What Influences the Environmental Actions of College Students in Mainland China? Environmental Literacy as An Analytical Framework

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Abstract. As an important index for assessing the effect of environmental education, environmental literacy has become the value consensus of various countries for implementing environmental education. The level of environmental literacy and main factors influencing environmental action are always the main focus of research performed in the field of environmental education. In this work, the current environmental literacy of college students in mainland China is discussed and analyzed. The analysis is based on the predictive degrees of three groups of environmental literacy variables (knowledge, awareness, and skill) related to environmental action. A questionnaire survey was carried out involving college students in Shanghai Municipality, Anhui Province, and Guangxi Province. Students majoring in three subjects were sampled from these areas that have different levels of economic development, yielding a total of 1,890 valid samples. Our descriptive statistical and hierarchical regression analyses reveal that: (1) College students in mainland China are not environmentally active enough, only performing well in ecologically civilized behavior. However, while they do at times exhibit persuasion-induced behavior that influences others, they hardly take any civil actions that benefit other citizens and society as a whole. (2) The college students have a medium-sized level of environmental literacy. Among the three groups of variables (knowledge, awareness, and skill), they perform well in terms of awareness. (3) If the three groups of variables are used synchronously, then they can account for up to 44.8% of the students' environmental actions, at most. Our results show that environmental desire, behavioral intent, and civic participation skills are the important factors for predicting environmental action. Based on this, the research results can be used to provide important suggestions for improving the environmental education of college students.

Keywords: *Mainland China; college students; environmental education; environmental literacy; environmental action*

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1. Introduction

Since the 1950s, humankind has caused unprecedented damage to the ecological environment under the combined effect of exploding population levels, technological revolution, and excessive consumption. In turn, the subsequent issues of environmental pollution and various ecological crises have eventually undermined human security and welfare. A better understanding of the connection between human behavior and underlying

mechanisms responsible for environmental problems is clearly needed and so environmental education is gradually becoming of great interest among the international community.

The first formal discussion of environmental education dates back to an international conference on education that was hosted by Kiel University in Germany in 1965. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) and International Union for Conservation of Nature later discussed the concept of environmental education at a conference held in Nevada, USA, in 1970. In a United Nations conference on Human Environment held in 1972, the slogan "There is only one earth for humans" was proposed and the term "environmental education "formally defined. UNESCO and the United Nations Environment programme also held an international conference on environmental education and training in Tbilisi in 1977. They put forward the idea that the last decade of the 20th century should be designated as the decade for environmental education and suggested that the objective categories for environmental education should involve awareness, knowledge, attitude, skill, and participation. It was thought at the time that, eventually, citizens would either individually or collectively take action to solve existing and future environmental problems (UNESCO, 1978; Ahmad et al., 2019).

Environmental action, as referred to as responsible environmental behavior (REB), has always been believed to be the ultimate aim of environmental education (Hungerford & Volk, 1990; Roth, 1992). In the early work on environmental education, it was thought that a positive environmental attitude will be formed following an accumulation of environmental knowledge, and this would further lead to proper environmental behavior. However, an increasing volume of research has shown that increasing environmental knowledge by itself fails to effectively form environmental behavior (Hungerford& Volk,1990; Jensen & Schnack,1997; Pelletier, Tuson, Green-Demers, Noels & Beaton,1998). Therefore, the knowledge–attitude–behavior model has gradually been replaced with new environmental behavior models since the 1980s. Thus, many scholars have discussed environmental behavior from the perspective of psychology, society, life backgrounded. and subsequently proposed different predictive models for it. Examples include: environmental literacy proposed by Hungerford and Tomera (1985); the REB model proposed by Hines, Hungerford, and Tomera (1985), and the environmental citizenship behavior model put forward by Hungerford and Volk (1990).

The aim of environmental education is to cultivate citizens with an ethos of environmental literacy. Some important indices (such as the environmental education centered on science and technology, sustainable development, and improvement of the environmental literacy of citizens), for assessing the effect of environmental education, have become the value consensus of various countries in developing environmental education.

The National Environmental Education & Training Foundation in the US a carried out a nationwide survey on the environmental literacy of adults aged over 18 years from 1997 to 2000 (Coyle, 2005). A survey of the environmental literacy of college students was performed in Turkey in 2006 wherein the effects of environmental knowledge, attitude, concern, and sense of environmental responsibility on their outdoor activities were discussed (Teksoz,Sahin, & Tekkaya-Oztekin, 2012). Scholars in New Zealandexplored the environmental literacy of their college students in 2012 (Shephard *et al.*, 2014). McBeth *et al.* (2014) carried out a national project in the USA during the period 2008–14 that concentrated on environmental literacy and designed measurement indices to gauge the environmental literacy of middle-school students. This work has since become an important guide for assessing environmental literacy.

In mainland China, the theoretical research carried out on environmental literacy is generally intermingled with research on environmental ethics, environmental awareness. Environmental literacy first started to be investigated in the 1990s. In 1994, the results of a survey on residents' environmental awareness carried out in Beijing and Shanghai by the China National Research Center for Science &Technology showed that populations with different levels of education differ greatly in their environmental awareness. The results of a similar survey focusing on elementary-and middle-school students in China conducted by China Environment Newsin 1994 revealed that urban students performed much better than rural students when it came to environmental awareness.

In 1995, a national survey was carried out on environmental awareness by the China Environmental Protection

Foundation and Renmin University of China which mainly involved the public's awareness of environmental protection, their cognitive level of environmental problems, and their participation in environmental protection. The results of a report published by the China State Environmental Protection Administration and Ministry of Education of PRC in 1998 (*Report on National Public Environmental Awareness*) suggest that education level is significantly and directly related to environmental awareness. The results of other research carried out by researchers in Beijing Forestry University in 2005 (*Investigation on Environmental Awareness of College Students in Beijing*) indicate that college students are in possession of a certain knowledge of environmental protection and often show concern about environmental events. However, they hardly ever participated in actual environmental events themselves (Liu and Lv, 2005).

In October, 2013, China published the document *Environment and Health Literacy of Chinese Citizens*, which provided a model for learning basic information about environment and health literacy. It also defined certain key points for carrying out environmental education and health popularization in the future and constitutes a fundamental reference work for assessing the environmental and health literacy of the general public. This shows that research on environmental and health literacy in China has kept pace with the times. Moreover, many scholars have suggested establishing and improving laws and mechanisms to facilitate environmental education, guarantee the healthy implementation of environmental education, and promote improved environmental literacy in students at different learning stages. The communist party and government in China have always been dedicated to building an ecological and beautiful nation. College students are a new force that can be exploited to accomplish this. Therefore, in this study, we mainly investigate the current level of environmental literacy in Chinese college students and try to discover what factors affect their environmental actions.

2. Literature review

Charles Roth first proposed the concept of environmental literacy in 1968. It was used to refer to an ability to perceive and describe an environmental system, based on which one can take appropriate action to maintain, preserve, and promote the soundness of the system (Disinger & Roth, 1992). Environmental literacy is deemed to progress in four stages: cognition, concern, understanding, and action. Harvey (1977) proposed that environmental literacy is the expected achievement of environmental education and partitioned it into three levels: environmental knowledge, environmental competence, and environmental concern. Hungerford et al. (1985) proposed that the citizens with the ability to engage in environmental behavior are actually those equipped with environmental literacy. They believed that environmental literacy consists of several parts: ecological concepts, environmental sensitivity, knowledge of issues, beliefs, values, attitude, and environmental behavior strategy. Cultivation of environmental literacy can promote environmental action (Roth, 1992; Wilke, 1995) and further highlight the value of environmental education (Roth, 1992). Therefore, researchers tend to explore the effect of environmental education by investigating environmental literacy.

During the period 1997–2000, the USA's National Environmental Education & Training Foundation surveyed the environmental knowledge, attitude, skill, and action of American adults aged over 18 years. The results revealed that 80% of the respondents suffered from remarkable environmental misunderstandings. Only 12% were basically aware of energy issues, while a mere 10% took action to save energy. Half of the respondents possibly recycled their waste, while only 10% avoided producing waste in the first place by decreasing their consumption. In terms of environmental action, 85% of the respondents were used to turning off lights and other powered devices when leaving buildings; 61% tried to save water, and 59% possibly recycled newspapers, iron, aluminum tanks, and glass. Environmental knowledge was also found to vary with age, gender, and location (Coyle, 2005).

In 2001, Hodgkinson and Innes in Australia surveyed the environmental attitudes of 399 freshmen studying different subjects at Murdoch University in Perth (Australia). Among the ten subjects surveyed, the students majoring in environmental studies, biology, and sociology had high scores in environmental attitude, followed by students majoring in veterinary science, psychology, and anthropology. Students studying law, business, and computer science performed poorly. These results are similar to those found in several other previous studies.

However, the research also showed that students are not willing to sacrifice economic benefits for the sake of the environment. This is quite enlightening and has had important ramifications for research on environmental education. That is, it is generally considered to be essential to give some consideration to the political and economic attitudes of such respondents (Hodgkinson and Innes, 2001).

The environmental literacy of college students was also explored by Turkish scholars in 2006. In this study, the researchers concentrated on the environmental knowledge, attitude, concern, sense of responsibility, and outdoor activity of the respondents. The interview results from the 1,345 college students revealed that environmental knowledge can be used to predict the environmental attitude, environmental concern, and sense of environmental responsibility of the students. On the other hand, it showed a negative correlation with outdoor leisure activity. Environmental attitude can affect the sense of environmental responsibility, whereas, environmental concern will influence environmental attitude and outdoor leisure activity (Teksoz et al., 2012).

In 2012, experts in New Zealand also investigated the environmental literacy of college students (considering their environmental knowledge, emotion, and ability). These workers intensively compared the differences in the backgrounds and environmental literacy of the college students. The results indicated that there were no differences in terms of environmental knowledge and emotion between students of different gender. However, college students studying different specialties did present a difference in environmental knowledge and ability (Shephard et al., 2014).

By exploring the relationships between environmental attitude, knowledge, intention, and behavior of college students in the USA, Levine and Strube (2012) found that environmental intention and knowledge could be used to predict environmental behavior accurately. No significant relationship was found between environmental knowledge and environmental attitude. However, determined attitude was found to be closely related to environmental intention, which is regarded as an intermediate variable between determined attitude and environmental behavior. Karnowski and Zhu developed the Undergraduate Students Environmental Literacy Instrument (USELI) as a scale to gauge the environmental literacy of Chinese college students and surveyed the degree of influence of several variables including awareness, skill, and knowledge on the environmental actions of the students (Zhu, 2015).

The investigation of environmental literacy in mainland China first started in the 1990s while targeted research on the environmental literacy of its college students can be traced back to the beginning of this century. In 2003, Chen and Lou working at the Northeastern University in Shenyang (in Liaoning Province, China) established an index system for evaluating environmental literacy consisting of three stages and four layers (Chen and Lou, 2003). Using this as a basis, they conducted empirical research by sampling freshmen in two schools (literature and science) using closed questionnaire. The results indicated that the respondents performed comprehensively well in terms of environmental literacy. Zeng (2004) working at the Nanjing Normal University in Jiangsu Province also constructed an index system for evaluating the environmental literacy of college students in normal universities. A questionnaire-based survey was conducted by separately choosing classes in 23 specialties across 13 schools of a certain normal university in Jiangsu Province.

Liu and Lyu (2005), applied quota sampling (a nonrandom sampling method) to carry out a questionnaire survey on college students studying various subjects in seven chosen universities in Beijing. These subjects included finance and economics, military, science and engineering, forestry farming, and medicine. The questionnaire mainly sought to discover the acquaintance the college students had had with environmental knowledge, their opinions on related environmental problems, and their participation in environmental protection events. The findings revealed that the college students had acquired affair amount of environmental knowledge and often paid attention to environmental events – however, they hardly ever participated in activities aimed at environmental protection.

In 2007, Bai published a paper (Survey and analysis of students' environmental literacy in normal universities) that was based on three-dimensional model of factors (Bai, 2007). That is, assessment was carried out based on their environmental knowledge, emotions, and behaviors. The results revealed that the students often paid attention to environmental events and thus showed a certain sense of environmental responsibility. However, the environmental

awareness they exhibited was, to a great extent, formed in direct consideration of their own benefits, rather than based on strategic thought and the need for sustainable development. Therefore, the college students presented relatively weak environmental emotion and ethics. The environmental protection activity that students actually took part in was found to breather limited (simple voluntary tree planting, recycling of waste batteries, signing petitions and other propaganda for environmental protection, and waste sorting and recycling).

The summary of the research given above shows that much of it merely explores the level of environmental literacy in certain populations. That is, the majority of the research fails to discuss the degrees to which the various environmental literacy-related factors influence the citizens' environmental actions. In this study, the current situation in mainland China is reassessed by surveying the environmental literacy of a collection of college students. We then use the results to investigate the predictive powers and degrees of influence of three groups of variables (awareness, skill, and knowledge) to provide a better understanding of the effect of environmental literacy on environmental action.

3. Research methods

3.1 Research framework and research hypotheses

According to the environmental literacy model proposed by Hungerford and Tomera (1985), the REB model by Hines et al. (1987), and the model for environmental citizenship behavior by Hungerford and Volk (1990), the environmental-literacy-related factors of interest can be divided into three classes. These are: knowledge variables (ecological and environmental science knowledge), awareness variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention) and skill variables (ability to analyze environmental issues and civic participation skills). The effects of these environmental-literacy-related factors on environmental action are to be discussed and we do this by establishing an appropriate framework, as shown in *Fig. 1*.

In this work, the correlations between the categorical and dependent variables are explored using Pearson correlation tests, t-tests, and F-tests. The predictive powers of the independent variables with respect to the dependent variables is analyzed by employing hierarchical regression. Hence, we start our analysis by clearly formulating the research problems and hypotheses to be tested.

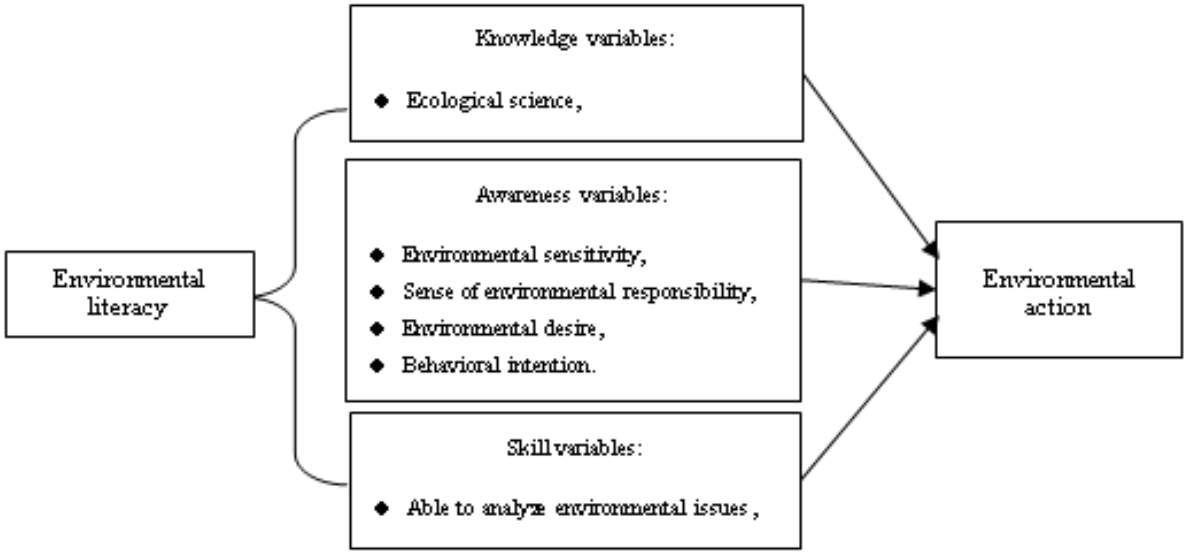

Figure 1. *Research framework.*

3.1.1 Research problems

The issues we wish to address are:

(1) What is the current level of environmental literacy of college students in mainland China? (In terms of

environmental sensitivity, sense of environmental responsibility, environmental desire, behavioral intention, environmental skill, knowledge, and action.)

(2) What are the relationships between the emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention) and environmental action of college students in mainland China?

(3) What are the relationships between the emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention) and knowledge variables (knowledge of ecological and environmental science) and environmental actions of college students in mainland China?

(4) What are the relationships between the emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention), knowledge variables (knowledge of ecological and environmental science), and skill variables (ability to analyze environmental issues and civic participation skills) and environmental actions of college students in mainland China?

3.1.2 Research hypotheses

The hypotheses to test are:

(1) The emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention) of college students in mainland China can be used as important indicators to predict their environmental actions.

(2) The emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention) and knowledge variables (knowledge of ecological and environmental science) of college students in mainland China can be used as significant indicators for predicting their environmental actions.

(3) The emotion variables (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention), knowledge variables (knowledge of ecological and environmental science), and skill variables (ability to analyze environmental issues and civic participation skills) of college students in mainland China can be employed as significant indicators for predicting their environmental actions.

3.2 Research objects and investigation methods

Students in several universities in mainland China were selected to use as study objects. In order to show representativeness, questionnaires were sent to different universities located in Shanghai Municipality, Anhui Province, and Guangxi Province, as these represent areas of China that are developed, moderately developed, and underdeveloped, respectively. Moreover, based on their discipline classification, the students were subordinated into three different disciplines: humanities and social science, business management, and technology and natural science. By combining quota sampling with random sampling, a total of 2,200 questionnaires were distributed.

In order to collect the representative opinions of college students from the different areas of China, the teachers in the universities were entrusted to distribute the questionnaires and perform further investigations. Eventually, 1,952 questionnaires were sent back to us. To ensure that freshmen, sophomores, juniors, and seniors separately accounted for 25.3%, 24.8%, 25.2% and 24.7% of the total number, 478, 469, 476, and 467 questionnaires from freshmen, sophomores, juniors, and seniors were separately selected from the sets of collected samples, respectively. Thus, a total of 1,890 valid samples were obtained.

The final valid set of samples consisted of 968 questionnaires from males and 922 from females (51.2% and 48.8% of the total, respectively). The number of questionnaires completed by college students in Shanghai (developed area), Anhui Province (moderately developed area), and Guangxi Province (underdeveloped area) accounted for 32.6%, 35.1%, and 32.3% of the total, respectively. The number of questionnaires completed by college students studying humanities and social science, business management, and technology and natural science accounted for 28.7%, 21.1%, and 50.2% of the total, respectively. College students coming from rural, urban, and other areas corresponded to 51.6%, 46.9%, and 1.5%, respectively. The details of the respondents are shown in *Table 1*.

Table 1. *Background information on the college students.*

Variable	Class	Sample size	Proportion (%)
Gender	Male	968	51.2
	Female	922	48.8
Grade	Freshman	478	25.3
	Sophomore	468	24.8
	Junior	476	25.2
	Senior	467	24.7
University location	Shanghai (developed)	616	32.6
	Anhui Province (moderately developed)	663	35.1
	Guangxi Province (underdeveloped)	611	32.3
Discipline classification	Humanities and social science	542	28.7
	Business management	399	21.1
	Technology and natural science	949	50.2
Birthplace of students	Rural area	975	51.6
	Urban area	886	46.9
	Others	29	1.5

3.3 Research tools

The purpose of this study is to become acquainted with the environmental literacy and activities of college students in mainland China. This was carried out through the use of questionnaires, which consisted of five parts: Part 1 – three questions about the students' knowledge of ecological and environmental science; Part 2 – four questions concerning environmental sensitivity, sense of environmental responsibility, and environmental desire, and three questions about behavioral intent; Part 3 – four questions about the students' ability to analyze environmental issues and their civic participation skills; Part 4 – 12 questions about environmental actions; and Part 5 – six questions about the students' personal backgrounds.

Five-point Likert scale were used in Parts 1–4 in which points 1–5 represent an increase from 'none' to 'frequent appearance' (or from 'strong disagreement' to 'strong agreement'). The question items about knowledge in Part 1 and skills in Part 4 were informed by the results detailed in the study by Zhu (2015) in which interviewees self-assessed their levels of related knowledge and skills. The other content of the questionnaire was mainly based on the USELI scale developed by Karnowski and Zhu (Zhu, 2015) and the environmental literacy scale developed by Roth (1998).

After completing the design of the questionnaire, the project group invited six experts (who are actively engaged in environmental education in universities in mainland China) to examine and revise the contents of the questionnaire. In this way, a pre-test questionnaire was obtained. Pre-test questionnaires were then sent to 216 students from three classes in a certain normal university of China to perform pre-testing. The returned questionnaires were used to implement further revisions to yield the formal questionnaires used in the main body of this work. The Cronbach's α coefficients derived for the students' ecological and environmental science knowledge are 0.89 and 0.86, respectively. Cronbach's α coefficients for environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention are 0.83, 0.81, 0.85, and 0.86, respectively. Cronbach's α coefficients for ability to analyze environmental issues and civic participation skills are 0.90 and 0.91,

respectively. The Cronbach's α coefficient for environmental action is 0.89. Thus, they all reach favorable validity.

4. Results and discussion

4.1Current environmental literacy of college students

4.1.1Knowledge variables

The knowledge variables considered relate to ecology and environmental science. There were three questions about ecological science which yielded a mean score of 3.28 (near the middle level of the scale), as shown in *Table 2*. The college students assessed themselves to be well acquainted with knowledge of the ecological system (3.52) and atmospheric science (3.37).

Three questions were also set about environmental science, producing a mean score of 3.51. *Table 2* shows that the students believed themselves to be knowledgeable in environmental pollution and in environmental and human health.

Table 2. *Analysis of knowledge variables.*

Variable	Mean	Standard deviation	Rank
Ecological science:	3.28	0.68	
The population (*e.g.* the changing population size)	2.95	0.86	3
Ecological systems (*e.g.* energy flow and matter cycle)	3.52	0.89	1
Atmospheric science (*e.g.* formation and evolution of the atmosphere and atmospheric motion)	3.37	0.82	2
Environmental science:	3.51	0.65	
Natural resources (*e.g.* renewable vs. non-renewable energy)	3.17	0.81	3
Environmental pollution (*e.g.* haze, water and atmospheric pollution, *etc.*)	3.58	0.76	2
Environmental and human health (*e.g.* relationship between pollution and disease)	3.79	0.79	1
Environmental knowledge	3.40	0.62	

4.1.2Awareness variables

The awareness variables considered in the study include environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention. Four questions were set on environmental sensitivity, producing a mean score of 3.47 (middle level in the scale), as shown in *Table 3*. Among these, two of the questions: "…the extent that I love and care about nature "and "…the extent that I'm concerned about humans damaging nature produced the highest scores of 3.89 and 3.65, respectively.

There were four question items related to sense of environmental responsibility and the mean score obtained for these items is 3.60 (at a middle level). Moreover, two of these items: "I recognize I'm responsible for changing my consumption habits to protect the environment (e.g. shop less and purchase energy-saving electric appliances)" (3.89) and "I recognize people should take responsibility for solving environmental problems" (3.73) elicited strong responsibility scores. Four question items were also designed to test environmental desire, producing a mean score of 3.50 (at a middle level). The two questions items: "Environmentally destructive behavior will inspire me to take action to protect the environment" (3.79) and "I am willing to learn from those who strive for China's environmental protection" (3.63) produced the highest scores.

There were three question items on behavioral intention, giving a mean score of 3.91 (at a middle level). The two items : "I will consciously protect the environment in daily life(pursue low-carbon environmental behavior,

including saving water and electricity, and use traffic modes that insignificantly affect the environment)" (4.17) and "I am willing to prevent and solve environmental problems by changing my consumption behavior" (3.86) indicate that the college students in mainland China possess a strong level of behavioral intent with respect to these two items.

Table 3. *Analysis of awareness variables.*

Variable	Mean	Standard deviation	Rank
Environmental sensitivity:	3.47	0.65	
Extent to which I love and care about nature	3.89	0.81	1
Frequency that I participate in natural leisure activities	2.98	0.93	4
Extent to which I'm concerned humans are damaging nature	3.65	0.76	2
Extent to which I care about air and water pollution	3.37	0.75	3
Sense of environmental responsibility:	3.60	0.67	
I recognize I'm responsible for solving environmental problems	3.52	0.82	3
I recognize people should take responsibility for solving environmental problems	3.73	0.86	2
I recognize I'm responsible for changing my consumption habits to protect the environment	3.89	0.84	1
I recognize that I should take responsibility for participating in civic action to solve environmental problems	3.26	0.96	4
Environmental desire:	3.50	0.68	
I have the power within me to protect the environment	3.23	0.86	4
Environmentally destructive behavior will inspire me to take action to protect the environment	3.79	0.90	1
I will persist in trying to protect the environment even though I'm likely to suffer frustration as a result	3.35	0.82	3
I am willing to learn from those who strive for China's environmental protection	3.63	0.89	2
Behavioral intention:	3.91	0.60	
I will consciously protect the environment in daily life	4.17	0.71	1
I am willing to prevent and solve environmental problems by changing my consumption behavior	3.86	0.71	2
I am willing to try my best to persuade others to prevent and solve environmental problems	3.70	0.71	3
Environmental awareness	3.62	0.58	

4.1.3Skill variables

The skill variables section tested the ability of the students to analyze environmental issues and also asked about their civic participation skills. A total of four questions were used to test their analysis skills, producing a mean score of 3.25 (*Table 4*). The student's responses were most favorable for the questions relating to them being: "…capable of collecting resources related to certain environmental problems or issues (e.g. using libraries, networks, or interviews)" (3.52) and able to"…identify certain local environmental problems or issues" (3.27).

There were also four questions about civic participation skills, giving a mean score of 2.85. The college students in mainland China thought that they are most skillful in the following two aspects: "I'm capable of implementing a certain environmental protection plan using existing protection schemes and supporting resources" (3.02) and "I'm

able to evaluate the benefits of a certain environmental protection plan" (2.97).

Overall, the college students in mainland China declared that their ability to analyze environmental issues (3.25) is slightly better than their civic participation skills (2.85).

Table 4. *Analysis of skill variables.*

Variable	Mean	Standard deviation	Rank
Skills relating to analyzing environmental issues:	3.25	0.71	
Icon identify certain local environmental problems or issues	3.27	0.79	2
I'm capable of collecting resources related to certain environmental problems or issues	3.52	0.89	1
I'm able to investigate and analyze certain environmental problems or issues	3.01	0.90	4
I can provide suggestions based on the research results of certain environmental problems or issues	3.19	0.89	3
Civic participation skills:	2.85	0.75	
Icon draft a targeted environmental protection plan	2.84	0.86	3
I'm capable of seeking resources (*e.g.* manpower and materials) to support certain environmental protection plan	2.57	0.89	4
I'm capable of implementing a certain environmental protection plan using existing protection schemes and supporting resources	3.02	0.87	1
I'm able to evaluate the benefits of a certain environmental protection plan	2.97	0.89	2
Environmental skill	3.05	0.70	

4.1.4Environmental action

The environmental actions section contained questions relating to ecologically-civilized behavior, persuasive actions, and civic actions. A total of five questions were designed to test their ecologically-civilized behavior, yielding a mean score of 3.95, as shown in *Table 5*. Of these, "Saving resources" (4.32) and "Being kind to wild animals" (4.12) were the most frequently implemented forms of behavior by the college students.

Three questions were set about persuasive actions, giving a mean score of 3.02. The persuasive action implemented most frequently by the college students is "I have encouraged others to take ecologically-civilized behavior" (3.34).

A total of four questions on civic actions were designed, producing a mean score of 1.79. In terms of civic action, the college students performed best in the following two aspects: "I have been involved with environmental protection organizations" (2.51) and "I have turned to the government to help solve environmental problems (using letters, e-mails, phone calls, etc.)" (1.83).

Comparing the results obtained for the three types of environmental action, it can be seen that the college students in mainland China do well in ecologically-civilized behavior and anti-consumptive action but do less well when it comes talking civic and persuasive actions.

Table 5. Analysis of environmental actions.

Variable	Mean	Standard deviation	Rank
Ecologically-civilized behavior:	4.07	0.60	

Saving resources	4.32	0.73	1
Actively performing garbage classification	3.97	0.72	4
Being kind to wild animals and plants	4.12	0.85	2
Actively do not use disposables	3.86	0.89	5
Use low-carbon modes of travel	4.01	1.00	3
Persuasive actions:	3.02	0.67	
I have tried to persuade others to stop damaging the environment	3.14	0.98	2
I have encouraged others to adopt ecologically-civilized behavior	3.34	1.00	1
I have actively propagandized environmental protection to others	2.57	1.05	3
Civic actions:	1.79	0.89	
I have turned to the government to help solve environmental problems (using letters, e-mails, phone calls, *etc*)	1.83	1.00	4
I have participated in hearings about environmental protection	1.46	0.98	1
I have been involved with environmental protection organizations	2.51	1.12	3
I have reported illegal acts related to environmental protection	1.35	0.99	2
Environmental actions	2.96	0.50	

4.2 Important predictors influencing the environmental actions of college students

4.2.1Relevance of knowledge, awareness, and skill variables to environmental actions

A correlation analysis was carried out using nine variables involving knowledge (knowledge of ecological and environmental science), awareness (environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention), skill (skill of surveying and evaluating environmental issues and civic participation skill) and environmental action, as shown in *Table 6*.

The results show that there are significant correlations among the nine variables.

Table 6. *Correlation table for knowledge, awareness, and skill variables and environmental action.*

	1	2	3	4	5	6	7	8	9
Environmental action	1.00								
Ecological science knowledge	0.32***	1.00							
Environmental science knowledge	0.36***	0.51***	1.00						
Environmental sensitivity	0.49***	0.46***	0.45***	1.00					
Sense of environmental responsibility	0.48***	0.62***	0.67***	0.75***	1.00				
Environmental desire	0.56***	0.63***	0.71***	0.73***	0.79***	1.00			
Behavioral intention	0.48***	0.42***	0.51***	0.58***	0.69***	0.71***	1.00		
Ability to analyze environmental issues	0.53***	0.51***	0.43***	0.49***	0.38**	0.48***	0.46***	1.00	
Civic participation skills	0.57***	0.48***	0.42***	0.47***	0.34***	0.41***	0.41***	0.78***	1.00

Note: * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

4.2.2 Important predictors influencing environmental action

Hierarchical regression analysis was conducted to evaluate the predictive powers of the knowledge, awareness, and skill variables with respect to environmental action. Three models were considered.

In Model 1, regression analysis was performed between the awareness variables and environmental action; the results are shown in *Table 7*. It can be seen from the table that the R2value obtained for the model is 0.37 and the adjusted value is also 0.37. This means that the awareness variables can significantly influence environmental action and their explanatory power is 37.2% ($F = 110.04$, $p<0.001$). Except for sense of environmental responsibility, which did not reach an appropriate level of significance, the other awareness variables (environmental sensitivity, environmental desire, and behavioral intention) all exhibit a significant effect on environmental action. Therefore, hypothesis 1 is partly accepted. Environmental desire ($\beta = 0.28$) and behavioral intention ($\beta = 0.22$) present the greatest predictive power for environmental action.

In Model 2, regression analysis was performed using knowledge and awareness variables and environmental action. It can be seen from *Table 7* that theR2value for Model 2 is 0.37 and the adjusted R2value reaches 0.38. This indicates that the knowledge and awareness variables significantly influence the students' environmental actions, within explanatory power of 38.1% ($F = 75.98$, $p<0.001$). Knowledge of ecological science exhibits a significant effect ($\beta = 0.10$) while knowledge of environmental science has an insignificant effect ($\beta = 0.05$). Thus, hypothesis 2 is partly confirmed.

In Model 3, regression analysis was carried out using knowledge, awareness, and skill variables and environmental action. As shown in *Table 7*, theR2value using Model 3 is 0.46 and the adjusted R2value is also 0.46. Hence, the knowledge, awareness, and skill variables all have significant effects on environmental action, their explanatory power amounting to 44.8% ($F = 79.15$, $p<0.001$). Furthermore, civic participation skills have a significant effect ($\beta = 0.30$), while the ability to analyze environmental issues has an insignificant effect ($\beta = 0.05$), on environmental action. Therefore, hypothesis 3 is partly accepted.

Table 7. *Hierarchical regression analysis of the variables affecting environmental action.*

Predictive variable	Model 1: Awareness variables			Model 2: Awareness and knowledge variables			Model 3: Knowledge, awareness, and skill variables		
	β	*t*	*p*	*β*	*t*	*p*	*β*	*t*	*p*
Ecological science knowledge				0.10	2.43	0.02	0.02	0.70	0.47
Environmental science knowledge				0.05	1.12	0.26	0.01	0.18	0.89
Environmental sensitivity	0.17	4.91	0.00	0.10	2.54	0.01	0.06	1.37	0.16
Sense of environmental responsibility	0.09	1.74	0.08	0.09	1.93	0.04	0.09	1.81	0.06
Environmental desire	0.28	5.59	0.00	0.25	5.36	0.00	0.15	3.75	0.00
Behavioral intention	0.22	6.51	0.00	0.22	6.24	0.00	0.21	6.10	0.00
Ability to analyze environmental issues							0.05	0.97	0.32
Civic participation skill							0.30	6.93	0.00

R^2	0.37	0.37	0.46
Adj R^2	0.37	0.38	0.46
F	110.04***	75.98***	79.15
ΔR^2	0.37	0.01	0.09
ΔF	110.04***	7.48***	54.07***

Note: * $p<0.05$; ** $p<0.01$; *** $p<0.001$.

4.2.3Discussion

In terms of awareness variables, the college students in mainland China performed the best in behavioral intention and their sense of environmental responsibility (*Table 3*). This suggests that they prefer to undertake environmental protection behavior in their daily lives and are willing to prevent and solve environmental problems by adjusting their consumption behavior. The students agree that they are "…responsible for solving environmental problems" and "…take responsibility for changing their consumption habits to solve environmental problems".

In terms of knowledge variables, the college students presented level of knowledge above the middle level and they are slightly more acquainted with environmental science than ecological science (*Table 2*). They are equipped with an abundant knowledge of environmental pollution.

In terms of skill variables, the college students showed a middle level in their ability to analyze environmental issues and in their civic participation skills. Compared to each other, they mastered skills related to analyzing environmental issues better than they did skills related to civic participation (*Table 4*). As for environmental action, the students frequently behaved in an ecologically-civilized manner and took action to reduce their consumption. However, they hardly engaged themselves in persuasive and civic action to influence others in the public interest.

In the first stage of the hierarchical analysis (*Table 7*), regression analysis was only performed between the awareness variables and environmental action. It was found that three variables – environmental sensitivity, environmental desire, and behavioral intention –exhibit a significant effect, producing an explanatory power of 37.2%. Environmental desire and behavioral intention had the largest predictive power. After the second stage of the analysis (adding in knowledge variables), the explanatory power reached 38.1%. However, only knowledge of ecological science had a significant effect. At the same time, the predictive powers of environmental sensitivity, environmental desire, and behavioral intention slightly declined, while that related to sense of environmental responsibility rose. After the third stage (adding in the skill variables), the explanatory power increased to 44.8%. However, only the effect of civic participation skill is significant while those of environmental sensitivity and knowledge of ecological science became insignificant.

When the awareness, knowledge, and skill variables are used synchronously, only environmental desire, behavioral intention, and civic participation skill have significant predictive powers. Moreover, civic participation skill and behavioral intention are the two factors that show the strongest predictive power with respect to environmental action.

The above results indicate that three variables (environmental sensitivity, environmental desire, and behavioral intention) significantly influence environmental action when just the effects of awareness variables are considered. With the addition of knowledge variables, it can be seen that knowledge of ecological science has a strong influence on environmental action and the influence of the three awareness variables is weakened. Finally, after adding in the skill variables in the third stage, civic participation skill becomes an important influencing factor and the influences of all the awareness and knowledge variables are reduced.

The above results are similar to those previously obtained by Zhu (2015) who also found that environmental sensitivity, behavioral intention, and civic participation skill are the three most important factors. However, in this study, knowledge of ecological science is found to be an influencing factor. This result differs from the work of Zhu (2015) who found that having a knowledge of ecological and environmental issues did not influence the students'

environmental action.

5. Conclusions and suggestions

5.1 Conclusions

5.1.1Suggestion on Active environmental actions of college students

Cultivating the REB of citizens is an important target of environmental education. The college students investigated have all received environmental education in schools (at different learning stages) but they only performed at a middle level in terms of comprehensive environmental action. They only implement certain ecologically-civilized behavior frequently (e.g. saving resources, actively avoiding the use of disposables, and adopting low-carbon modes of travel). They will sometimes engage in persuasive behavior to influence others (e.g. persuading others to stop destroying the environment) and rarely take civic action that benefits others and society (e.g. joining hearings aimed at environmental protection, reporting illegal acts that damage the environment, etc.).

Overall, it seems that the college students in mainland China usually undertake ecologically-civilized behavior in their environmental action but they hardly go in for more actively persuasive and civic action.

5.1.2The level of environmental literacy of the college students

The environmental literacy surveyed in this study involves three groups of variables, i.e. knowledge, awareness, and skill, in which the knowledge variables correspond to knowledge of ecological and environmental science. Our results for the college students yielded a score for the knowledge variables of 3.40, which is at the middle level in the five-point scale.

The awareness variables considered relate to environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intention. The resulting average score obtained for these awareness variables is 3.62, at the middle level in the five-point scale. The skill variables (ability to analyze environmental issues and civic participation skills) scored 3.05, only just reaching the middle level in the five-point scale. Thus, these comprehensive research results suggest that the environmental literacy of the college students in mainland China is at a middle level. In general, citizens are not likely to undertake relatively active environmental action unless they present a high level of environmental literacy.

5.1.3 Important predictors influencing the environmental action of college students

Our results imply that if the knowledge, awareness, and skill variables are considered synchronously, they have an explanatory power for environmental action that can be up to 44.8%. When only awareness variables are used, environmental sensitivity, environmental desire, and behavioral intention are the predictors influencing environmental action. If knowledge and awareness variables are taken synchronously, then environmental sensitivity, environmental desire, behavioral intention, and knowledge of ecological science are the important predictors. However, when knowledge, awareness, and skill variables are used synchronously, environmental desire, behavioral intention, and civic participation skills are the important predictors. In terms of level of predictive power, these variables are ranked: civic participation skill, behavioral intention, and environmental desire in descending order of importance.

It can thus be seen that it is important to improve the civic participation skills of the college students, strengthen their willingness to become engaged in environmental protection, and enhance their optimism for sustainable development of the environment. If this can be done, then the college students can be expected to undertake more active environmental action.

5.2 Suggestions

5.2.1Suggestions for improving the environmental education of college students

The objective of the environmental education provided to college students in mainland China should be shifted and less attention need to pay to increasing environmental knowledge and more to promoting active environmental action. To this end, the environmental education in China's universities needs to place more emphasis on cultivating

students' environmental sensitivity, sense of environmental responsibility, environmental desire, and behavioral intent.

As an example, it is suggested that the students visit different environments (healthy and damaged) during social practice education to establish their awareness of environmental concern, and strengthen the students' willingness to undertake active environmental action. More importantly, it is essential to cultivate their civic participation skills. For example, they could be taught to draft environmental protection plans and target a specific area locally. Following this up, they should seek the related supporting resources required (manpower and material) brighter plan into fruition. This would clearly help to solve local environmental problems at the same time.

Considering that there are no specific courses pertaining to environmental education currently set in mainland China, it is necessary to devise courses related to ecological civilization for students in universities and elementary and middle schools. This should drive the implementation of more voluntary environmental action. Most importantly, as there Isa lack of legislation for environmental education at the state level, the level of environmental education in China is improving relatively slowly. This is in stark contrast to other countries that have legislated to take the lead in environmental education. The call for environmental education legislation in China is growing steadily among the general public, and more far-sighted people are going around essentially shouting for that situation to change. Hence, we suggest that environmental education legislation should be included in the next legislative plan.

5.2.2 Suggestions for strengthening the environmental literacy of college students

The factors promoting environmental action are quite complex. Our study investigated the environmental literacy of college students in mainland China and the factors influencing their environmental action. It reveals that environmental sensitivity, sense of environmental responsibility, environmental desire, behavioral intention, knowledge of ecological science, and civic participation skills are important predictors but their total explanatory power is only 44.8%. This means that there are other factors, possibly vary many, that remain to be elucidated. Scholars who explore the environmental literacy and environmental education of college students in the future are therefore recommended to consider adding other variables, e.g. social mentality and individual development history, and then reassessing the total explanatory power once more. In terms of measurement tools for environmental literacy, the question items we used about knowledge and skill were evaluated by the research objects themselves. Thus, the results derived are likely to be somewhat different from the actual situation due to the strong subjectivity of this measurement technique. It is therefore suggested that a standardized scale be developed for assessing environmental literacy knowledge and skills in subsequent research. Moreover, the scale devised needs to be verified based on normative construct validity and criterion-related validity, thus providing assistance for researchers as they carry out in-depth investigations.

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