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A Nationwide Survey Evaluating the Environmental Literacy of Undergraduate Students in Taiwan

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Abstract: The aim of this nationwide survey was to assess undergraduate students' environmental literacy level in Taiwan. A total of 29,498 valid responses were received from a number of selected colleges and universities in Taiwan, using stratified random sampling method. A total of 70 items were used to assess the environmental literacy and the results revealed that undergraduate students had a relatively low level of environmental knowledge and behavior, while a moderate level of environmental attitudes was attained. The findings also indicated no significant correlations between knowledge and attitudes or between knowledge and behavior. However, a higher level of environmental knowledge correlated significantly with a higher degree of pro-environmental behavior, and a higher level of environmental knowledge correlated with stronger attitudes. The results also suggested that females outperformed the males in all categories. Results from this study could contribute towards further relevant policy discussion and decision-making, curriculum design and development to the improvement of environmental education in the higher education sector.

Keywords: assessment; environmental education; environmental literacy; higher education; Taiwan

1. Introduction

The on-going environmental problems nowadays can be attributed to the increasing population, economic development and industrialization, pollution, urbanization, and resource depletion globally. The fundamentals of these on-going problems are predominantly associated with people's lifestyles and their extensive activities occurring in the natural surroundings [1,2], which gives rise to the importance of balancing the relationship between human and natural environments that was already recognized and supported by the World Commission on Environment and Development in 1987. The development of environmental awareness, knowledge and skills are considered as essential to help minimize environmental problems, and environmental education is seen as a key element in creating an environmentally literate society [3,4]. Through this, a responsible environmental behavior can be developed and help prevent and minimize environmental problems in a sustainable manner [5,6].

Current environmental education literature reveals a range of prior studies conducted that consistently related to the development of an environmentally literate citizenry [7,8]. Some of these areas of studies include: reviews of environmental education literature [9,10], definitions and frameworks [11,12], purpose and goals [13,14], and responsible environmental behavior [15,16]. However, there are limited studies conducted on a national scale and in the higher education context, which is the focus of this study.

1.1. Environmental Education in Taiwan

In Taiwan, the government has recognized the importance of environmental education and substantial efforts have been made to promote it in the past decades, with the intention to develop responsible environmental behavior [17]. In fact, environmental education has been taught in elementary, junior and middle level schools in the 1980s and 1990s, where the curricula incorporate basic environmental concepts that mainly seek to generate children's awareness about the environment and its related issues. The success of this has led to the extension in the curricula to include motivation and commitment elements that further enhance children's knowledge and skills in solving environmental problems. And consequently, environmental education was formally incorporated into the national curriculum framework in 2000. The government's support is evident by the environmental education development plan initiated by the National Science Council in 1993, which has recommended that more environmental behavior studies to be conducted in order to establish a responsible environmental behavior model appropriate for the Taiwanese. Despite this acknowledgement, there are still inadequate evidences in both practice and research in environmental education in Taiwan and this may be attributed to the early stage of environmental behavior research and development in the country itself [18]. Although there are numerous EE studies [15,19] conducted and responsible environmental behavior model developed but most of which have focused on Western developed countries and may not be appropriate in the context of Eastern countries, specifically for Taiwan.

Accordingly, formal education system plays an important role in environmental education efforts and in particular at the higher education level where transdisciplinary curriculum is offered that can help to further facilitate and enhance university students' environmental literacy that aims to develop their responsible environmental behavior [20,21]. Over the years, significant efforts had been made to the design and development of environmental education curriculum in Taiwan's higher education sector in order to create the necessary awareness, and develop critical knowledge and skills towards achieving a responsible environmental behavior. However, there has been inadequate evidence to provide greater insights about the success or failure of these efforts. Given that there is a general lack of existing empirical knowledge about the significant aspects of environmental literacy in Taiwan, this study aims to fill this gap by investigating the level of environmental literacy in university students whom have been exposed to transdisciplinary curriculum that can potentially further enhance the development of their responsible environmental behavior.

The significance of this study includes the provision of greater insights into the considerable efforts that the Taiwanese government has made towards environmental education over the years by assessing university students' environmental literacy on a national scale. This contributes towards further relevant policy discussion and decision-making, curriculum design and development to the improvement of environmental education, so that an environmentally literate society can be achieved. More importantly, the findings can also provide a benchmark for any future studies on environmental literacy at different levels in Taiwan and other countries, especially those that are developing and characterized by rapid industrialization and urbanization. Furthermore, this study contributes to the literature of environmental literacy as well as in the field of responsible environmental behavior.

1.2. Framework and Elements of Environmental Literacy

Although environmental literacy has been investigated in numerous research studies since 1960s, but there is still no one single agreed definition of it. Many of these prior studies had attempted to define environmental literacy by considering their scope of research and the context involved, and some of these definitions include: the possession of basic skills, understanding, and feelings for the human-environment relationship [21,22]; an understanding of the interaction between human beings and their natural environment in terms of living and non-living things [23,24]; the cognitive skills and knowledge needed at macro level for behavioral change towards a better environment [25,26]; knowledge of the environment that also involves values, attitudes, and skills that can be converted into actions [21,27]. For the purpose of this study, environmental literacy is regarded as an individual's knowledge and attitudes about the environment and its related issues, and through the acquired skills to help minimize and/or resolve environmental problems and remain an active participation that contributes towards an environmentally literate society [28].

The key environmental literacy variables to be investigated in this study are based on the environmental literacy framework developed by the Environmental Literacy Assessment Consortium and this framework has been used by researchers to undertake national assessments of environmental literacy in several countries such as South Korea [29], Israel [30], Turkey [31], and the United States [32]. This framework outlines three key elements that need to be considered when evaluating environmental literacy, and these include: (1) cognitive (knowledge and skills), (2) affective, and (3) behavioral.

The cognitive element refers to the ability to identify, investigate, analyze and evaluate environmental problems and issues based on the knowledge of ecological and socio-political foundations. This element also includes having the necessary knowledge and ability to develop and evaluate appropriate action strategies that seek to influence outcomes on environmental problems and issues. The key purpose of this element is to assess people's understanding of natural systems, environmental issues, and action strategies.

The affective element considers an individual's empathetic and caring attitude towards the environment who recognizes the values of environmental quality and is willing to take on appropriate actions to help prevent and resolve environmental problems and issues. This element seeks to evaluate people's environmental awareness and sensitivity, decision-making attitude on environmental issues and taking environmentally responsible action, and environmental values on ethical considerations and reflective thinking about the relationships between humans and the environment.

The behavioral element focuses on the belief of an individual or a group of individuals about their ability to influence outcomes of environmental problems and issues. There is also an assumption of personal responsibility to take reasonable actions that help influence the environment. These environmentally responsible actions are generally classified into five categories: (1) eco-management such as recycling, energy conservation, (2) economic/consumer action focuses on the use of monetary support or financial pressure such as financial donation to environmental groups, (3) persuasion to appeal to others to help minimize or resolve environmental problems/issues, (4) political action through voting, lobbying over concern for environmental problems/issues, and (5) legal action such as lawsuits, reporting pollution violations to authorities that aim to enforce existing laws. The key focus of this element is to investigate people's intentions to act upon environmentally friendly behaviors, environmental action strategies and skills to identify and evaluate environmental issues, and involvement in responsible environmental behavior.

Based on the above, the respective elements and components to be explored in this study are as shown in Table 1 below.

Table 1. Elements and components of environmental literacy.

Elements	Components
Cognitive	• Knowledge of natural systems • Knowledge of environmental issues • Knowledge of appropriate action strategies
Affective	• Environmental awareness and sensitivity • Environmental values • Decision-making attitude on environmental issues
Behavioral	• Intentions to act • Environmental action strategies and skills • Involvement in responsible environmental behavior

The key purpose of this study is to examine the undergraduate students' environmental literacy level on a nationwide scale in Taiwan by considering the three key environmental literacy elements as outlined in the literature. Specifically, the following objectives are investigated.

- To assess the level of environmental literacy of undergraduate students in Taiwan on the following elements: (1) cognitive (knowledge and skills), (2) affective, and (3) behavioral.
- To identify any significant correlations in the undergraduate students' scores on the three elements.
- To identify information sources from which undergraduate students gather environmental information.

2. Materials and Methods

This study was part of a nationwide survey assessment in Taiwan that was carried out with 32,321 undergraduate students by using an environmental literacy instrument developed based on the established environmental literacy framework. The large-scale survey adopted in this study was regarded as valuable in educational research domains, especially when "education policy debates are framed by questions about 'what works' and how 'big' the effects of specific educational practices are" on learning performance [33].

2.1. Participants

The participants of the study consisted of first-, second-, third-, and fourth-year undergraduate students in Taiwan. According to the annual report of Education Statistical Indicators published by the Ministry of Education, the target population was 1,077,396 students from 163 colleges and universities in Taiwan in the 2012 academic year when this survey was conducted. A sample of 57 colleges and universities were selected based on a stratified random sampling method with key considerations given to geographic (22 regions) and demographic (size and level of colleges and universities) stratum. With an average sampling rate of 3%, a total of 32,321 questionnaires were distributed and surveyed in the selected colleges and universities, of which 29,498 valid responses were received that represented a return rate of approximately 91.3%. To determine the representativeness of the sample, the chi-square (χ^2) test was used to test between sample and population demographics, which resulted in Pearson chi-square (χ^2) being 393.901, and a p value of approximately 0.000. Thus, the sample size of 29,498 was deemed to be representative of the population. The key demographic profiles of the respondents were briefly outlined in Table 2.

The findings revealed that both male and female were equally represented in this study with a respond rate of 49.1% and 49.6% respectively. In terms of the year level, first-year students accounted for 28.4% and this was followed by second-year (25.6%), third-year (23%) and fourth-year (22.4%) students. While majority of the students lived with their families (40%), other accommodation arrangements also included outside school rentals (30%) and school dormitory (27.5%). The most common type of family structure identified was nuclear family (65.9%) with the remaining being three generations (19.1%) and single-parent families (11.1%).

Table 2. General descriptive information of the sample (N = 29,498).

Variables	Frequency	Percent (%)
Gender		
Male	14,483	49.1
Female	14,626	49.6
Unanswered	389	1.3
Year level		
Freshman (first-year)	8370	28.4
Sophomore (second-year)	7544	25.6
Junior (third-year)	6774	23.0
Senior (fourth-year)	6598	22.4
Other	212	0.7
Accommodation arrangement		
With family	11,795	40.0
School dormitory	8115	27.5
Renting out	8854	30.0
Other	272	0.9
Unanswered	462	1.6
Family structure		
Three generations	5621	19.1
Nuclear family	19,436	65.9
Single-parent families	3271	11.1
Unanswered	1170	4.0

2.2. Instrument and Instrumentation

When designing these questionnaire items, the following steps were undertaken that acknowledged the differences of various assessment frameworks in existence and sociocultural contexts, which in this case the environmental literacy instrument was compiled with consideration given to the alignment of the contextual issues in Taiwan.

- Step 1: More than 30 research papers and articles related to environmental literacy in Taiwan and abroad [27,31,32,34] were reviewed to establish the item pools to be considered.
- Step 2: Using a similar process by Erdogan and Ok [31], items in the pool were selected in accordance to the research objectives guided by the definition of each elements and related components. The table of specifications, and the initially compiled questions items were subsequently prepared for panel review.
- Step 3: This initially compiled question items were given to a panel of 10 experts from various areas of specialization, such as environmental education, earth science, geography, and urban planning, for their formal review and expert opinions. The experts were required to evaluate the items on their appropriateness, relevance and language used from which content validity has to be reached. Each question item had received at least 80% agreement by the experts.
- Step 4: The instrument was revised based on the experts' opinions and feedback, and subsequently pre-tested with 20 randomly selected undergraduate students. The item analysis with regards to difficulty and discrimination for knowledge items and the factor analysis for scale items were conducted to determine the question items to be included in the final version of the questionnaire survey.

The final questionnaire survey consisted of two main sections; (1) demographic items, and (2) environmental literacy assessment items. Although there were 12 survey items in the demographic section, only some items were presented as variables for analysis as shown in Table 1. As for the environmental literacy assessment section, there were a total of 70 items used to assess the three main elements (i.e., cognitive, affective, and behavioral) as discussed in the literature.

Sixteen question items were developed for the cognitive element that aimed to assess undergraduate students' knowledge and understanding of natural systems, environmental issues,

and action strategies. Of these 16 questions, nine were True-False questions and remaining seven were Multiple-Choice questions. Next, 23 items were included in the affective element which sought to assess undergraduate students' environmental awareness and sensitivity, values, and decision-making attitude on environmental issues. These 23 question items were designed in the form of a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The score was reversed when the question item was presented in a negative manner. Lastly, the behavioral element was designed to investigate undergraduate students' intentions to act, their action strategies and skills, and involvement in responsible environmental behavior. It consisted of 31 question items using a five-point frequency scale (never, rarely, sometimes, often, always) that focused on undergraduate students' environmentally responsible actions, including persuasion, eco-management, consumer and economic action, and legal and political action.

2.3. Data Collection and Analysis

The questionnaire survey was conducted face-to-face with undergraduate participants at the respective randomly selected colleges and universities in Taiwan. The study involved data collection, data analysis using descriptive statistics, item analysis, an independent sample *t*-test, a one-way analysis of variance (ANOVA), and structural equation models (SEMs). Each of these methods is further illustrated as follows.

2.3.1. Descriptive Statistics

The mean and standard deviation (SD) of the test were used to determine the distributions of the participants' background variables and environmental literacy in the cognitive, affective, and behavioral dimensions [35].

2.3.2. Item Analysis

Item analysis was used to determine a set of quality question items suitable for inclusion in the questionnaire. In this study, the critical ratio (CR) was analyzed and the item-total correlation (ITC) was corrected to measure environmental literacy in the three elements, namely cognitive, affective, and behavioral. Through these procedures, unsatisfactory items were eliminated and resulting in only those question items that were highly relevant to the alignment of the contextual issues in Taiwan.

2.3.3. Reliability Analysis

Cronbach's α coefficient was used to determine the reliability of the data obtained from the questionnaires at the pretest and actual survey stages. If the Cronbach's α coefficients of the individual factors were 0.70 or greater, then the factors have exhibited satisfactory reliability. If the Cronbach's α coefficients of the factors were 0.80 or greater on a total scale, then the questionnaire has achieved overall reliability.

2.3.4. Independent Samples T-Test

A *t*-test was used to examine if there were any differences between two groups. The implementation of the dichotomous variables at object background variables were examined and used to determine whether significant variations existed in each set of samples on their environmental literacy (i.e., cognitive, affective, and behavioral dimensions). Specifically, the gender and club participations were investigated in this study.

2.3.5. Structural Equation Modelling (SEM)

A multivariate statistical technique combining factor analysis and path analysis from a series of formulas were used to determine the causal relationships among the variables [36]. A series of formulas in structural equation modeling (SEM) includes a diverse set of mathematical formulas to

report a selection of different fit measures, such as chi-squared test and confirmatory factor analysis. Of the 29,498 valid questionnaires received, only 27,249 were used in the SEM, since the remaining questionnaires were incomplete and therefore rejected.

3. Results

3.1. General Descriptive Findings

The findings indicated that majority (85.7%) of the survey participants did not participate in any clubs or societies at the university/college, while only 13.2% were involved. Approximately three-quarter (75.1%) of the undergraduate students spent two-hour or less per week to obtain environmental related information, 8.8% spent two or more hours and the remaining 15.8% never spent time on it. Television news (61.5%), online learning (48.4%), and television programs (32.6%) were considered to be the three major sources for acquiring environmental related information. The top five-favored type of environmental education were outdoor experiential learning (45.8%), watch movies (43.7%), visiting museums or conservation centers (35.6%), online learning (29.3%), and attend lectures (23.4%). A more detailed descriptive statistics summary findings for each of the variables highlighted above is provided in Table 3 below.

Table 3. Descriptive information of the sample on club and society participation, and environmental information search.

Variables	Frequency	Percent (%)
Participation in clubs or societies		
Yes	3897	13.2
No	25,290	85.7
Unanswered	311	1.1
Average weekly search for environmental information (by hours)		
Never	4665	15.8
Less than 30 min	10,814	36.7
30 min to one hour	7796	26.4
One to two hours	3554	12.0
Two to three hours	747	2.5
Three to four hours	818	2.8
More than four hours	1024	3.5
Unanswered	80	0.3
Major information source to gather environmental information		
Television news	18,151	61.5
Online learning	14,286	48.4
Television programs	9612	32.6
Class lectures	7418	25.1
Books and magazines	7110	24.1
Environmental NGOs	3503	11.9
Textbooks	3393	11.5
Friends and relatives	3060	10.4
Radio	1400	4.7
Others	151	0.5
Favorite types of environmental education		
Outdoor experiential learning	13,504	45.8
Watch movies	12,901	43.7
Visit museums/conservation centers	10,501	35.6
Online learning	8654	29.3
Attend lectures	6903	23.4
Discussion with classmates	5889	20.0
Experiment	4650	15.8
Classroom studies	3915	13.3
Others	112	0.4

3.2. Environmental Literacy

3.2.1. Cognitive Element

In the cognitive element, the component on knowledge of natural systems was evaluated by four True-False questions (i.e., K1 to K4) and five Multiple-Choice questions (i.e., K5 to K9). The participants answered 58.1% of the questions correctly, indicating that their environmental knowledge of natural systems was generally inadequate. As shown in Table 4, only Question K7 on the "description of the function of tropical rainforests" exhibited a correct response rate of greater than 80%, whereas the correct response rates for Questions K1, K2, K5, K8, and K9 were below 60%. This indicated that the undergraduate students' knowledge about the natural systems was generally insufficient, particularly on the cognitive issues of biodiversity, greenhouse gases, natural disasters, and ecological conservation.

Table 4. Mean and standard deviation for the cognitive element.

Items	Correct Rate	
	%	95% C. I.
K1. The ultimate goal for natural environment conservation is to attain "Biodiversity", which signifies the utmost variety of different species.	41.9	$41.3 \leq \hat{p} \leq 42.5$
K2. Greenhouse effect is perfect for the earth's surface temperature to maintain an appropriate environment suitable for living organisms.	41.3	$40.7 \leq \hat{p} \leq 41.9$
K3. Excessive burning of coal, oil, and fossil fuels will lead to ozone depletion.	69.2	$68.7 \leq \hat{p} \leq 69.7$
K4. Having algae in the rivers can help the ecological balance of the river system.	70.9	$70.4 \leq \hat{p} \leq 71.4$
K5. Which of the following gas type is not a greenhouse gas?	24.1	$23.6 \leq \hat{p} \leq 24.6$
K6.Which of the following type of power generation is most environmentally friendly?	61.0	$60.4 \leq \hat{p} \leq 61.6$
K7. Rainforest ecosystem is important to the earth, which of the following statement is not a function of tropical rainforests?	86.4	$86.0 \leq \hat{p} \leq 86.8$
K8. What is the major reason contributing to the problems associated with natural disaster in Taiwan?	39.0	$38.4 \leq \hat{p} \leq 39.6$
K9. Which of the following statement about information on conservation is correct?	59.8	$59.2 \leq \hat{p} \leq 60.4$
K10. "Kyoto Protocol" is an agreement signed for global economic development.	67.2	$66.7 \leq \hat{p} \leq 67.7$
K11. Ancestors like to drink realgar wine as part of their traditional customs in Mid-autumn Festival, to protect them from diseases.	45.5	$45.0 \leq \hat{p} \leq 46.1$
K12. The wisdom pass down by our ancestors is adequate to help us cope with the current climate problems and environmental changes.	85.9	$85.5 \leq \hat{p} \leq 86.3$
K13. Which of the following statement is not correct about the damage done on the nature from acidic rain?	61.0	$60.4 \leq \hat{p} \leq 61.6$
K14. The reason for uneven distribution of the earth's natural resources is due to the high resource consumption in high population countries. Is this statement correct?	61.6	$61.0 \leq \hat{p} \leq 62.2$
K15. The road work maintenance in *Saharan Africa* is to prevent landslides due to debris flows and reduce the loss of life and property. Is this statement correct?	59.1	$58.8 \leq \hat{p} \leq 59.7$
K16. Which of the following icons represent environmental-friendly labelling? Please select one correct icon.	89.3	$88.9 \leq \hat{p} \leq 89.7$

The second component, knowledge of environmental issues in the cognitive element was assessed through three True-False questions (i.e., K10 to K12) and one Multiple-Choice questions (i.e., K13). The participants answered 64.9% of the questions correctly, suggesting that their environmental knowledge of social, cultural, political, and economic issues was at a moderate level. In particular, only Question K12 on "The wisdom pass down by our ancestors is adequate to help us cope with the current climate problems and environmental changes" achieved a correct response rate greater than 80%, while the correct response rate of Question K11 was below 50% (refer to Table 4). This indicated that the undergraduate students' environmental knowledge about the customary cultural issues (such as the Chinese tradition of drinking realgar wine during the autumn season to protect themselves from illness and stay healthy) was generally inadequate.

When assessing the knowledge of appropriate action strategies component in the cognitive element, two True-False questions (i.e., K14 to K15) and one Multiple-Choice question (i.e., K16) were used. The participants answered 61.5% of the questions correctly, revealing that their knowledge of appropriate action strategies was moderately inadequate. Although Question K16 on the "identification of environmental labelling" had attained a correct response rate greater than 80%, however, the correct response rate for Question K15 was below 60% (refer to Table 4). This indicated that undergraduate students' knowledge of appropriate action strategies was generally insufficient, particularly regarding the concern of the "cognitive awareness level of resource consumption ratio".

3.2.2. Affective Element

In the affective element, the environmental awareness and sensitivity component was evaluated with seven questions ranked on a five-point Likert scale. All of the questions were positive. The average score with the standard deviation was 3.75 $\pm$ 0.688 (a maximum of 5 points on the Likert-type scale). Question A6, "I have the initiative to learn environmental knowledge," elicited a relatively low average score (3.45 $\pm$ 0.844), whereas Question A3, "I believe that toxic emissions from anthropogenic waste can cause a negative environmental impact" had achieved a relatively high average score. A moderate degree of environmental awareness and sensitivity was evident in the undergraduate students.

There were eight questions ranked on a five-point Likert scale used to assess the environmental values component in the affective element. All of the questions were positive. The average score with the standard deviation was 3.95 $\pm$ 0.769 (a maximum of 5 points on the Likert-type scale). The average scores for Questions A10, A12, and A15 were 4 points or more, and the average scores of the remaining questions were 3.5 points or more. The items in the environmental values component demonstrated relatively high scores by the undergraduate students.

The component on decision attitude about environmental issues in the affective element involved eight questions ranked on a five-point Likert scale for evaluation. All of the questions were positive. The average score with the standard deviation was 3.71 $\pm$ 0.69 (a maximum of 5 points on the Likert-type scale). The average scores for all of the items ranged between 3.5 and 4. The items in the decision attitude about environmental issues component revealed relatively high scores in the affective element. However, the attitudes of "discussed with colleagues" (3.46 $\pm$ 0.90) and "advised misconducted behavior" (3.54 $\pm$ 0.897) indicated relatively low scores, which suggested that undergraduate students disregard the incentive of environmental justice and the altruistic perspective for making correct decisions. A summary finding of the affective elements is presented in Table 5.

Table 5. Mean and standard deviation for the affective element.

Items	Mean	Standard Deviation
A1. I am aware of environmental issues related to air pollution, food safety, and habitat destruction.	3.64	0.874
A2. I care about environmental problems caused by climate change.	3.71	0.849
A3. I believe that toxic emissions from anthropogenic waste (i.e., motor vehicles, factories, etc.) can cause a negative environmental impact.	4.09	0.957
A4. I think human lives are critically dependent on the supply of the earth's natural resources.	3.96	0.973
A5. I think the practice of environmentally friendly behavior can solve many environmental problems in lives.	3.58	0.976
A6. I have the initiative to learn environmental knowledge (i.e., interactions between people and the environment), to enhance my understanding of the natural world.	3.45	0.844
A7. I will be very angry if I saw someone throw trash on the road or into the river.	3.82	0.932
A8. I will give thanks and cherish "Mother Nature" more for a better environment.	3.93	0.910
A9. Earth's resources are limited, so I will cherish resources.	3.96	0.920
A10. I think there is a meaning and value for the existence of the plants and trees.	4.06	0.957

Table 5. *Cont.*

Items	Mean	Standard Deviation
A11. I think the aboriginal customary manners are worthy of respect and learning, given that they contribute towards a positive ecological relationship.	3.86	0.949
A12. I think there is no way to restore the original look of the nature if it is destroyed.	4.11	1.018
A13. I think environmental and ecological protection are more important than that of the economic development.	3.84	0.951
A14. I believe that technological advances cannot solve all the environmental pollution problems.	3.83	1.023
A15. I think the environmental pollution problems in other countries will also affect Taiwan.	4.02	0.951
A16. I think that polyethylene terephthalate bottled drinks affect the environment.	3.83	0.919
A17. I know my lifestyle can affect the environment.	3.68	0.924
A18. I have a responsibility to participate in activities that will help slow down global warming.	3.86	0.909
A19. As long as I am willing to try, I can solve or minimize environmental problems.	3.67	0.936
A20. I can discuss environmental issues with other students to clarify the cause and effects.	3.46	0.900
A21. I will advise others to stop environmental destruction (e.g., dumping trash and waste water, etc.).	3.54	0.897
A22. While traveling through local communities, I will respect local customs and traditions, and to reduce interference on the local environment and residents.	3.90	0.894
A23. I believe no advanced technology can solve all pollution problems.	3.84	1.35

3.2.3. Behavioral Element

In the behavioral element, the intentions to act component was evaluated through eight questions ranked on a five-point Likert scale. All of the questions were positive regarding whether the participants participated in private acts, shallow green behavior, or altruistic behavior. The average score with the standard deviation was 3.54 $\pm$ 0.679 (a maximum of 5 points on the Likert-type scale). The participants obtained relatively high scores for Questions BEH1 to BEH4. In contrast, the participants attained relatively lower scores for Questions BEH5 to BEH8, which indicated that students exhibited a certain responsibility and sense of mission and were willing to cooperate with government policy regarding the implementation of environmental actions. However, the undergraduate students' environmental behavioral intentions were relatively negative regarding participation in discussions on environmental concerns, provision of opinions, and initiatives to attend environmental activities.

The assessment of the environmental actions and skills component in the behavioral element consisted of 19 questions ranked on a five-point Likert scale. All of the questions were positive. The average score with the standard deviation was 3.16 $\pm$ 0.742 (a maximum of 5 points on the Likert-type scale). The participants obtained relatively low scores for all of the items in this component, indicating that undergraduate students maintained negative behavior and acted as bystanders regarding environmental action. Only items on the basic classification of garbage recycling exhibited higher scores than the other items did, and all of the other items received relatively low scores regarding learning from the environment, suggestions of environmental protection, idea communication, and action capabilities.

The responsible environmental behavior component in the behavioral element was measured by four questions ranked on a five-point Likert scale. All of the questions were positive. The average score with the standard deviation was 3.717 $\pm$ 0.878 (a maximum of 5 points on the Likert-type scale). On the scale, Questions R1 to R4 displayed averages scores between 3.74 $\pm$ 0.876 and 3.65 $\pm$ 0.882, and the results did not reveal any particular prominent signs for this element. Table 6 provides a summary of the results for the behavioral elements.

Table 6. Mean and standard deviation for the behavioral element.

Items	Mean	Standard Deviation
BEH1. While I go out, I am willing to give priority to walking, cycling, taking public transportation, and other transportation modes.	3.67	0.966
BEH2. I am willing to turn on air conditioner's temperature at 26 °C~28 °C to save energy.	3.84	0.988
BEH3. I am willing to take care of our living environment (including school and neighborhood) and make changes to the environmental conditions.	3.59	0.870
BEH4. I am willing to take the initiative to find out more about climate change, carbon reduction, and other related information.	3.63	0.853
BEH5. I am willing to take the initiative to follow through in my daily life on the opinions and ideas I have about the environmental issues.	3.43	0.861
BEH6. I am willing to discuss environmental issues as the main theme in the school report.	3.36	0.876
BEH7. I support the reduction on the number of household garbage collection days, in order to reduce air pollution generated by garbage truck.	3.44	0.963
BEH8. I am willing to participate in the environmental events (i.e., natural conservation, monitoring, and maintenance activities).	3.36	0.897
BEH9. I am capable of classifying different types of recyclable items.	3.67	0.926
BEH10. I know how to use different recycling methods.	3.24	0.941
BEH11. I am capable of observing the terrain to determine if a place will be flooded or not.	2.84	1.043
BEH12. I will use multi-media, such as newspapers, magazines, or the Internet to obtain information related to environmental issues.	3.29	0.974
BEH13. I am able to identify environmental problems and find solutions to them.	3.00	0.964
BEH14. I can integrate different viewpoints on environmental issues and form my personal opinions.	3.10	0.975
BEH15. I can reflect on my own behavior about the social and environmental impacts.	3.31	0.933
BEH16. I am able to communicate relevant environmental-related information to others.	3.18	0.956
BEH17. I am able to convince my family members and friends to undertake environmental actions.	3.14	0.999
BEH18. I know how to use appropriate channels to promote environmental knowledge and environmental friendly policies.	3.09	0.974
BEH19. I use appropriate channels to appeal environmental complaint issues, to help avoid environmental pollution incident.	2.95	1.036
BEH20. I will buy polyethylene terephthalate bottled beverages.	3.14	0.895
BEH21. I will bring my own personal water bottle when I go out.	3.28	1.156
BEH22. I will carry reusable utensils (i.e., chopsticks, spoons, etc.).	2.69	1.102
BEH23. I will convey environmental protection information to my family members or friends.	2.90	0.941
BEH24. I have participated in environmental organizations (i.e., green squad, green campus groups, etc.) on campus.	2.21	1.020
BEH25. I have attended schools' or extracurricular experiences in environmental activities (i.e., beach cleaning, ecological ponds' cleaning, and other ecological activities).	2.30	1.021
BEH26. I have used appropriate channels on environmental complaint issues to help appeal environmental pollution incident (i.e., open burning, free dumping wastes).	2.00	1.066
BEH27. I have participated in related rallies, marches, or petition activities on environmental policies.	3.14	0.895
R1. I have the responsibility to improve the surrounding environment.	3.74	0.876
R2. It is my duty to prevent environmental pollution incidents.	3.69	0.878
R3. It is my responsibility to solve any environmental problems caused by myself.	3.79	0.876
R4. It is my responsibility to influence the people around me to have better awareness on environmental protection.	3.65	0.882

3.3. T-Test and Chi-Square Test

Gender and participation in clubs and societies at universities/colleges were investigated to determine their relationship with environmental literacy. According to the level of clustering, three categories were identified based on the average scores; (1) lower quartile group (i.e., the lowest 20% of the average scores from 0.99 to 2.99), middle quartile group (i.e., between 20% and 80% of the average scores from 3.00 to 3.73), and top quartile group (i.e., top 20% of the average scores from 3.74 to 4.86). The test of independence in calculating the chi-square (χ^2) was then used to determine the associations between gender (χ^2 = 393.901, df = 2, p = 0.000; likelihood ratio tests = 396.577, df = 2, p = 0.000) and participation in clubs and societies at universities/colleges (χ^2 = 233.102, df = 2, p = 0.000; likelihood-ratio tests = 232.369, df = 2, p = 0.000) on environmental literacy. The test results indicated that gender and participation in clubs and societies were positively associated with undergraduate students' environmental literacy.

Female undergraduate students scored higher than the male students in seven of the nine components of environmental literacy investigated in this study, namely (1) knowledge of natural systems, (2) knowledge of environmental issues, (3) knowledge of appropriate action strategies, (4) environmental awareness and sensitivity, (5) environmental values, (6) decision-making attitude on environmental issues, and (7) intentions to act. In contrast, male students performed better in the remaining two components (i.e., environmental action strategies and skills, and involvement in responsible environmental behavior). Table 7 below provides a summary result of the *t*-test between gender and environmental literacy. As shown in Table 8, undergraduate students who participated in clubs and societies at the university/college exhibited a higher level of environmental literacy in all nine components than their counterparts who did not.

Table 7. T-test between gender and environmental literacy.

Elements	Components	Gender	Mean	SD	*t* Value	*p* Value
Cognitive	Knowledge of natural systems	Male Female	2.85 2.97	0.738 0.716	−13.153	<0.000 ***
	Knowledge of environmental issues	Male Female	3.17 3.33	1.340 1.306	−9.695	<0.000 ***
	Knowledge of appropriate action strategies	Male Female	3.06 3.11	0.937 0.851	−4.553	<0.000 ***
Affective	Environmental awareness and sensitivity	Male Female	3.66 3.84	0.735 0.621	−22.4023	<0.000 ***
	Environmental values	Male Female	3.82 4.08	0.810 0.702	−28.618	<0.000 ***
	Decision-making attitude on environmental issues	Male Female	3.62 3.81	0.725 0.638	−24.239	<0.000 ***
Behavioral	Intentions to act	Male Female	3.46 3.61	0.715 0.629	−18.818	<0.000 ***
	Environmental action strategies and skills	Male Female	3.18 3.14	0.762 0.719	4.734	<0.000 ***
	Involvement in responsible environmental behavior	Male Female	2.60 2.54	0.718 0.612	7.071	<0.000 ***

*** At the significant level of 0.001 (two-tailed).

Table 8. T-test between students' participation in clubs/societies and environmental literacy.

Elements	Components	Participation in Clubs/Societies	Mean	SD	*t* Value	*p* Value
Cognitive	Knowledge of natural systems	Yes No	3.02 2.89	0.674 0.736	11.249	<0.000 ***
	Knowledge of environmental issues	Yes No	3.46 3.22	1.236 1.335	11.217	<0.000 ***
	Knowledge of appropriate action strategies	Yes No	3.14 3.07	0.852 0.903	4.329	<0.000 ***
Affective	Environmental awareness and sensitivity	Yes No	3.88 3.73	0.665 0.687	12.884	<0.000 ***
	Environmental values	Yes No	4.11 3.93	0.739 0.769	13.888	<0.000 ***
	Decision-making attitude on environmental issues	Yes No	3.84 3.70	0.680 0.688	12.141	<0.000 ***
Behavioral	Intentions to act	Yes No	3.65 3.52	0.686 0.675	11.373	<0.000 ***
	Environmental action strategies and skills	Yes No	3.27 3.15	0.741 0.741	9.117	<0.000 ***
	Involvement in responsible environmental behavior	Yes No	2.62 2.56	0.640 0.672	4.602	<0.000 ***

*** At the significant level of 0.001 (two-tailed).

3.4. Confirmatory Factor Analysis

To test the integrity of the measurement model, confirmatory factor analysis (CFA) was conducted. The following conventional goodness-of-fit criteria were recorded for evaluating this model [37,38]: GFI = 0.929, AGFI = 0.870, RMSR = 0.033, RMSEA = 0.107, TLI = 0.894, NFI = 0.931, χ^2 = 11,162.750, df = 36, Sig. = 0.000, n = 27,249, and χ^2/df = 310.076. The coefficients were significant for all of the pro-environmental elements of the Analysis of a Moment Structures (AMOS) model. The χ^2 = 11,162.750, with 11 degrees of freedom at a significance level of 0.000. However, it should be noted that the large sample size of 27,249 in this study could be regarded as vulnerable to the overestimation of the significant differences [39].

The composite reliability (CR) of cognitive element was considerably low (ρ = 0.273) (knowledge of natural systems, ρ = −0.025; knowledge of environmental issues, ρ = 0.356; and knowledge of appropriate action strategies, ρ = −0.153). This low reliability could potentially be explained by the nature of the dichotomous (i.e., True-False questions), and Multiple-Choice questions, and also a lack of adequate number of items, which prevented the removal of unrepresentative items that can result in improving the reliability. On the other hand, the reliability of the affective element was considerably high (ρ = 0.957) with the respective components as follow: environmental values (ρ = 0.920), decision-making attitude on environmental issues (ρ = 0.883), and environmental awareness and sensitivity (ρ = 0.870). The reliability of the behavioral element was also high (ρ = 0.903), and this included the following components: involvement in responsible environmental behavior was high (ρ = 0.921), as were the items of the environmental actions and skills (ρ = 0.928), intentions to act (ρ = 0.886), and environmental action experience (ρ = 0.797).

From Figure 1, the standardized regression weights, which indicate convergent validity were calculated for knowledge of appropriate action strategies (0.386), knowledge of environmental issues (0.427), and knowledge of natural systems (0.398) within the cognitive element. The standardized regression weights for the affective element (please refer to Figure 2) were relatively high in the decision-making attitude on environmental issues (0.927), environmental values (0.893), and environmental awareness and sensitivity (0.875) components. In terms of the behavioral element (as shown in Figure 3), the standardized regression weights for the involvement in responsible environmental behavior (0.710), environmental actions and skills (0.491), and intentions to act (0.980) components were relatively high value.

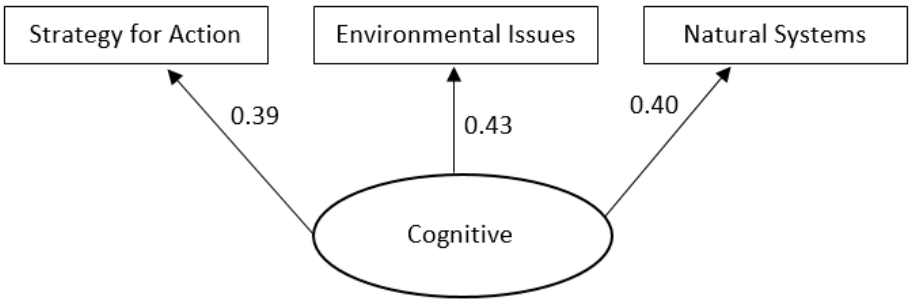

Figure 1. The AMOS model estimates of parameters in structural model of the cognitive element (with standardized estimates of coefficients of standardized value, coefficients in *t* values, coefficients of determination).

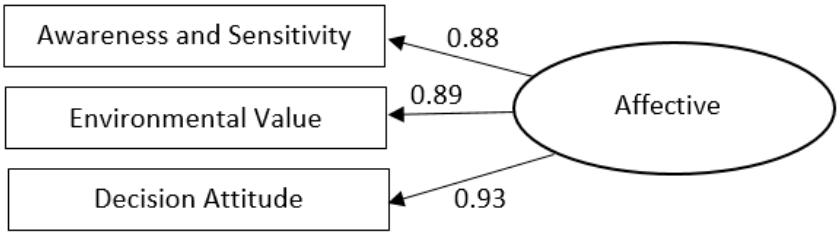

Figure 2. The AMOS model estimates of parameters in structural model of the affective element (with standardized estimates of coefficients of standardized value, coefficients in *t* values, coefficients of determination).

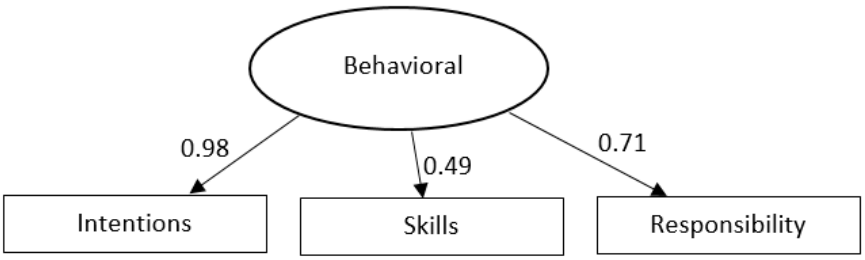

Figure 3. The AMOS model estimates of parameters in structural model of the behavioral element (with standardized estimates of coefficients of standardized value, coefficients in *t* values, coefficients of determination).

4. Discussion and Implications

This study was a nationwide assessment conducted to evaluate the Taiwanese undergraduate students' level of environmental literacy, specifically in three key elements (i.e., cognitive, affective, and behavioral). On the whole, the undergraduate students' environmental literacy indicated a relatively low level of environmental knowledge and behavior, while a moderate level of environmental attitudes was attained. The findings also revealed no significant correlations between knowledge and attitudes or between knowledge and behavior. However, a higher level of environmental knowledge correlated significantly with a higher degree of pro-environmental behavior, and a higher level of environmental knowledge correlated with stronger attitudes.

4.1. Relationships between Environmental Knowledge, Attitudes and Behavior

There had been substantial debates over the years about environmental literacy and the relationships among knowledge, attitudes, and behavior [30,31,40]. Through the SEM technique used in this study, it was observed (as shown in Table 9) that there were no significant correlations

between cognitive (r = 0.215) and behavioral elements, and cognitive and affective elements (r = 0.385). However, the results determined that affective and behavioral elements were highly correlated with r value of 0.76 [32,41]. The results suggested that the possession of only environmental knowledge and awareness of environmental issues could not always be successfully transformed into environmental action [42].

Table 9. AMOS correlations between each element by their estimates for all students.

Elements	Cognitive	Affective	Behavioral
Cognitive	1	0.385	0.215
Affective	0.385	1	0.760
Behavioral	0.215	0.760	1

While some studies [2,30,43] had reported no positive relationship between environmental awareness and knowledge and pro-environmental behavior, but researchers have continued to be inspired to investigate the relationships among intrinsic, self-determined, and self-esteemed motivation induced by personal behavior since personal self-efficacy is directly associated with pro-environmental behavior [44,45]. In this study, the highest average score observed was in the attitude element (M = 3.73, SD = 0.631), followed by the behavioral element (M = 3.09, SD = 0.546), with the lowest average value being the knowledge element (M = 3.08, the average correct response rate = 60.5%). The correlation between students' environmental attitudes and environmental behaviors was moderate, and the value of this correlation was low in the knowledge element. Overall, the undergraduate students' environmental literacy indicated low environmental knowledge, moderate environmental attitudes, and low environmental behavior. Further analysis revealed that these students could be broadly divided into two groups according to the following continuum of the states of environmental literacy: ecocentric and egocentric [46,47].

Ecocentric engaged students accounted for about 60.2% of the entire sample in this study. A high ratio of these ecocentric students were female, lived in school dormitories, enjoyed searching environmental information, and participated in clubs and societies. The results showed that these students had a moderate level of environmental knowledge (M = 3.35, SD = 0.455), strong environmental attitudes (M = 4.07, SD = 0.398), and moderate environmental behavior (M = 3.03, SD = 0.493). In contrast, the remaining 39.8% of the sample that represented the egocentric engaged students were mainly male who lived with their families or rented apartments, did not enjoy acquiring environmental information, and limited participation in clubs and societies. Findings suggested that these students had a low level of environmental knowledge (M = 2.82, SD = 0.731), moderate environmental attitudes (M = 3.31, SD = 0.581), and a low value of environmental behavior (M = 2.86, SD = 0.512).

From Table 10 above, the results revealed that there were no significant correlations between cognitive (r = −0.261) and affective elements, or affective (r = −0.392) and behavioral elements for egocentric engaged students. However, the findings indicated a moderate relationship between cognitive (r = −0.552) and behavioral elements whereby egocentric engaged students might have the environmental knowledge and awareness, but did not necessarily converted into environmental actions.

Table 10. AMOS correlations between each element by their estimates for the bottom 20% of egocentric engaged students.

Elements	Cognitive	Affective	Behavioral
Cognitive	1	−0.261	−0.552
Affective	−0.261	1	−0.392
Behavioral	−0.552	−0.392	1

4.2. Gender Comparison on Environmental Literacy

Overall, female undergraduate students exhibited a more satisfactory fit in environmental literacy than male undergraduate students did, which is consistent with previous studies [48,49]. The females in the top 20% with excellent environmental literacy accounted for approximately 56%, while the remaining 44% were males. On the other hand, about 38.5% of the females and 61.5% of the males in the bottom 20% were regarded as having poor environmental literacy. The higher level of environmental literacy attained by females could be explained by their social status and norms expectation in the Eastern society. For example, females in Taiwan have traditionally been taught to love and maintain cleanliness, and their home caring role of being responsible for household cleaning have also contributed to this effect. A brief summary of the findings is provided in Table 11 below.

Table 11. Cross-tabulation for gender—bottom 20%, 20% to 80%, and top 20%.

		Total Clustering			Total
		Bottom 20%	**20% to 80%**	**Top 20%**	
Gender	Male	3293	7577	2461	13,331
	Female	2062	8432	3071	13,565
Total		5355	16,009	5532	26,896

4.3. Relationship between Clubs and Societies Participation and Environmental Literacy

Undergraduate students who participated in clubs and societies at universities/colleges generally performed better in their environmental literacy than those who did not. This could be explained with the fact that being involved in activities through clubs and societies provide more opportunities for creative thinking, problem solving, leadership, and prosocial behavior than regular courses do [50]. In addition, participants who had pro-environmental experience in these activities gained considerably self-respect, self-esteem, and self-confidence [51–53]. Majority (91%) of the undergraduate students in the bottom 20% who had poor environmental literacy did not participate in clubs and societies while the remaining 9% had participation. Table 12 below provides a summary of the findings.

Table 12. Cross-tabulation for participation in clubs and societies—bottom 20%, 20% to 80%, and top 20%.

		Total Clustering			Total
		Bottom 20%	**20% to 80%**	**Top 20%**	
Participate in clubs and societies	Yes	471	2103	1039	3613
	No	4892	13,949	4526	23,367
Total		5363	16,052	5565	26,980

4.4. Sources of Environmental Information

In this study, television news (61.5%), online learning (48.4%), and television programs (32.6%) were determined to be the three major sources from which undergraduate students acquire environmental knowledge. These results were similar to those discovered in a prior study [54] about the perception of environmental problems by young people at the University of Maria Curie-Sklodowska (UMCS) and the Technical University (TU) in Poland whereby television (53.5% at the UMCS and 70% at the TU) and newspapers (52% at the UMCS and 32% at the TU) had been identified as key sources to acquire environmental information. These results indicated that the majority of students perceived television as the mainstream medium for gathering environmental knowledge.

The findings in this study revealed that only a minority (11.5%) of the undergraduate students acquired their knowledge from ecological textbooks, and this was consistent with Pawlowski's study [54]. This suggested a need to further investigate the appropriateness of using the textbook as a

medium to disseminate environmental knowledge. With the increasing ease of access and vast amount of information available via the internet, online learning has become an important environmental knowledge source and this was supported by approximately 48.4% of the undergraduate students who participated in this study. Given this, a focus on utilizing the online channel as a source of environmental knowledge is deemed to be critical since students nowadays are more internet savvy than ever.

4.5. Study Implications

Firstly, environmental education in Taiwan primarily emphasizes on knowledge and cognitive memory; therefore, developing students' capabilities to explore environmental issues and engage in environmentally friendly behavior and responsible environmental behavior (attitudes, personal investment, locus of control) have been neglected [8,55,56]. Relevant studies in the past have also suggested that environmental knowledge is acquired from the teaching materials offered by the university/college and learners automatically generate positive environmental attitudes and behavior in Western societies. However, the results of this study suggested that environmental knowledge did not create positive environmental behavior and skills; the association between the environmental literacy elements was considerably low. Simply focusing on teaching environmental knowledge does not fully achieve the goal of environmental education. As such, environmental knowledge based on science itself is insufficient for eliciting attitudes, values, and behavior, which constitute a substantial part of environmental literacy [57]. Therefore, it is recommended that environmental attitudes should be enhanced through interaction with the environment, which enables students to learn useful skills, develop a sense of responsibility, and increase a personal and collective sense of competence for promoting responsible environmentally friendly behavior [15].

Next, understanding students' perceptions and interpretations of processes, as well as the reasons behind certain behavior is crucial in assessing sustainable education perspectives [58]. Thus, it is important to understand how knowledge can be converted into a person's actual attitude, emphasizing altruism in all civic actions, and focusing on learners' affective areas of goals are current challenges facing environmental education in Taiwan. It is recommended to strengthen the curriculum development specifically in the areas of environmental education in students' learning materials to enrich their learning content. For example, students are encouraged to explore the outdoors, maintain correct perceptions, and obtain environmental information from the nature. Environmental pedagogy does not always provide accurate answers, but should provide opportunities for students and encourage them to investigate the causes for and solutions to problems [30], recognize lifelong environmental subjectivity, and appreciate multiple perspectives [59,60].

Lastly, the university curriculum can be designed to teach students how to differentiate between issues of fact from those of value, and how to study various levels of uncertainty based on paradoxical information in a chaotic world [61,62]. Higher education can be facilitated through an educational strategy that enhances environmental stewardship through a "greening outdoor curricula", referring to science-based actions for sustainability [63]. In addition, students are encouraged to participate and form environmental-related organizations and activities (e.g., the International Youth Conference on the Environment, green camp, nature exploring) to enhance life experiences towards a dynamic and synthetic essence and learning opportunities.

In conclusion, this built-in framework addresses practical pedagogies for hands-on experience and is crucial to reforming environmental education for undergraduate students in Taiwan, as well as serving as a reference point for other similar investigations in the future.

4.6. Study limitations

This study has three key limitations. The first being the research focused on a huge sample from Taiwan [64]. The results are based on the current values and skills covered in the national curriculum and mainly considered the major environmental threats affecting Taiwan. Therefore, the identified

components and corresponding items were more closely related to local issues and dimensions in the Taiwanese context. However, it is recommended that the results in this study be used as a benchmark for comparison with other similar studies conducted in other countries, especially those that are developing and characterized by rapid industrialization and urbanization.

Next, prior studies investigated the predictions about pro-environmental behavior based on moral or ethical elements have found that personal norms played a critical role. However, since this study did not explore the effects of the moral and ethical elements, therefore, conclusions could be provided in this aspect. Thus, it is recommended that further detailed studies about the impact of moral and/or ethical norms on environmental literacy could be conducted in Taiwan in the future, in order to gain further insights and understanding in this field.

Lastly, the low composite reliability of the cognitive element was an indication that some items were not necessarily representative but because of the limited number of items, therefore the removal of some odd items was deemed unsuitable. Thus, it is recommended to increase the items (in interval measurement Likert-type scale format) in the questionnaire to improve the reliability.

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