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Analysis of Undergraduates' Environmentally Friendly Behavior: Case Study of Tzu Chi University Environmental Education Program

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Abstract: The Tzu Chi University Environmental Education Program, based on a theory of change, consisted of four weeks of lessons involving environmental and sustainability topics, followed by hands-on sorting of recyclables and four weeks of weekly documenting of environmentally friendly behavior. The Program was analyzed using written thoughts from the Experimental Group, as well as 78 and 116 valid survey responses of the Control and Experimental Groups, respectively. The survey consisted of questions regarding demographics and five constructs: environmental awareness, attitudes, norms, efficacy and behavior. No significant average differences were found between the pre-tests of the Control and Experimental Groups, or between the pre- and post-test of the Control Group. The post-test of the Experimental Group displayed a significantly higher average value when compared to both the pre-test of the Experimental Group and the post-test of the Control Group, as the means of the self-reported environmental awareness, attitudes, norms, efficacy and behavior significantly improved statistically after participating in the Program. Analysis revealed that lessons from the Program increased undergraduates' environmental awareness and attitudes; "hands-on recyclables sorting" and "weekly documentation of environmentally friendly behavior" strengthened undergraduates' environmental norms and efficacy, while their combination resulted in a significant improvement toward environmentally friendly behavior.

Keywords: environmental education; undergraduates; environmentally friendly behavior; awareness; attitude; efficacy; norms

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1. Introduction

The widespread deterioration of environmental ecosystems and the convening of the United Nations Conference on the Human Environment in Stockholm, Sweden in 1972 (Stockholm Conference) marked the start of a modern global environmental movement, including the establishment of the United Nations Environment Programme. A decade later, with no significant improvements in various global environmental problems, the Brundtland Commission was founded in 1983, popularizing the term "sustainable development" after the release of its Brundtland Report. Another decade later, after realizing that global environmental challenges needed worldwide cooperation among nations, the United Nations Conference on Environment and Development (Earth Summit) was held in Rio de Janeiro, Brazil in 1992. A significant achievement of the Earth Summit was the formation of the United Nations Framework Convention on Climate Change (UNFCCC) which, in turn, led to the Kyoto Protocol in 1997 and the Paris Agreement in 2015.

The Paris Agreement aimed to maintain the rise in global average temperature at 2 °C above pre-industrial levels, in an attempt to substantially reduce the effects of climate

change. In order to achieve the above aim, significant improvements needed to be implemented regarding personal environmental behaviors. Working alongside other environmental stakeholders, environmental education programs served to increase awareness, influence attitudes, strengthen norms and efficacy, as well as improve actual environmentally friendly behavior.

Traditional environmental educators employed the Bloom taxonomy [1] of educational learning whereby environmentally friendly behavior was achieved via the interactions between the cognitive, affective and psychomotor domains of learning, although the taxonomy was criticized for lacking a systematic rationale of construction [2]. Another widely used educational theory is the Hungerford learning method [3], whereby environmental education imparted knowledge and raised awareness regarding environmental protection; in turn, this changed attitudes, leading to better environmentally friendly decisions and behaviors. This "Knowledge-Attitudes-Behavior" theory was widely challenged after more than twenty years of research [4] due to its narrow definition of education. In addition, the ABC theory of emotions [5] used in environmental education—emphasizing that an activating event did not directly cause any consequence, but rather, the belief regarding that event did—was often a focus of criticism due to a lack of conceptually discrete definitions of constructs, as well as the overlapping definitions between activating events, beliefs and consequences [6]. Recently, drawing upon research in environmental economics, psychology and sociology, environmental education programs were positioned as part of broader cultural and social movements that included knowledge and attitudes, as well as norms, identity, efficacy, connections and trust [7].

Traditionally, there were three approaches to environmental education. Education about the environment approached the environment as a scientific topic and aimed to improve awareness, knowledge and understanding of the human–environmental interface. Education about the environment used the outdoor environment as a teaching medium, encouraging awareness and concern through personal interaction with nature. Education about the environment developed a sense of responsibility and active participation in the resolution of environmental issues using an issue-based approach. As all three of the mentioned approaches were unable to fully complete the cycle of awareness, knowledge, understanding, concern, responsibility, action, and back to awareness in the area of environmental education, these approaches were integrated into a threefold approach, forming an education about, in and for the environment [8]; this has been widely adopted in Taiwan's current environmental education [9].

This research aimed to employ a theory-of-change approach to design an environmental education program which incorporated the above-mentioned threefold approach, where in-class lessons sought to improve the awareness and attitudes of university undergraduates. The outdoor environment was used as a teaching medium to improve personal interaction with existing environmental problems, as well as to develop active participation in changing their personal environment-related behaviors in order to contribute toward reducing carbon emission. The undergraduates were separated into an Experimental Group and a Control Group in order to examine whether the designed environmental education program was successful in improving their environmentally friendly behavior.

2. Literature Review

The integrated approach to environmental education has become an important area of research, with the environmental behaviors of undergraduates becoming a promising area of research, as they play an important role in protecting the environment in the future. Teksoz et al. [10] proposed an environmental literacy components model in order to understand the relationships between environmental knowledge, attitudes, responsibility and concern, as well as outdoor activities among Turkish undergraduates. Using structural equation modeling, environmental knowledge was found to significantly pre-

dict environmental concern, attitudes, and responsibility, while having significantly indirect relationships with environmental attitudes and responsibility. Vicente-Molina et al. [11] examined the influences of environmental knowledge, education, gender, motivation, attitudes and perceived effectiveness on environmental behavior among undergraduates from America, Spain, Mexico and Brazil. The survey results showed that motivation and perceived effectiveness were significant factors in influencing environmentally friendly behavior.

Surveying undergraduates from separate universities from Spain, Brazil and the United Arab Emirates, Chuvieco et al. [12] found that undergraduates from environment-related majors had better environmentally friendly behavior, while their country of origin had no significant effects. Liang et al. [13] conducted an environmental literacy survey among undergraduates in Taiwan, showing no significant correlations between knowledge and attitudes, or between knowledge and behavior, although stronger environmental attitudes were significantly correlated with behaviors. Jurdi-Hage et al. [14] examined the environmentally friendly behavior of undergraduates from a Canadian University and found that convenience and habits played significant roles in improving undergraduates' environmentally friendly behavior. Zhao et al. [15] asked undergraduates from Macau, China about their awareness, attitudes, knowledge and behaviors regarding energy saving. More than 90% of students surveyed understood the importance of energy saving. However, less than 10% of students participated in energy-saving activities, while around 20% of students never participated in any energy-saving activities.

Hansmann et al. [16] tried to determine the environmentally friendly behavior of the students and staff of the Swiss Federal Institute of Technology, Lausanne. Results from an online survey showed that gender, age and class standings had a positive correlation with environmentally friendly behavior. Balinska et al. [17] tried to understand the role of eco-friendly mobile applications on the environmentally friendly behavior of undergraduates in Poland. The results showed that applications widely promoted in traditional media gained stronger recognition, while statistically, females understood the usefulness of these applications better then males. Grodek-Szostak et al. [18] surveyed undergraduates from Poland, Ukraine and the Czech Republic in order to understand their awareness and behaviors in energy conservation, where the results showed that roughly 60% of undergraduates followed the principles of energy conservation, although their behaviors varied across countries. Leiva-Brondo et al. [19] attempted to understand the awareness and perception of sustainable development goals (SDGs) of Spanish undergraduates, reporting that only 15.9% of those surveyed had a good understanding of SDGs and the sustainability literacy level was 63%, indicating a lack of knowledge.

The impacts of environmental education programs on environmentally friendly behavior [20–22] are a constant topic of research, with residents as the majority of targeted audiences [23–25], although the impacts of environmental education programs on undergraduates are a growing area of research. Hse [26] conducted an environmental education program during an entire semester on a class of undergraduates. The results showed that the undergraduates had stronger environmentally friendly behaviors after the Program, which were further maintained after two months. By providing accurate and useful environment-related information to the students and staff of Fudan University, Jiang et al. [27] found that combined with supporting low-carbon management, environmental awareness improved, which led to stronger environmentally friendly behavior.

Dupre and Meineri [28] displayed a persuasive message, feedback chart and social comparative feedback chart of recycled weights within three cafeterias in a French university, respectively. The results showed that only the social comparative feedback approach statistically increased recycling behaviors which continued even after the feedback was removed. Godfrey and Feng [29] examined the effectiveness of an environmental education program within a university whereby a communication campaign was

designed to showcase the water footprint of food available in the campus dining hall, in an attempt to improve environmentally friendly behavior in food consumption. The results showed that food consumption behaviors did not change significantly, due to the preference for convenience and time pressure over environmental protection.

Cosic et al. [30] found that raising awareness and including an external descriptive social norm successfully improved the recycling rate of plastic coffee cups within a university in Italy. Moreover, by reducing the size of the rubbish bin and maintaining a relatively bigger recycling bin, the recycling rate was successfully "nudged" to almost 98%. Similarly, Poortinga and Whitaker [31] installed environmental awareness posters at twelve universities and business cafeterias to determine their influences on the usage of reusable coffee cups. Together with the charging of disposable cups, the usage of reusable coffee cups increased by 33.7%.

Henkel et al. [32] focus on strengthening undergraduates' environmentally friendly behavior by employing "nudging" in the field of green information systems. The results showed that the Experimental Group undergoing nudging with status quo bias improved their environmentally friendly behavior. Using prompts and support cues, Leoniak and Cwalina [33] found that an injunctive norm successfully induced the energy saving behavior of undergraduates in terms of switching off lights after leaving the restrooms. Telesiene et al. [34] attempted to understand the impact of an intervention course, "Sustainable Development", using the competence–learning–intervention–assessment model. The Environmental Citizenship Questionnaire was used, which includes questions regarding environmental knowledge, attitudes and values, as well as connections with nature. The pre- and post-test results showed a significant improvement in the mean values of students' scores.

From the review of existing literature, the framework for environmental education programs, which lead to improved environmentally friendly behavior in undergraduates, needs to be further developed. This research attempts to construct a theory of change [7,35–39] involving in the improvement of undergraduates' environmental awareness, attitudes, norms and efficacy, as well as an increase in environmentally friendly behavior as the ultimate environmental outcome, in order for stakeholders to learn from experience and continue to challenge existing assumptions; the following hypotheses are proposed:

Hypothesis 1 (H1): The Tzu Chi University Environmental Education Program's lessons involving environmental and sustainability topics will significantly improve the environmental awareness and attitudes of undergraduates from the Experimental Group.

Hypothesis 2 (H2): The Tzu Chi University Environmental Education Program's personal interaction of recyclables sorting at a recycling center, as well as active participation and documentation of personal environmentally friendly behavior, will significantly improve the environmental norms and efficacy of undergraduates from the Experimental Group.

Hypothesis 3 (H3): By significantly improving the environmental awareness, attitudes, norms and efficacy of undergraduates from the Experimental Group, the Tzu Chi University Environmental Education Program will significantly improve their environmentally friendly behavior.

3. Methodology

As shown in Table 1 and Figure 1, Tzu Chi University's Environmental Education Program was designed and based on its theory of change. The Environmental Education Program consisted of nine weeks of compulsory lessons and assignments (known as "activities" within our theory-of-change framework); these involved various environmental and sustainability topics, aiming to improve undergraduates' environmental

awareness, attitudes, norms, efficacy (known as "capacity changes" within our theory-of-change framework), which, in turn, aimed to improve environmentally friendly behavior (known as "behavioral changes" within our theory-of-change framework). The first four weeks of lessons was conducted on a weekly basis over a period of two hours, wherein topics included global warming, sustainable development, plant-based diet and climate-change-induced disasters. The first assignment consisted of arranging for undergraduates to visit a local recycling center and participate hands-on in the sorting of recyclables. The next four weeks of assignments consisted of weekly documenting of the efforts and challenges faced while seeking to improve their environmentally friendly behavior.

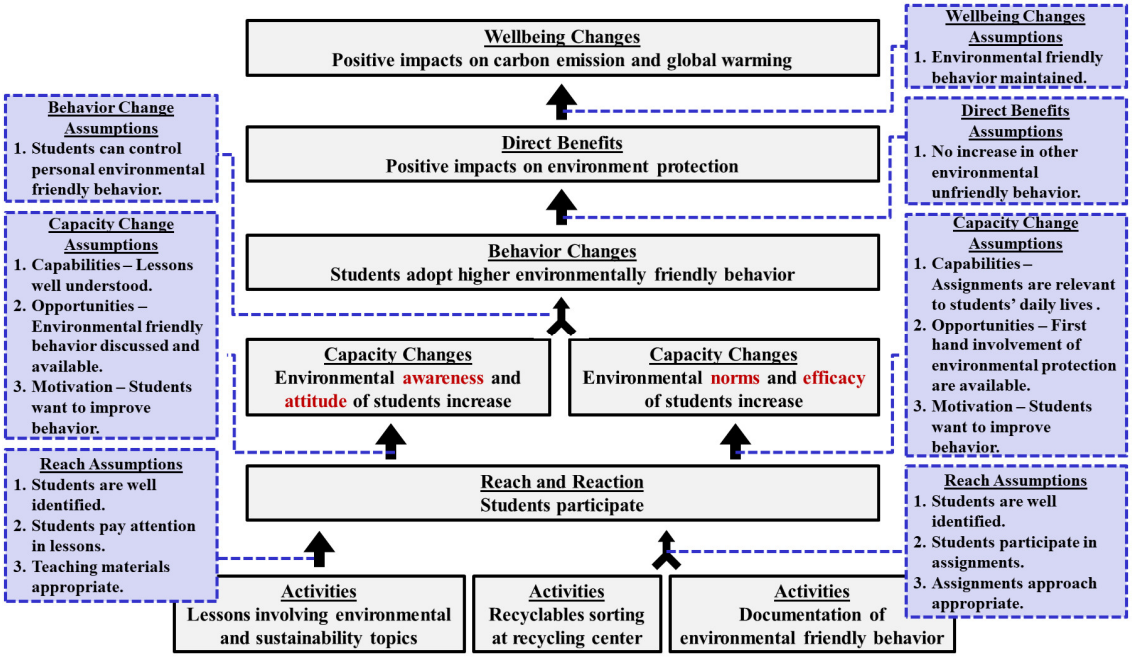

Figure 1. Tzu Chi University Environmental Education Program and its theory of change.

Table 1. Tzu Chi University Environmental Education Program.

Week		Topics
1	Lesson	Introduction to global warming and sustainable development
2	Lesson	Introduction to plant-based diet and its effects on environmental protection
3	Lesson	Climate-change-induced disaster: technology-assisted disaster relief
4	Lesson	Climate-change-induced disaster: case study of cyclone Idai and its effects
5	Assignment	Hands-on recyclables sorting at a recycling center
6–9	Assignment	Weekly documentation of individual environmentally friendly behavior

All freshmen of Tzu Chi University were required to enroll in two freshmen courses: "Education for Life" during the first semester and "Tzu Chi Humanities and Service Learning" for the second semester; each course was further separated into 15 classes. The Control Group consisted of 87 freshman undergraduates, predominately from the department of Nursing (two classes) while the Experimental Group (known as "reach and reaction" within our theory-of-change framework) consisted of 142 freshman undergraduates from the departments of molecular biology and human genetics, human

development and psychology, communication studies, English language and literature, as well as international service industry management (three classes). Undergraduates were informed beforehand about the Environmental Education Program, and were free to switch to another 10 classes not involved in this research. Undergraduates from the Experimental Group underwent the entire Environmental Education Program while undergraduates from the Control Group only participated in hands-on recyclables sorting at a recycling center.

This research employed the parallel mixed methods of research, whereby qualitative and quantitative data were collected and analyzed concurrently [40]. Qualitative data were written thoughts submitted by the undergraduates at the end of each lesson and assignment, while quantitative data were survey findings. As a quasi-experimental design, the respondents of the Control Group and Experimental Group were not randomly selected, and hence, there was a possibility that undergraduates from the Experimental Group were more open to environmental protection. Furthermore, as direct or indirect observations were not carried out due to their heavy demands on manpower, another limitation of this research was that only self-reported feedback and survey responses were collected.

In total, 289 written thoughts regarding the first four weeks of lessons were collected from the Experimental Group. At the same time, 127 written thoughts regarding the assignment of "hands-on recyclables sorting at a recycling center" and 121 written thoughts regarding the assignment of "weekly documentation of individual environmentally friendly behavior" were collected from the Experimental Group.

The criteria for the theory-of-change analysis involved well-defined and measured results following a logical sequence within a plausible timeframe [35–39]. The Environmental Education Program was administrated within the plausible timeframe of the academic year 2021/2022, where pre-tests and post-tests using the survey were conducted. Undergraduates from those 5 classes made up around 35% of the entire cohort of freshmen and voluntarily participated in answering the surveys. For the Control Group, 78 valid pre- and post-tests result (90% response rate) were obtained, while for the Experimental Group, 116 valid pre- and post-test results (82% response rate) were obtained, with both groups fulfilling the 5% margin of error at a 95% confidence level.

The pre-tests and post-tests were identical surveys (shown in Appendix A) performed online, thus ensuring a logical sequence. SurveyCake, which is frequently used as a survey tool in Taiwan, had "required questions" built in to ensure the quality of answers. Since all the questions were required questions in the online surveys, there were no missing data. The design of the survey underwent a pilot-test of 20 personnel to assess its validity and identify unresolved ambiguities, and the content of the survey was later modified based on feedback obtained.

The survey consisted of two sections, with a total of 30 questions. The first section had a total of five questions, collecting basic demographic data (as shown in Table 2) which included gender, national identification number (last four digits), age, department of studies, and nationality. The last four digits of the national identification number, which were not known to those involved in this research, and hence, did not compromise the anonymity of the questionnaire participant, were used to match undergraduates' pre- and post-test responses. The second section had a total of 25 questions and was further divided into five constructs, attempting to understand the environmental awareness, attitudes, norms, efficacy and behavior of undergraduates. Each construct, as shown in Table 3, was rated based on five-point Likert scale questions, whereby 1 indicated "strongly disagree" or "never" and 5 indicated "strongly agree" or "always", producing well-defined and measured results. The measures of norms and efficacy were modified from previous studies [41–45], while the measures of environmental awareness, attitudes and behavior were created based on previous studies [43–47] and discussions with university personnel involved with environment protection policies.

Table 2. Basic demographic of survey samples.

Variables	Control Group		Experimental Group	
	n = 78	%	n = 116	%
Gender				
Male	13	16.6%	38	32.8%
Female	64	82.1%	78	67.2%
Declined to disclose	1	1.3%	-	-
Age				
19	38	48.7%	54	46.6%
20	29	37.2%	48	41.4%
21	6	7.7%	7	6.0%
22	2	2.6%	4	3.4%
≥23	3	3.8%	3	2.6%
Department of				
Nursing	75	96.2%	-	-
Molecular biology and human genetics	-	-	28	24.1%
Human development and psychology	-	-	28	24.1%
Communication studies,	-	-	27	23.3%
English language and literature	-	-	12	10.3%
International service industry management	-	-	10	8.6%
Others	3	3.8%	11	9.5%
Nationality				
Republic of China (Taiwan)	75	96.2%	107	92.2%
Others	3	3.8%	9	7.8%

Table 3. Mean and standard deviation of survey items.

Item	Control Group						Experimental Group					
	Pre-Test			Post-Test			Pre-Test			Post-Test		
	Mean	S.D.	*r*	Mean	S.D.	*r*	Mean	S.D.	*r*	Mean	S.D.	*r*
Awareness												
A1.	4.54	0.935	0.709	4.41	0.859	0.781	4.61	0.669	0.656	4.69	0.501	0.703
A2.	4.37	0.775	0.696	4.35	0.770	0.800	4.54	0.638	0.806	4.57	0.515	0.812
A3.	4.32	0.655	0.732	4.28	0.643	0.859	4.41	0.710	0.721	4.55	0.565	0.779
A4.	4.35	0.680	0.706	4.29	0.723	0.730	4.40	0.696	0.776	4.55	0.623	0.812
A5.	4.29	0.723	0.728	4.15	0.774	0.752	4.37	0.679	0.740	4.48	0.639	0.809
Attitude												
T6.	4.53	0.528	0.850	4.37	0.584	0.762	4.45	0.637	0.888	4.56	0.579	0.860
T7.	4.27	0.617	0.807	4.27	0.678	0.895	4.41	0.633	0.891	4.50	0.611	0.883
T8.	3.90	0.731	0.788	3.95	0.754	0.812	4.08	0.759	0.863	4.27	0.773	0.887
Norms												
N9.	4.18	0.679	0.728	4.10	0.815	0.675	4.10	0.848	0.731	4.30	0.760	0.777
N10.	3.83	0.763	0.764	3.99	0.730	0.756	3.95	0.903	0.826	4.24	0.787	0.793
N11.	3.45	0.878	0.790	3.63	0.955	0.776	3.66	0.845	0.808	3.94	0.887	0.818
N12.	3.81	0.722	0.835	3.87	0.812	0.822	3.89	0.810	0.878	4.11	0.755	0.905
Efficacy												
E13.	2.86	1.003	0.758	3.09	1.153	0.863	3.16	1.046	0.837	3.55	1.074	0.821
E14.	3.64	0.882	0.827	3.88	0.853	0.763	3.88	0.846	0.823	4.24	0.809	0.812
E15.	3.83	0.932	0.814	3.94	0.873	0.817	4.03	0.849	0.824	4.24	0.753	0.824
Behavior												

B16.	3.60	1.049	0.494	3.56	1.076	0.469	3.53	1.067	0.433	4.02	0.769	0.484
B17.	4.17	0.918	0.678	4.14	0.922	0.751	4.14	0.932	0.567	4.55	0.609	0.503
B18.	3.78	0.878	0.608	3.72	0.938	0.681	3.91	0.965	0.645	4.28	0.800	0.648
B19.	4.46	0.863	0.563	4.19	1.033	0.613	4.48	0.818	0.518	4.57	0.688	0.493
B20.	3.79	0.985	0.574	3.76	1.095	0.664	3.72	1.124	0.513	3.93	1.069	0.650
B21.	3.32	1.087	0.474	3.38	1.154	0.681	3.46	1.091	0.633	3.89	0.949	0.752
B22.	3.14	1.102	0.529	3.44	1.088	0.753	3.29	1.072	0.752	3.76	0.929	0.819
B23.	4.04	0.986	0.562	4.05	0.938	0.776	4.21	0.860	0.554	4.27	0.858	0.657
B24.	3.81	0.757	0.615	3.55	1.065	0.780	4.12	0.876	0.632	4.10	0.784	0.742
B25.	2.76	1.164	0.517	2.58	1.212	0.587	2.78	1.259	0.534	3.31	1.058	0.525

Note: r refers to Pearson correlation value, where the corresponding critical Pearson correlation value for the Control Group and Experimental Group are $r_c = 0.223$ (degrees of freedom = 76) and $r_c = 0.182$ (degrees of freedom = 114), respectively, for a significance level of 0.05 (two-tailed). All values of r are significant at *** $p < 0.001$.

To analyze the collected data, descriptive statistics were carried out using the software tool SPSS 25.0 [48]. As the five-point Likert scale was of ordinal scale, non-parametric statistical testing was performed. Wilcoxon rank-sum test (between the Control Group and Experimental Group) and Wilcoxon signed-rank test (between pre- and post-test), which were identified according to the last four digits of the national identification numbers of the undergraduates, were performed at a 95% confidence interval, with the null hypotheses stating that the difference between the population means was equal to zero.

4. Findings and Discussion

4.1. Theory of Change for the Environmental Education Program

In order for our theory of change to be feasible, the assumptions shown in Figure 1 needed to be well defined, justified, realizable and measurable [35–39]. Within the "reach" assumption, undergraduates from the Experimental Group were well defined, realizable and measurable, as they were registered for the courses throughout the semesters. Furthermore, the rates of attendance to lessons and assignments handed in were above 90%. Regarding the "capacity changes" assumption, more than 70% of undergraduate feedback stated "very satisfied" regarding the topic and content of the lessons conducted, according to the five-point Likert scale.

Opportunities for recyclables sorting within the local recycling center were also constantly available due to the high number of recyclables sent in daily, as shown in Figure 2. The undergraduates performed hands-on recyclables sorting within the semi-enclosed spaces of the recycling center, and remarked, in their written thoughts, that most of the plastic bottles gave off a pungent smell as they were unwashed before recycling. Furthermore, most of the recycled plastic bottles were bottled water instead of other beverages, and undergraduates realized that using water bottles filled with plain water would have significantly reduced the production of plastic bottles.

Figure 2. Undergraduates performing hands-on recyclables sorting within the recycling center.

The "behavior change" assumption that undergraduates could control their personal environmentally friendly behavior was found to be justified, realizable and sustainable, as more than 90% of undergraduates from Tzu Chi University stayed in university dormitories with freshmen from the same major assigned among each other as roommates. Hence, away from senior family members and together with roommates participating in the Environmental Education Program, undergraduates from the Experimental Group could independently control their personal environmentally friendly behavior. The "direct benefits" assumption was also found to be well defined, justified and realizable, as the ten environmentally friendly behaviors used during the weekly assignment and survey were common behaviors within the local setting and, after discussion, with undergraduates and various stakeholders. Finally, the "wellbeing changes" assumption was well defined, justified and measurable, as the post-test survey was conducted two weeks after the end of the Environmental Education Program.

4.2. Statistical Analysis of Surveyed Results

With respect to the results of the pre- and post-test, the mean, standard deviation and Pearson correlation values of the survey items are presented in Table 3, while the Cronbach's alpha, mean and standard deviation of each construct are presented in Table 4. The Cronbach's alpha values across the various groups and tests were greater than 0.7 [47] and ranged from 0.713 to 0.879, indicating excellent internal consistency reliability of the scales. At the same time, the Pearson correlation values across the various groups and tests were greater than the critical Pearson correlation values r_c of 0.223 (degrees of freedom = 76 for the Control Group) and 0.182 (degrees of freedom = 114 for the Experimental Group), respectively, indicating strong validity.

Table 4. Cronbach's alpha, mean and standard deviation of survey constructs.

Item	Control Group						Experimental Group					
	Pre-Test			Post-Test			Pre-Test			Post-Test		
	α	Mean	S.D.	α	Mean	S.D.	α	Mean	S.D.	α	Mean	S.D.
Awareness	0.751	4.37	0.538	0.838	4.30	0.590	0.792	4.47	0.502	0.841	4.57	0.447
Attitudes	0.728	4.23	0.508	0.758	4.20	0.554	0.849	4.31	0.595	0.840	4.44	0.574
Norms	0.780	3.82	0.593	0.747	3.90	0.627	0.825	3.90	0.690	0.839	4.15	0.656
Efficacy	0.713	3.44	0.750	0.740	3.64	0.786	0.764	3.69	0.757	0.735	4.01	0.720
Behavior	0.747	3.69	0.544	0.863	3.64	0.707	0.772	3.76	0.581	0.828	4.07	0.541

For the environmental awareness construct, the average scores for all items were above 4.15, with standard deviations ranging from 0.501 to 0.935, showing that undergraduates have high environmental awareness. The pre- and post-test average scores for the Control Group for environmental awareness were 4.37 and 4.30 (as shown in Table 4), with the Wilcoxon signed-rank test showing no significant average difference (z_{76} = −1.123, p = 0.261, as shown in Table 5) at the 95% confidence interval. However, the pre- and post-test average scores for the Experimental Group for environmental awareness were 4.47 and 4.57 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference at the 95% confidence interval (z_{114} = −2.758, p < 0.01, as shown in Table 6).

Table 5. Wilcoxon signed-rank tests between pre- and post-test for the Control Group.

Construct	Test	Mean	S.D.	*z*-Value	*p*-Value
Awareness	Pre-test	4.37	0.538	−1.123	0.261(NS)
	Post-test	4.30	0.590		
Attitudes	Pre-test	4.23	0.508	−0.915	0.360(NS)
	Post-test	4.20	0.554		
Norms	Pre-test	3.82	0.593	−1.484	0.138(NS)
	Post-test	3.90	0.627		
Efficacy	Pre-test	3.50	0.657	−2.138	0.033 *
	Post-test	3.75	0.709		
Behavior	Pre-test	3.69	0.544	−0.371	0.710(NS)
	Post-test	3.64	0.707		

Note: * p < 0.05 (two-tailed), and NS means non-significant.

Table 6. Wilcoxon signed-rank tests between pre- and post-test for the Experimental Group.

Construct	Test	Mean	S.D.	*z*-Value	*p*-Value
Awareness	Pre-test	4.47	0.502	−2.758	0.006 **
	Post-test	4.57	0.447		
Attitudes	Pre-test	4.31	0.595	−2.785	0.005 **
	Post-test	4.44	0.574		
Norms	Pre-test	3.90	0.690	−4.016	0.000 ***
	Post-test	4.15	0.656		
Efficacy	Pre-test	3.76	0.739	−4.755	0.000 ***
	Post-test	4.07	0.691		
Behavior	Pre-test	3.76	0.581	−4.939	0.000 ***
	Post-test	4.07	0.541		

Note: ** p < 0.01 and *** p < 0.001, respectively (two-tailed).

Regarding the environmental attitude construct, the average scores for all items were above 3.90, with standard deviations ranging from 0.528 to 0.773, showing that undergraduates have high and consistent environmental attitudes. The pre- and post-test average scores for the Control Group for environmental attitude were 4.23 and 4.20 (as shown in Table 4), with the Wilcoxon signed-rank test showing no significant average difference (z_{76} = −0.915, p = 0.360, as shown in Table 5) at the 95% confidence interval. At the same time, the pre- and post-test average scores for the Experimental Group for environmental attitude were 4.31 and 4.44 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference (z_{114} = −2.785, p < 0.01, as shown in Table 6) at the 95% confidence interval.

The average scores for all items belonging to the environmental norms construct ranged from 3.45 to 4.30, with standard deviations ranging from 0.679 to 0.955, where undergraduates had slightly diverse views on environmental norms. The pre- and

post-test average scores for the Control Group for environmental norms were 3.82 and 3.90 (as shown in Table 4), with the Wilcoxon signed-rank test showing no significant average difference ($z_{76} = -1.484$, $p = 0.138$, as shown in Table 5) at the 95% confidence interval. Subjected to the Environmental Education Program, the pre- and post-test average scores for the Experimental Group for environmental norms were 3.90 and 4.15 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference ($z_{114} = -4.016$, $p < 0.001$, as shown in Table 6) at the 95% confidence interval.

Next, the average scores for all items from the environmental efficacy construct ranged from 2.86 to 4.24, with standard deviations ranging from 0.753 to 1.153, giving the insight that undergraduates were divided on the topic of environmental efficacy. The pre- and post-test average scores for the Control Group for environmental efficacy were 3.50 and 3.75 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference ($z_{76} = -2.138$, $p < 0.05$, as shown in Table 5) at the 95% confidence interval. As undergraduates from the Control Group only participated in hands-on recyclables sorting at a recycling center, this exposure prompted undergraduates to realize that they had the capacity to contribute to environmental protection. Similarly, the pre- and post-test average scores for the Experimental Group for environmental efficacy were 3.76 and 4.07 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference ($z_{114} = -4.016$, $p < 0.001$, as shown in Table 6) at the 95% confidence interval.

Finally, the average scores for all items from the ultimate outcome of environmentally friendly behavior construct ranged from 2.58 to 4.57, with standard deviations ranging from 0.609 to 1.259, giving the insight that undergraduates had a wide range of environmentally friendly behavior. The pre- and post-test average scores for the Control Group for environmentally friendly behavior were 3.69 and 3.64 (as shown in Table 4), with the Wilcoxon signed-rank test showing no significant average difference ($z_{76} = -0.371$, $p = 0.710$, as shown in Table 5) at the 95% confidence interval. However, the pre- and post-test average scores for the Experimental Group for environmentally friendly behavior were 3.76 and 4.07 (as shown in Table 4), with the Wilcoxon signed-rank test showing a significant average difference at the 95% confidence interval ($z_{114} = -4.939$, $p < 0.001$, as shown in Table 6).

In addition, when the Control and Experimental Groups, together with pre- and post-test, are compared based on the average of all constructs within the surveys, the results indicate meaningful and significant differences, as seen in Figure 3 and Table 7. The Wilcoxon rank-sum test at the 95% confidence interval revealed that no significant average differences were found between the pre-tests of the Control Group and Experimental Group ($z = -1.345$, $p = 0.179$). Likewise, no significant average differences were found in the Wilcoxon signed-rank test between pre- and post-test of the Control Group ($z_{76} = -0.141$, $p = 0.888$). However, the post-test of the Experimental Group displayed a significantly higher average value when compared to both the pre-test of the Experimental Group ($z_{114} = -5.623$, $p < 0.001$) and the post-test of the Control Group ($z = -4.708$, $p < 0.001$).

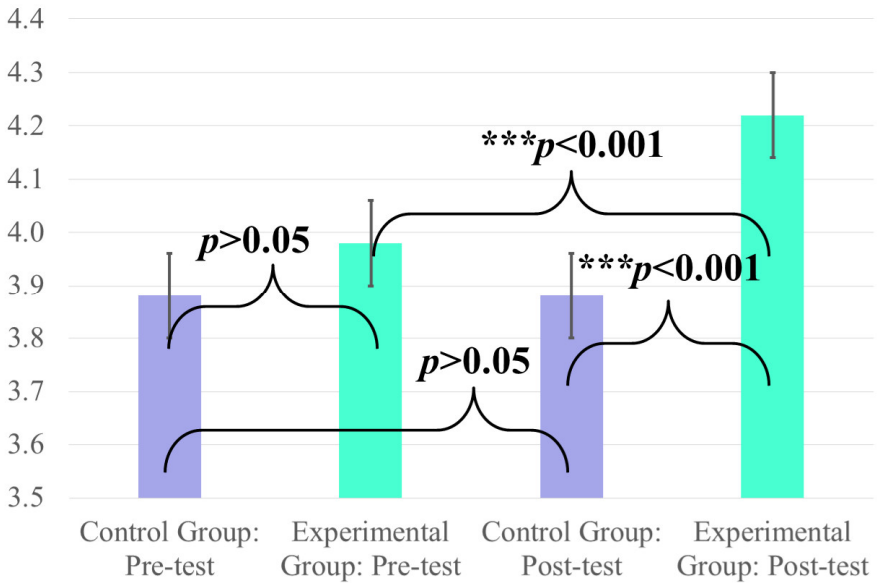

Figure 3. Mean values for Control and Experimental Groups and their significance of mean differences.

Table 7. Wilcoxon rank-sum tests and Wilcoxon signed-rank tests between Control and Experimental Groups.

Construct	Test	Mean	S.D.	*z*-Value	*p*-Value
Control	Pre-test	3.88	0.411	−1.345	0.179(NS)
Experimental	Pre-test	3.98	0.450		
Control	Pre-test	3.88	0.411	−0.141	0.888(NS)
Control	Post-test	3.88	0.493		
Experimental	Pre-test	3.98	0.450	−5.623	0.000 ***
Experimental	Post-test	4.22	0.448		
Control	Post-test	3.88	0.493	−4.708	0.000 ***
Experimental	Post-test	4.22	0.448		

Note: *** $p < 0.001$, respectively (two-tailed), and NS means non-significant.

4.3. Correlations between Constructs

Statistically, the relationship between two variables was generally considered high when the magnitude of the Pearson correlation coefficient (r) was greater than 0.7; the correlation was moderate when r was between 0.5 and 0.7; the correlation was low when r was between 0.3 and 0.5; and there was no significant correlation when r was less than 0.3 [48]. As shown in Tables 8 and 9, the Pearson correlation analysis was conducted to understand the relationship between environmental awareness, attitudes, norms, efficacy and behaviors among undergraduates from Tzu Chi University. For the pre-test, 65.1% of the variability in environmental attitudes was explained by the variability in environmental awareness, while 64.7% of the variability in environmental efficacy was explained by the variability in environmental norms. Similarly, 22.7%, 38.5%, 35.6% and 32.1% of the variability in environmentally friendly behavior was explained by the variability in environmental awareness, attitudes, norms and efficacy, respectively. For the post-test, 81.6% of the variability in environmental attitudes was explained by the variability in environmental awareness, while 73.3% of the variability in environmental efficacy was explained by the variability in environmental norms. Furthermore, 38.3%, 49.1%, 44.1% and 29.7% of the variability in environmentally friendly behavior was explained by the variability in environmental awareness, attitudes, norms and efficacy, respectively.

Table 8. Correlations among constructs for Experimental Group (pre-test).

Pearson, *r*	Awareness	Attitudes	Norms	Efficacy	Behavior
Awareness	1				
Attitudes	0.651 ***	1			
Norms	0.485 ***	0.646 ***	1		
Efficacy	0.368 ***	0.599 ***	0.647 ***	1	
Behavior	0.227 *	0.385 ***	0.356 ***	0.321 ***	1

Note: * $p < 0.05$ and *** $p < 0.001$, respectively (two-tailed).

Table 9. Correlations among constructs for Experimental Group (post-test).

Pearson, *r*	Awareness	Attitudes	Norms	Efficacy	Behavior
Awareness	1				
Attitudes	0.816 ***	1			
Norms	0.614 ***	0.756 ***	1		
Efficacy	0.537 ***	0.661 ***	0.733 ***	1	
Behavior	0.383 ***	0.491 ***	0.441 ***	0.297 **	1

Note: ** $p < 0.01$ and *** $p < 0.001$, respectively (two-tailed).

4.4. Discussion

By interacting with undergraduates from both the Control and Experimental Groups, as well as examining the written thoughts from the Experimental Group, a better understanding emerged. "Introduction to global warming and sustainable development" and other lessons allowed undergraduates a greater in-depth understanding of the impacts of global warming internationally, and on their future lifestyles. The trip to the "recycling center together with hands-on recyclables sorting", where they were active participants, gave undergraduates a visual insight into daily environmentally unfriendly behaviors; several undergraduates reflected upon the countless food boxes with food residuals giving off a pungent smell, and realized that it was what they did daily. This led to an increase in environmental efficacy, accounting for the statistically improvement in efficacy between the pre- and post-test of the Control Group. However, this sole improvement in efficacy in the Control Group did not continue to have an effect on environmentally friendly behavior.

In addition, undergraduates reflected that the inertia to adopt more environmentally friendly behavior was still very high; the habits of ordering takeout for meals meant that paper boxes, wooden chopsticks and plastic bags were disposed almost daily. The success of improving environmentally friendly behavior in using reusable coffee cups from Cosic et al. [30] and Poortinga and Whitaker [31], as well as the lack of improvement in the consumption of meals with a low water footprint from Godfrey and Feng [29], showed the importance of convenience, with similar results also reported by Jurdi-Hage et al. [14]. For example, the environmentally friendly behavior of "B24. During a week, I use reusable eating utensils instead of disposable eating utensils" did not improve statistically (mean of 4.12 and 4.10 for the pre- and post-test of the Experimental Group, respectively) after the Environmental Education Program, wherein written thoughts by undergraduates showed that the inconvenience of bringing a bulky reusable container for meals hampered undergraduates' willingness to be more environmentally friendly. At the same time, the environmentally friendly behavior of "B20. During a week, I walk or cycle (non-electric) for distances less than a kilometer or requiring less than 10 min" did not improve statistically (mean of 3.72 and 3.93 for the pre- and post-test of the Experimental Group, respectively) after the Environmental Education Program. As Hualien, the location of Tzu Chi University, did not have an existing public transport system, undergraduates commonly travelled using their personal motorcycles. In addition, under the hot and humid summer of Hualien, undergraduates would not

walk under the hot sun for more than 500 m or more than 5 min. These insights would be useful for future modifications to the Environmental Education Program, wherein the importance of convenience and habits regarding undergraduates' environmentally friendly behavior needs to be further incorporated.

Furthermore, forgetfulness led to the behavior of not switching off lights and other electrical appliances when not in use, and laziness led to the behavior of taking the elevator instead of stairs, even when only going up or down less than three floors. However, significant changes were observed during and after the four weeks of "weekly documentation of individual environmentally friendly behavior", wherein undergraduates realized that eating a plant-based diet instead of meat- and plant-based diet was not as unappetizing as initially thought, and improves skin complexion; constant encouragement among friends in taking the stairs instead of the elevator when only going up or down less than three floors actually resulted in a shorter commuting time; mutual reminders among roommates to switch off lights and other electrical appliances when not in use strengthened this environmentally friendly behavior. Hence, environmental efficacy was strengthened. Furthermore, the widespread usages of social media (Instagram and Facebook) by undergraduates to document their individual environmentally friendly behavior strengthened their personal and social norms, as seen from the various photos within their written thoughts (Figure 4). These constant reminders from friends and roommates, who were also participating as undergraduates from the Experimental Group, successfully fulfilled the roles of nudges and social influences, which were similar to the results in the published literature carried out by Henkel et al. [32], as well as Leoniak and Cwalina [33].

Figure 4. Photos within written thoughts of undergraduates from Experimental Group documenting their environmentally friendly behavior: (clockwise from top left) cycle for distance less than a kilometer or requiring less than 10 min; walk for distance less than a kilometer or requiring less than 10 min; take the stairs instead of the elevator when walking up/down less than three floors; use reusable bags instead of disposable bags; turn off the tap while brushing teeth; switch off electrical appliances when not in use; drink plain water instead of bottled beverages; use reusable instead of disposable eating utensils; eat plant-based diet instead of meat- and plant-based diet.

Moreover, undergraduates, indeed, sought to improve their environmentally friendly behavior after realizing the additional benefits of better skin complexion and a healthier body. As suggested in the mitochondrial free-radical theory of aging, mitochondrial free radicals are by-products of metabolism and result in oxidative damage to

cells which, in turn, is one of the major causes of aging [49,50]. Research has shown that plants are enriched with antioxidative compounds, and a plant-based diet could induce more antioxidative enzyme production in the body and in cells. Thus, a plant-based diet was able to lower oxidative stress and, subsequently, reduce the aging of skin [51,52].

The environmental education program conducted by Hsu [26] was carried out during the academic year of 1998/1999, which was more than 20 years ago, although both National Dong Hwa University and Tzu Chi University were located in Hualien, Taiwan. Furthermore, the environmentally friendly behavior reported by Hsu [26] covered the five aspects of eco-management, consumer action, persuasion, political action and legal action, while the current research only concentrated on personal individual behaviors. Hence, the basis for comparison was limited. However, the environmental education program performed by Jiang et al. [27] was implemented in the year 2010. Measures included raising environmental awareness, providing information to highlight the impact of individual changes in environmentally friendly behavior, and personal pledges to overcome personal habitual barriers, which were similar to the approach of this research. However, Jiang et al. [27] went further and included measures to overcome university-level barriers for greater environmentally friendly behavior, as well as long-term systematic commitment towards environmental protection. For instance, the open display of the consumption of energy and water in various buildings within the campus, as well as monetary discounts for energy and water savings, could be implemented within Tzu Chi University to complement the current Environmental Education Program.

5. Conclusions

In the context of environmental education, researchers are going beyond the narrow "Knowledge-Attitudes-Behavior" theory, and instead, are emphasizing the importance of connecting the influences of environmental education programs and their wider impacts on environmental behavioral changes. This study provided a response to this direction of study by investigating the influence of a unique Environmental Education Program developed by Tzu Chi University, to target the characteristics of environmentally friendly behavior using a holistic and multidisciplinary approach, as well as implementing various teaching methods associated with developing environmental awareness, attitudes, efficacy and norms.

The results showed that the self-reported environmental awareness, attitudes, norms, efficacy and behavior of undergraduates significantly improved statistically after participating in the Environmental Education Program, as seen from the increase in the mean values among all constructs between the pre- and post-test of the Experimental Group. Statistical analysis and written thoughts from undergraduates revealed that lessons from the Environmental Education Program, showcasing real-life instances of the destructive impacts of global warming and climate change from all over the world, significantly increased the environmental awareness and attitudes of undergraduates from the Experimental Group, thus allowing us to accept Hypothesis 1. Together with encouragement and reminders from friends within the Environmental Education Program and via social media, the trip to the "recycling center together with hands-on recyclables sorting" and four weeks of "weekly documentation of individual environmentally friendly behavior" significantly strengthened the environmental efficacy and norms of undergraduates from the Experimental Group, thus allowing us to accept Hypothesis 2. Regarding Hypothesis 3, although low correlations were observed between environmental awareness, attitudes, norms, efficacy and environmentally friendly behavior among undergraduates from the Experimental Group, the Environmental Education Program significantly improved their awareness of the importance of environmental protection, changed their environmental attitudes, and increased their environmental norms and efficacy towards physical participation; finally, there was also a significant improvement in their environmentally friendly behavior.

However, it is important to note that self-reporting of surveys ran the risk of undergraduates having different interpretations of the five-point Likert scale or not being honest regarding their environmentally friendly behavior. Another limitation of the study lies in its execution during the COVID-19 pandemic, where many eateries stopped the usage of reusable eating utensils, and instead, provided disposable eating utensils out of public health concerns. Indeed, out of hygiene concerns, undergraduates also preferred to use those disposable eating utensils provided by the eateries, or use personal reusable utensils if they carry them with them. This overarching concern due to the COVID-19 pandemic did not enable undergraduates to fully realize their potential in improving their environmentally friendly behavior. Furthermore, the lack of direct or indirect observations meant that undergraduates not paying attention during lessons or assignments might have introduced uncertainties into the applied analysis.

Moreover, it was important to note that the unique arrangement of undergraduates staying together in the university dormitories and the compulsory nature of the Environmental Education Program fostered an ambience that encouraged and maintained the assumptions of our theory-of-change framework. In view of the aim of connecting undergraduates' environmentally friendly behavior and the Tzu Chi University's Environmental Education Program, it is important to repeat this study with improved and modified assumptions. Future research could expand the sample sizes to the majority of the freshman population, further randomizing the selection of freshmen for the Experimental Group, as well as arrange interviews and direct or indirect observations for selected participants in order to strengthen the process of data collection. Lastly, a delayed post-test could be arranged in order to determine whether the undergraduates' environmentally friendly behavior was retained after two months of the completion of the Environmental Education Program. This might allow clearer identification of the influences of the specific constructs of the Program.

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Informed Consent Statement: All subjects gave their informed consent for inclusion before they participated in the study.

Data Availability Statement: The dataset will be provided upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Survey Items

	Section 1: Basic Demographics
1.	Gender
2.	Last four digits of the national identification number
3.	Age
4	Department of studies and level
5.	Nationality
	Section 2: Constructs
A1.	Global warming is happening
A2.	Global warming caused climate change
A3.	Environmental protection allows human to co-exist with the Earth
A4.	Sorting of rubbish is beneficious for the environment
A5.	Green products benefit the environment
T6.	I believe that environmental protection is very important

T7. I will protect our Earth's environment
T8. I am glad to adopt environmental protection behaviors
N9. Environmental protection is a moral issue
N10. My friends and family supported me in concerning about environmental protection
N11. Environmental protection allowed me to find extra meaning in life
N12. My friends and family supported me in adopting environmental protection behaviors
E13. I have sufficient money to protect the environment
E14. I have limitless potential in protecting the environment
E15. It is mostly up to me whether I adopt environmental protection behaviors
B16. During a week, I drink plain water instead of bottled beverages
B17. During a week, I eat in moderation and do not waste food
B18. During a week, I switch off lights and other electrical appliances when not in use
B19. During a week, I turn off the tap while brushing my teeth
B20. During a week, I walk or cycle (non-electric) for distances less than a kilometer or requiring less than 10 min
B21. During a week, I take the stairs instead of using the elevator when walking up/down less than three floors
B22. During a week, I use reusable bags instead of disposable bags
B23. During a week, I sort my rubbish according to regulations
B24. During a week, I use reusable eating utensils instead of disposable eating utensils
B25. During a week, I eat a plant-based diet instead of meat and plant-based diet

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