Responsibility	0.181	0.203	0.384
Global Environmental Concerns	Environmental Responsibility	0.328	0.000	0.328

6. Discussion and Conclusions

This study first found that environmental attitude (EA) was very weak in predicting environmental responsibility (ER). Moreover, EA had no direct effect on students' ER. This finding could be supported by some previous studies, which found a poor power of EA in predicting pro-environmental behaviors and ER. Paço and Lavrador [40] also found that EA had a weak relationship with the environmental behaviors of students from the University of Beira Interior, Portugal. Similarly, Olli et al. [39] reported that environmental behaviors were weakly correlated with EA. Vermeir and Verbeke [41] indicated that EA, as a single variable, poorly explained people's engagement in PEBs and that more relevant variables should be included together in the analysis. According the VBN theory [26], EA had no direct effect on PEBs, but it has a significant effect on PEBs through environmental consciousness and a sense of moral obligation to protect the environment. Therefore, the current study's findings could be supported by the VBN theory; however, it should be indicated that the power of EA in affecting ER was still very weak as it showed an indirect effect on ER of only 0.133. Regarding this total indirect effect value, the greatest value was generated from the indirect effect of EA on ER through the combination of DEC and GEC. This result suggests that students with higher levels of positive environmental attitudes had constructed more environmental

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concerns. This, in turn, affected their sense of environmental responsibility. Widegren [67] also showed that acquiring EA over time could help increase an individual's EC, and Wu et al. [65], Lin and Huang [71], and Prakash and Pathak [72] stated that individuals' EC encourages them to construct a sense of responsibility to protect the environment, and this sense of responsibility guides them to act in an environmentally-friendly manner.

Regarding the role of environmental knowledge (EK), EK had the strongest effect on ER, including both direct and indirect effects. For the direct effect, it can be explained that EK could help individuals understand the qualifications and functions of environmental systems, the potential negative effects of human activities on nature, the severity of adverse consequences and the opportunities available to solve the problems. EK can enhance people's recognition of their important roles in solving or avoiding environmental problems; thus, EK could help enhance people's perceived moral responsibility to protect the environment. In addition, EK had an indirect effect on ER through domestic environmental concern (DEC), global environmental concern (GEC) and EA. The path analysis showed that the indirect effect of EK on ER through the combination of DEC and GEC was the strongest. Ünal et al. [51] and Slavoljub et al. [21] stated that EK can encourage people to construct environmental concerns and awareness for environmental problems, and these environmental concerns and awareness affect people's moral responsibility to protect the environment [65, 71, 72]. However, the novelty of this research is that encouraging people to acquire both concerns about domestic environmental problems and global environmental problems is the most powerful way to create a sense of environmental responsibility to protect the environment. Having both GEC and DEC could enable people to realize the severity of the problems and how each catastrophic environmental event can potentially cause adverse impacts on both the environment and human well-being. Most importantly, people could recognize the negative consequences of an unsustainable relationship between humans and nature, which can potentially cause problems worldwide. Thus, people with appropriate levels of environmental concerns can be aware of their roles in minimizing these problems. As stated by Abdul-Muhmin [64], the occurrence of environmental events that pose a threat to nature and interrupt the balance between humans and nature, both on the regional and international levels, appear to positively affect ecological and environmental concern.

When considering the role of DEC and GEC in creating students' environmental responsibility, the results demonstrated that GEC had the greatest direct effect. By seeing global environmental problems, such as the death of aquatic animals due to waste in the oceans, and fires in the Amazon rainforest, students might realize the seriousness of global environmental problems. Likewise, they might better understand that these issues can generate vast negative impacts, not only on people in the place where those problems exist, but also on people around the world. Consequently, this realization might influence a student's perception of the urgent need for environmental problem-solving measures. More interestingly, DEC was found to have a great indirect effect on ER through GEC. This result suggests that students having greater relative levels of DEC also have greater levels of GEC, and they exhibit higher levels of ER than those students reporting lower levels of DEC and GEC. This finding was probably due to the fact that all of the catastrophic environmental events had some connection, and most events represented adverse consequences of climate change happening both in Thailand and in other parts of the world. Moreover, students may realize that the global environment is just one ecological system. When the system is disrupted and destroyed, it could generate widespread negative impacts on humans and the environment all around the world.

Finally, this study has implications for the development of communication strategies. The results suggest that educating students about both global and domestic environmental events together could effectively help promote students' sense of environmental responsibility. Both global and domestic environmental concerns can also transfer students' environmental attitudes and environmental knowledge into a sense of responsibility to protect the environment. Therefore, all four elements should be promoted in learning and teaching activities. Additionally, it should be noted that communicating with students only about domestic catastrophic environmental events may have the least effect on their sense of environmental responsibility.

7. Limitations of the Study

There are some limitations which should be addressed. This study relied on self-reporting for measuring environmental knowledge. This study merely emphasized on the effect of environmental concerns, attitudes, and environmental knowledge on students' environmental responsibility; whereas, social relevant factors which may affect sense of responsibility were not included in this study. Further study which can include social factors such as social norms and social relations are recommended.

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