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Differences in Water-Saving Behaviors Among College Students: Research Based on the Theory of Planned Behavior

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Abstract: The implementation of water-saving methods has become imperative in college water management to facilitate the promotion of the sustainable growth of water resources within educational institutions. This research aimed to identify differences in water-saving behaviors (WSBs) among college students due to different environmental education in their schools and to determine the corresponding driving factors. The specific steps were as follows: Firstly, specific factors based on the theory of planned behavior (TPB) and specific WSBs were selected for conducting a questionnaire. Then, 347 college students from HUE's School of Water Conservancy and Hydroelectric Power (S1) and School of Mathematics and Physics (S2) were surveyed. Finally, factor analysis and gray relational analysis were utilized to analyze the data. The results show that the college students from S1 scored better in regard to three WSBs than the students from S2. This can be attributed to the better environmental education offered by S1, which improved the students' understanding of the importance of water saving. This paper highlights the differences in WSBs among college students and suggests ways for college administrators in departments concerned with course offerings, such as the Ministry of Education and the Office of Academic Affairs, to improve these behaviors.

Keywords: college students; environmental education; water-saving behaviors; the theory of planned behavior

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1. Introduction

Water is a vital natural resource and a finite commodity. In the contemporary world, water scarcity has become an increasingly serious environmental issue due to rapid economic development and population growth [1,2]. The United Nations' *2030 Agenda for Sustainable Development* predicts that 79 countries worldwide will experience drought as a result of water shortages [3]. Additionally, 2.3 billion people lack adequate access to fresh water, and nearly 1.4 billion lack enough drinking water [4]. At the same time, it is projected that by the year 2050, over 5 billion individuals will be confronted with the challenge of water scarcity on a worldwide scale, according to the World Meteorological Organization [5]. Faced with serious water shortages, countries around the world have adopted many methods, such as financial incentives [6], water resources allocation [7], water-saving management contracts [8], and so on, to alleviate their water shortage problems. Improving individuals' water-saving behaviors (WSBs) is an easy method to implement, and so it has featured widely in many areas [9] and has been adopted by various countries.

Among the key groups of WSBs, colleges possess attributes akin to a substantial volume of water and are intricate water consumers [10]. Furthermore, as college students constitute a significant demographic within educational institutions, their level of awareness and adoption of WSBs can serve as an indicator of the overall state of water conservation efforts in colleges. And, in comparison to other key groups engaged

in water-saving initiatives, college students exhibit a higher degree of efficiency in their WSBs. Therefore, the study of WSBs among college students is the main priority in research on water saving in colleges, which is necessary to alleviate the water shortage problem. Meanwhile, with the development of higher education in China, college students are increasingly numerous. According to the statistics of the Ministry of Education in China, the number of college students in China reached 47,631,900 in 2023. In addition, the National Development and Reform Commission and the Ministry of Water Resources of China simultaneously published the *National Water-saving Action Plan* in 2019, which included a proposal to construct water-saving colleges. This shows that water saving has become a key problem in China's colleges. Therefore, for the water resources management of China's colleges, it is essential to identify the specific factors affecting WSBs among college students.

In recent years, research on the WSBs of college students has mainly focused on discovering driving factors and specific patterns. Scholars have conducted research on the impact of sociodemographic characteristics, situational factors, environmental traits, psychological traits, and the strategies of colleges in regard to the WSBs of their students [10–12]. It is evident that the research on the driving factors behind WSBs and specific patterns of WSBs among college students is comprehensive. Accordingly, some scholars have conducted research to ascertain whether there are differences in WSBs among college students at the present time. Based on the descriptive statistics method, Gao et al. showed that, in regard to college students' water-saving consciousness and behaviors, there are major differences among college students [13]. Based on Spearman correlation analysis, Augustine et al. showed that college students from Universiti Kebangsaan Malaysia (UKM) had a high level of awareness of water saving but that the implementation rate of their WSBs was low [14].

Although there is research on the differences in WSBs among college students, the existing research has the following deficiencies. Firstly, previous research has shown that there are differences in the WSBs of college students, but it has not explored the driving factors behind these differences. Secondly, due to the diversity of schools, the school where the college students are from may have an impact on their WSBs and may be the cause of different WSBs among college students from different schools, but there has been little research focused on this topic. Therefore, research should be conducted to determine whether there are differences in WSBs among college students from different schools and to discover the driving factors behind these differences. These are the objectives of this study.

In order to achieve the objectives of this paper, the main tasks are as follows: (1) to use contingency table analysis (CTA) to determine whether there are differences in WSBs and TPB factors among college students from S1 and S2; (2) to use factor analysis (FA) and gray relational analysis (GRA) to determine which TPB factors lead to differences in the WSBs of college students from S1 and S2; (3) to discuss the results of this and other research and to provide relevant recommendations for college administrators.

The innovations and contributions of this study are as follows. Firstly, this research determines whether there are differences in the WSBs of college students from different schools. Secondly, this research recognizes the precise factors behind the differences in the WSBs of college students. Thirdly, based on its findings, this research provides relevant recommendations for water-saving management in colleges. Finally, the framework of this research can serve as a reference for research into differences in other pro-environment behaviors among college students.

The methodology adopted to achieve the objectives of this paper is described in the next section.

2. Methodology

This paper sought to determine whether there are differences in WSBs among college students and to explore the driving factors behind these differences. However, these driving factors are hard to quantify, so it is necessary to decide which variables affect the WSBs and to determine whether there are differences in these variables among college

students. If there are differences in WSBs and the chosen variable among college students, the differences in this variable might lead to differences in WSBs. Among the variables that have an impact on WSBs, environmental education is an indispensable variable, and previous research has shown that it has a positive impact on WSB [4,15,16]. Based on the diversity among schools, different environmental education may be received by college students from different schools. Therefore, there may be differences in the WSBs of college students based on different environmental education. If differences exist, we can explore how different environmental education affects the differences in WSBs. Therefore, environmental education is chosen as the variable that affects WSBs in this research.

Based on the variable that this research chose, the purpose is to determine whether there are differences in WSBs among college students based on the different environmental education offered by various schools. Meanwhile, the scientific problems in this research are determining whether there are differences in the environmental education received by college students from different schools, exploring whether these differences lead to differences in the WSBs of college students, and discovering how these differences cause differences in the WSBs of college students. According to the literature review and inquiries of college students, it is found that environmental education has two major aspects related to WSBs. One aspect refers to the school curriculum and activities, such as curriculum design and school water-saving activities, and the other aspect refers to the comprehension of water-saving information among students, including the level of comprehension regarding the value of local water resources and the environmental implications of water conservation. It can be seen that these two aspects belong to the categories of subjective norms and perceived behavioral control in the theory of planned behavior (TPB).

Therefore, this study constructed a theoretical model according to the TPB to accomplish its purpose. Based on the TPB, individual behavior is influenced by behavioral intention, which is influenced by attitude, subjective norms, and perceived behavioral control [17]. According to the purpose of environmental education, it is included in subjective norms (SNs) and perceived behavioral control (PBC), two subparts for research. To guarantee the credibility and reliability of the study, this research also selected factors under the category of attitude (At). Therefore, this research conducted a questionnaire based on the theoretical model. Environmental education at the School of Water Conservancy and Hydroelectric Power (S1) of HUE is better than that at other schools, while students from the School of Mathematics and Physics (S2) of HUE come from various regions in China, and they do not have access to sufficient environmental education. Thus, the students of S1 and S2 can represent a majority of college students, so this research performed its investigation among 347 college students from S1 and S2.

CTA, FA, and GRA were used on the data from the survey to accomplish the study objectives. The following methodology was adopted, and its specific processes are shown in Figure 1.

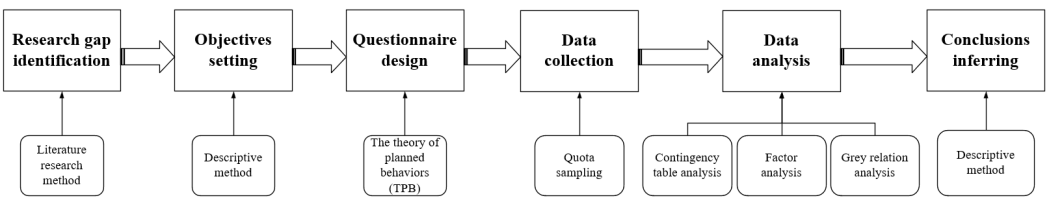


Figure 1. A flowchart of the adopted methodology.

Based on the adopted methodology, the specific theories and methods of the paper are described next.

2.1. Theories and Hypotheses

2.1.1. Theoretical Model Building

To determine whether there are differences in the WSBs of college students from different schools, the WSBs should be investigated first. Two major WSBs were selected for

research: behaviors linked to faucets and behaviors regarding washing. These behaviors can be referred to as WSBs for Faucets (WSBF) and WSBs for Washing (WSBW). The selected WSBs are shown in Table 1.

Table 1. Investigation of water-saving behaviors.

Subparts	Behaviors	Indexes
WSBF	WSBF1	The behavior of shutting off faucets quickly.
	WSBF2	The behavior of turning off faucets that are turned on by someone else.
WSBW	WSBW1	The behavior of collecting waste water when the respondents wash their clothes by hand.
	WSBW2	The behavior of rinsing less frequently when the respondents wash their clothes by hand.
	WSBW3	The behavior of washing with basins when the respondents wash their faces and rinsed their mouths.
	WSBW4	The behavior of washing more clothes at once when the respondents wash their clothes by machine.

To investigate the primary variables contributing to the disparity, the initial step is to identify the elements influencing the WSBs of college students. To examine the factors affecting WSBs among college students, it is crucial to possess a thorough grasp of the psychological characteristics linked to these behaviors [10]. Numerous social-psychological theories have been employed to elucidate the psychological attributes of WSBs, including the TPB [18], the Norm Activation Model (NAM) [19], Social Cognitive Theory (SCT) [20], Protection Motivation Theory [21], and the Health Belief Model (HBM) [22], among others. Among these theories, the TPB demonstrates substantial explanatory power in the ecological and managerial domains [23], particularly for pro-environmental behaviors, as it may demonstrate the dynamic character of human actions and establish a robust framework for elucidating behavioral complexities [17,24,25].

Furthermore, the SN component of the TPB examines the impact of external pressures on individual behavior [17], specifically investigating how various external factors, such as water-saving infrastructure or water availability in educational institutions, affect WSBs among college students. Simultaneously, the At part of the TPB examines the impact of many internal factors on WSBs among college students. Moreover, SNs and PBC are associated with environmental education. The application of the TPB in this research is deemed reasonable.

In the actual investigation, all data were collected simultaneously based on past behavior, whereas behavioral intention predominantly influences future behavior, with past behavior serving merely as a proxy for future behavior [26]. Consequently, the behavioral intention variable is excluded from the theoretical model. The theoretical model of this research is shown in Figure 2. Meanwhile, the specific variables of the TPB relevant to this questionnaire are shown in Table 2 and were derived from a literature review and inquiries of college students.

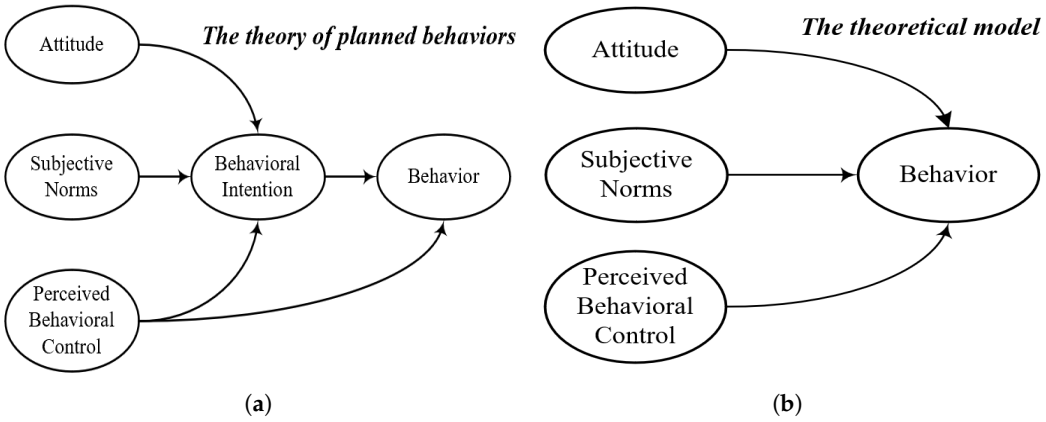


Figure 2. The specific process of the TPB and the theoretical model. (**a**) The specific process of the TPB. (**b**) The theoretical model of this research.

Table 2. Investigation of specific variables of different TPB parts.

Subparts	Variables	Indexes
At	At1	Responsibility Consciousness
	At2	Perceived Barriers
	At3	Perceived Benefits
SN	SN1	School Environment
	SN2	Curriculum Design
	SN3	Public Water-Saving
	SN4	Public Opinion
	SN5	School Water-Saving Publicity
	SN6	School Water-Saving Activities
PBC	PBC1	Value of Local Water Resources
	PBC2	Impact on the Environment
	PBC3	Impact on Life of Each Person

Among the variables in Table 2, the variables At2 and At3 are from previous research [27], and the other variables were selected based on the results of a pre-survey.

2.1.2. Research Hypotheses

Based on previous research, the hypotheses of this research are shown in Table 3.

Table 3. Hypotheses of this research.

Hypothesis	Hypothetical Content
H1a	The college students from the two schools differ in WSBF1.
H1b	The college students from S1 are better at WSBF1.
H2a	The college students from the two schools differ in WSBF2.
H2b	The college students from S1 are better at WSBF2.
H3a	The college students from the two schools differ in WSBW1.
H3b	The college students from S1 are better at WSBW1.
H4a	The college students from the two schools differ in WSBW2.
H4b	The college students from S1 are better at WSBW2.
H5a	The college students from the two schools differ in WSBW3.
H5b	The college students from S1 are better at WSBW3.
H6a	The college students from the two schools differ in WSBW4.
H6b	The college students from S1 are better at WSBW4.
H7	There are differences between college students from the two schools in the At subpart.
H8	There are differences between college students from the two schools in the SN subpart.
H9	There are differences between college students from the two schools in the PBC subpart.

The hypotheses comprised four components: hypotheses about differences in the WSBs of college students from the two schools, hypotheses about differences in the variables of the At subpart between students from the two schools, hypotheses about differences in the variables of the SN subpart between students from the two schools, and hypotheses about differences in the variables of the PBC subpart between students from the two schools. The specific derivations of the hypotheses are as follows.

1. Hypotheses about differences in the WSBs of college students from the two schools.

Based on previous research, it is apparent that there are differences in the WSBs of college students [4,13]. Therefore, based on the purpose of this research, the following hypotheses are proposed:

H1a. *The college students from the two schools differ in WSBF1.*

H1b. *The college students from S1 are better at WSBF1.*

H2a. *The college students from the two schools differ in WSBF2.*

H2b. *The college students from S1 are better at WSBF2.*

H3a. *The college students from the two schools differ in WSBW1.*

H3b. *The college students from S1 are better at WSBW1.*

H4a. *The college students from the two schools differ in WSBW2.*

H4b. *The college students from S1 are better at WSBW2.*

H5a. *The college students from the two schools differ in WSBW3.*

H5b. *The college students from S1 are better at WSBW3.*

H6a. *The college students from the two schools differ in WSBW4.*

H6b. *The college students from S1 are better at WSBW4.*

2. Hypotheses about differences in the variables of the At subpart between students from the two schools.

According to Ajzen, the more positive the attitude of an individual, the more powerful their intention to engage in the corresponding behavior [28]. As a result, if there are differences in the At subpart between students from the two schools, it is inferred that these differences affect the differences in WSB between students from the two schools. Therefore, the following hypothesis is proposed:

H7. *There are differences between college students from the two schools in the At subpart.*

3. Hypotheses about differences in the variables of the SN subpart between students from the two schools.

Based on previous research, the influence of SNs on WSBs is evidently beneficial [29]. Moreover, SNs are related to environmental education. As a result, if there are differences in the SN subpart between students from the two schools, it is inferred that these differences affect the differences in WSBs between students from the two schools. Moreover, it is obvious that the environmental education received by college students from the two schools is different, and these differences cause the differences in WSBs. Therefore, the following hypothesis is proposed:

H8. *There are differences between college students from the two schools in the SN subpart.*

4. Hypotheses about differences in the variables of the PBC subpart between students from the two schools.

According to previous research, PBC exerts a favorable influence on WSBs [29]. Moreover, PBC is related to environmental education. As a result, if there are differences in the PBC subpart between students from the two schools, it is inferred that these differences affect the differences in WSBs between students from the two schools. Moreover, it is obvious that the environmental education received by college students from the two schools is different, and these differences cause the differences in WSBs. Therefore, the following hypothesis is proposed:

H9. *There are differences between college students from the two schools in the PBC subpart.*

2.2. Analysis Methods

2.2.1. Contingency Table Analysis

This research aimed to ascertain disparities in WSBs between college students from S1 and S2 and identify the underlying variables influencing these differences. Numerous methodologies exist to ascertain whether two sample groups differ regarding a specific variable, including the independent-sample T test (IST) [10], paired-samples T test (PST) [15], analysis of variance (ANOVA) [30], and contingency table analysis (CTA) [31], among others.

Among those methods, the results of CTA are more concise than the results of other methods, because this analysis can classify data and test the correlation of different variables by a chi-squared test [32]. Therefore, this research used CTA to determine whether there are differences in WSBs and in variables that have an impact on the WSBs of college students from S1 and S2.

2.2.2. Factor Analysis

Significant differences in important factors among college students from S1 and S2 indicate that variations in environmental education lead to disparities in WSBs. The subsequent phase of this research entails determining how variations in environmental education influence differences in WSBs. However, the multitude of variables complicates the analysis. Consequently, researchers should minimize the number of variables and identify the principal aspects to enhance the analysis. Numerous techniques can be employed to address this issue, including linear discriminant analysis (LDA) [33], principal component analysis (PCA) [34], and factor analysis (FA) [35], among others.

Among these methods, FA enables researchers to identify which variables within a dataset constitute a logically independent subset [36], indicating that FA provides superior explanatory power compared to alternative methods. Consequently, this study employed component analysis to diminish the variable count and identify the principal factors.

2.2.3. Gray Relation Analysis

This paper employed gray relation analysis (GRA) to identify the driving factors of environmental education influencing WSBs among college students according to the factor scores. GRA can be utilized to determine correlations between a primary factor and all other factors within a specified system, hence facilitating the identification of the optimal relationship [37]. In comparison to alternative approaches, GRA exhibits simplicity in its operation and has minimal analytical requirements. Consequently, this study performed a gray connection analysis based on the factor scores of WSB factors and TPB factors. The GRA for this research was conducted using the steps described below.

Step one: Determine the comparison sequences and the reference sequence.

According to the purpose of this research, the sequence of WSB factors was the reference sequence, i.e., $X_0 = \{X_{01}, X_{02}, \cdots, X_{0n}\}$ $n = 1, 2, \ldots, 347$. Similarly, the comparison sequences were $X_k = \{X_{k1}, X_{k2}, \cdots, X_{kn}\}$, $k = 1, 2, n = 1, 2, \ldots, 347$, where X_1 is the sequence of SN factors, and X_2 is the sequence of PBC factors.

Step two: Perform dimensionless processing.

The processing method adopted in this research was the initial value method, and the specific formula was as follows:

$$X_i' = \frac{X_i}{X_{i1}} = \{X_{i1}', X_{i2}', \cdots, X_{in}'\}, \quad i = 0, 1, 2 \tag{1}$$

where Formula (1) represents the dimensionless forms of the corresponding sequences. The purpose of this step is to eliminate the effects of dimensionality.

Step three: Find the sequence of differences Δ_j:

$$\Delta_{jk} = \left| X_{0k}' - X_{jk}' \right|, j = 1, 2, k = 1, 2, \ldots, 34 \tag{2}$$

$$\Delta_j = \{\Delta_{j1}, \Delta_{j2}, \cdots, \Delta_{jn}\}, j = 1, 2, n = 347 \quad (3)$$

where Δ_1 represents the sequence of differences between the sequence of WSB factors and the sequence of SN factors, and Δ_2 represents the sequence of differences between the sequence of WSB factors and the sequence of PBC factors.

Step four: Find the maximum and minimum differences:

$$M = \max_j \max_k \Delta_{jk}, m = \min_j \min_k \Delta_{jk} \quad (4)$$

where M represents the maximum difference, and m represents the minimum difference.

Step five: Find the gray relation coefficients:

$$\gamma_{0j}(k) = \frac{m + \xi M}{\Delta_{jk} + \xi M}, \xi \in (0, 1), j = 1, 2, k = 1, 2, \cdots, 347 \quad (5)$$

Here, ξ is the distinguishing coefficient, which this research took as 0.5. When j = 1, $\gamma_{01}(k)$ represents the gray relation coefficient for the kth sample between the sequence of WSB factors and the sequence of SN factors; when j = 2, $\gamma_{02}(k)$ represents the gray relation coefficient for the kth sample between the sequence of WSB factors and the sequence of PBC factors.

Step six: Calculate the gray relation degree:

$$\gamma_{0j} = \frac{1}{n} \Sigma_{k=1}^{n} \gamma_{0j}(k), j = 1, 2, n = 347 \quad (6)$$

When j = 1, γ_{01} represents the gray relation degree for the sequence of WSB factors and the sequence of SN factors; when j = 2, γ_{02} represents the gray relation degree for the sequence of WSB factors and the sequence of PBC factors.

2.3. Questionnaire Design and Data Collection

Based on the theoretical model, a questionnaire was designed in this research. The questionnaire included three parts, which are the sociodemographic characteristics (SC) part, the WSB part, and the TPB part. In order to establish the reliability and validity of the questionnaire, a preliminary survey was conducted online in December 2021, resulting in the retrieval of 77 completed questionnaires. For the preliminary survey, this research used IBM SPSS Statistics 26.0 software to test the reliability and validity of the data recovered from it. Through the tests of the recovered data from the preliminary survey, it is found that Cronbach's α coefficient = 0.894, KMO = 0.786, and Bartlett's spherical test $p < 0.001$. The findings indicate that the retrieved data exhibit favorable levels of reliability and validity.

Informed by the data from the preliminary survey and the respondents' recommendations, the questionnaire items were changed. The questionnaire asked for the gender, grade, and school of the respondents in the SC part; the variables of the WSBF and WSBW subparts were evaluated in the WSB part; and the variables of the At, SN, and PBC subparts were examined in the TPB part. The Likert scale scoring method, spanning from 1 to 5, was utilized for both the WSB part and the TPB part. A higher score for a given item corresponded to a greater level of agreement. The study's questionnaire is presented in Appendix A.

This research selected college students from HUE and adopted quota sampling to distribute the formal survey questionnaire. The survey questionnaires were distributed in April 2022. On account of the COVID-19 epidemic in China in 2022, the questionnaires were distributed online (https://www.wjx.cn/wjx/design/previewmobile.aspx?activity=158136216&s=1, accessed on 7 September 2024). Because of the particularities of online questionnaire distribution, a total of 347 questionnaires were distributed, and all the items were successfully retrieved, with a 100% efficiency rate. The sample size exceeds 200, which is considered the minimum required sample size [38]. As with the preliminary survey, this research employed IBM SPSS Statistics 26.0 software to assess the reliability and validity

of the collected data derived from the formal survey questionnaires. Through the tests of recovered data from the formal survey, it is found that Cronbach's α coefficient = 0.900, KMO = 0.885, and Bartlett's spherical test $p < 0.001$. The findings indicate that the retrieved data exhibit favorable levels of reliability and validity.

3. Results

3.1. Descriptive Statistics Analysis

According to the data from the preliminary survey and the suggestions of respondents, the formal survey only included three grades of respondents: juniors, seniors, and postgraduates. The descriptive statistics of respondents are presented in Tables 4 and 5. Among the respondents, 68.50% were male, 43.80% were juniors, and 56.48% were from S1, which are the same as the distribution at HUE.

Table 4. Descriptive statistics of SC part and WSB part.

Variables	Categories	Frequencies	Percentages
Gender	Male	237	68.3
	Female	110	31.7
Grade	Junior	152	43.8
	Senior	125	36.0
	Postgraduate	70	20.2
School	S1	196	56.5
	S2	151	43.5
WSBF1	Strongly disagree (1)	7	2.0
Mean = 4.71	Disagree	0	0
SD = 0.72	Neutral	12	3.5
	Agree	48	13.8
	Strongly agree (5)	280	80.7
WSBF2	Strongly disagree (1)	7	2.0
Mean = 4.67	Disagree	0	0
SD = 0.7	Neutral	9	2.6
	Agree	68	19.6
	Strongly agree (5)	263	75.8
WSBW1	Strongly disagree (1)	21	6.1
Mean = 3.57	Disagree	49	14.1
SD = 1.25	Neutral	101	29.1
	Agree	62	17.9
	Strongly agree (5)	114	32.9
WSBW2	Strongly disagree (1)	6	1.7
Mean = 4.21	Disagree	17	4.9
SD = 0.97	Neutral	46	13.3
	Agree	106	30.5
	Strongly agree (5)	172	49.6
WSBW3	Strongly disagree (1)	12	3.5
Mean = 4.09	Disagree	17	4.9
SD = 1.08	Neutral	66	19.0
	Agree	86	24.8
	Strongly agree (5)	166	47.8
WSBW4	Strongly disagree (1)	6	1.7
Mean = 4.24	Disagree	16	4.6
SD = 0.97	Neutral	45	13.0
	Agree	100	28.8
	Strongly agree (5)	180	51.8

Table 5. Descriptive statistics of TPB part.

Variables	Categories	Frequencies	Percentages
At1	Strongly disagree (1)	4	1.2
Mean = 4.72	Disagree	0	0
SD = 0.64	Neutral	11	3.2
	Agree	60	17.3
	Strongly agree (5)	272	78.4
At2	Strongly disagree (1)	4	1.2
Mean = 4.63	Disagree	2	0.6
SD = 0.70	Neutral	15	4.3
	Agree	77	22.2
	Strongly agree (5)	249	71.8
At3	Strongly disagree (1)	5	1.4
Mean = 4.63	Disagree	2	0.6
SD = 0.74	Neutral	17	4.9
	Agree	70	20.2
	Strongly agree (5)	253	72.9
SN1	Strongly disagree (1)	12	3.5
Mean = 3.94	Disagree	21	6.1
SD = 1.07	Neutral	74	21.3
	Agree	109	31.4
	Strongly agree (5)	131	37.8
SN2	Strongly disagree (1)	12	3.5
Mean = 3.97	Disagree	14	4.0
SD = 1.02	Neutral	71	20.5
	Agree	124	35.7
	Strongly agree (5)	126	36.3
SN3	Strongly disagree (1)	9	2.6
Mean = 4.08	Disagree	15	4.3
SD = 0.97	Neutral	52	15.0
	Agree	133	38.3
	Strongly agree (5)	138	39.8
SN4	Strongly disagree (1)	9	2.6
Mean = 4.04	Disagree	14	4.0
SD = 0.98	Neutral	64	18.4
	Agree	127	36.6
	Strongly agree (5)	133	38.3
SN5	Strongly disagree (1)	10	2.9
Mean = 4.04	Disagree	14	4.0
SD = 1.00	Neutral	65	18.7
	Agree	121	34.9
	Strongly agree (5)	137	39.5
SN6	Strongly disagree (1)	11	3.2
Mean = 4.03	Disagree	14	4.0
SD = 1.01	Neutral	62	17.9
	Agree	127	36.6
	Strongly agree (5)	133	38.3
PBC1	Strongly disagree (1)	8	2.3
Mean = 3.64	Disagree	42	12.1
SD = 1.05	Neutral	101	29.1
	Agree	113	32.6
	Strongly agree (5)	83	23.9
PBC2	Strongly disagree (1)	5	1.4

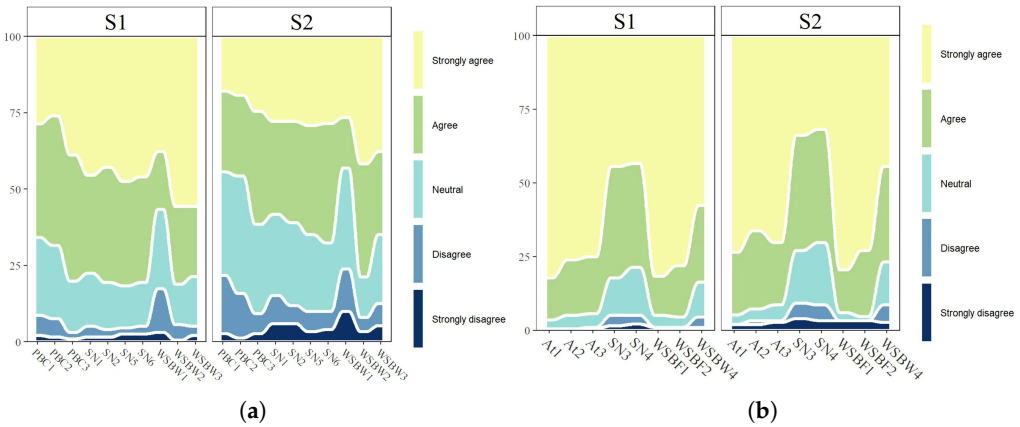
Table 5. *Cont.*

Variables	Categories	Frequencies	Percentages
Mean = 3.69	Disagree	34	9.8
SD = 0.98	Neutral	105	30.3
	Agree	123	35.4
	Strongly agree (5)	80	23.1
PBC3	Strongly disagree (1)	6	1.7
Mean = 3.97	Disagree	14	4.0
SD = 0.93	Neutral	77	22.2
	Agree	137	39.5
	Strongly agree (5)	113	32.6

Moreover, for the variables of the WSB and TPB parts, it is found that the range of mean values for each variable is between 3.57 and 4.72, indicating that most respondents attach importance to WSBs and related contents. And, the range of SDs for each variable is between 0.64 and 1.25, indicating that there is essentially no variation in these data.

3.2. Contingency Table Analysis

To ascertain the differences in relevant variables among college students from S1 and S2, this research employed the school variable as the classification criterion and performed a CTA on the variables from the WSB and TPB parts. Figure 3 illustrates both the variables that differed between schools and those that were the same between schools. The outcomes of the chi-squared tests are presented in Table 6. Both are supported by IBM SPSS Statistics 26.0. The findings indicate that the *p* values of the various variables successfully passed chi-square testing. Consequently, notable disparities existed among college students from the two schools regarding those characteristics.



(**a**) (**b**)

Figure 3. Plot of variable percentage pile area. (**a**) Variables that differed between schools. (**b**) Variables that were the same between schools.

Based on the findings of the contingency table analysis, the results of the hypothesis tests in this research are as follows: H3a–H5b and H8–H9 were tenable, and H1a–H2b and H6a–H7 were not tenable. The outcomes of the hypothesis test are shown in Table 7.

The contingency table analysis revealed significant disparities among the areas of the different variables. The proportion of Strongly Agree and Agree responses from S1 exceeds that from S2, whereas the proportion of the other responses from S1 is inferior to that from S2. Thus, it has been determined that college students from S1 and S2 exhibit differing WSBs, with students from S1 demonstrating superior performance. Furthermore, it is determined that there were no significant differences between college students from the two schools in the At subpart, whereas significant differences were observed in the other two subparts of the TPB part. This study determined that there are disparities in

environmental education obtained by college students from S1 and S2, as it is associated with SN and PBC. Hence, it is evident that variations in environmental education result in disparities in WSBs among college students. In conclusion, the data indicate that there are disparities in environmental education received by students from the two schools, and these disparities contribute to variations in WSBs among college students.

Table 6. Results of chi-squared tests.

Variables	*p* Value	Results
WSBF1	0.4106	
WSBF2	0.1480	
WSBW1	0.0198	*
WSBW2	0.0269	*
WSBW3	0.0082	**
WSBW4	0.1350	
At1	0.1875	
At2	0.1052	
At3	0.5191	
SN1	0.0005	***
SN2	0.0008	***
SN3	0.1648	
SN4	0.2062	
SN5	0.0013	**
SN6	0.0093	**
PBC1	0.0004	***
PBC2	0.0005	***
PBC3	0.0017	**

* $p < 0.050$. ** $p < 0.010$. *** $p < 0.001$.

Table 7. Results of hypothesis tests of this research.

Hypothesis	Hypothetical Content	Results
H1a	The college students from the two schools differ in WSBF1.	✕
H1b	The college students from S1 are better at WSBF1.	✕
H2a	The college students from the two schools differ in WSBF2.	✕
H2b	The college students from S1 are better at WSBF2.	✕
H3a	The college students from the two schools differ in WSBW1.	✓
H3b	The college students from S1 are better at WSBW1.	✓
H4a	The college students from the two schools differ in WSBW2.	✓
H4b	The college students from S1 are better at WSBW2.	✓
H5a	The college students from the two schools differ in WSBW3.	✓
H5b	The college students from S1 are better at WSBW3.	✓
H6a	The college students from the two schools differ in WSBW4.	✕
H6b	The college students from S1 are better at WSBW4.	✕
H7	There are differences between college students from the two schools in the At subpart.	✕
H8	There are differences between college students from the two schools in the SN subpart.	✓
H9	There are differences between college students from the two schools in the PBC subpart.	✓

✕ *indicates that the hypothesis is false.* ✓ *indicates that the hypothesis is true.*

3.3. Factor Analysis

Based on Table 6, two FAs were performed on the different variables to reduce the number of variables and obtain the main factors. All analyses were carried out using IBM SPSS Statistics 26.0. The FA of the WSB part can be renamed the WSBFA, and the FA of the TPB part can be renamed the TPBFA.

The first step in FA is to perform KMO and Bartlett's tests on the data, and the results of the KMO and Bartlett's tests are shown in Table 8. The results show that the KMO values for the two FAs are both above 0.7, and the *p* values of Bartlett's test for the two FAs are both less than 0.05. Therefore, the two FAs are both effective. Moreover, it is found that the total variance explained by the WSBFA is 70.088% and that by the TPBFA

is 85.639%, which means the two FAs both retain most of the information in the data and have favorable validity.

Table 8. KMO and Bartlett's tests for two factor analyses.

Tests		WSBFA	TPBFA
KMO		0.701	0.795
Bartlett's test	Chi-square	299.569	2472.250
	Df	3.000	21.000
	Sig	0.000	0.000

The component matrix of the two FAs is shown in Table 9. According to the component matrix, the explanatory degrees of the variables of the WSBFA are greater than 0.8; thus, component 1 of the WSBFA can be renamed the WSB factor. In the TPBFA, component 1 can be renamed the SN factor because the explanatory degrees of the variables of the SN subpart are greater than 0.8 for component 1. And, component 2 can be renamed the PBC factor because the explanatory degrees of variables of the PBC subpart are greater than 0.8 for component 2. Therefore, the factor scores were determined and are shown in Table 10.

Table 9. Component matrix of two factor analyses.

Variables	Component 1	Variables	Component 1	Component 2
WSBW1	0.854	SN1	0.843	0.208
		SN2	0.915	0.210
WSBW2	0.843	SN5	0.928	0.198
		SN6	0.938	0.184
WSBW3	0.814	PBC1	0.165	0.923
		PBC2	0.189	0.941
		PBC3	0.245	0.829

Table 10. Factor scores in this research.

Sample	WSB Factor	SN Factor	PBC Factor
1	0.02	−1.20	0.58
2	−1.08	1.83	−3.51
3	0.79	−0.07	0.28
4	1.12	0.81	1.22
5	−1.79	−1.57	−1.63
6	1.12	0.81	1.22
7	0.79	0.81	1.22
8	−0.25	−1.34	−1.29
9	1.12	−0.35	1.12
10	0.47	−0.64	−0.73
...	...	...	...
343	0.14	−1.45	1.71
344	1.12	0.81	1.22
345	−0.43	0.95	−0.35
346	−1.46	−0.55	0.02
347	−1.46	−0.06	−0.85

3.4. Gray Relation Analysis

Based on the processes of GRA and the factor scores, the gray relation degrees in this research are shown in Table 11. All analyses were carried out using Matlab, version 2018b. The results indicate that the PBC factor was the main factor affecting WSBs, which means that the differences in the PBC subpart between college students from the two different schools mainly caused differences in the WSBs of college students.

Table 11. Gray relation degrees in this research.

Factors	Gray Relation Degree	Rank
WSB factor and SN factor	0.7034	2
WSB factor and PBC factor	0.7074	1

According to the specific aspects of environmental education, aspects of understanding water-saving issues among students belong to the category of PBC. Therefore, it is found that the differences in environmental education affected the differences in the WSBs of college students mainly by improving their understanding of water-saving. In conclusion, this research obtained the following results:

1. College students from S1 and S2 have different WSBs, and college students from S1 perform better.
2. Better environmental education is received by college students from S1, and these differences lead to the differences in WSBs among college students.
3. The differences in environmental education affected the differences in WSBs among college students mainly by improving their understanding of water saving.

4. Discussion

According to the results, this research found that there are differences between college students from S1 and S2, and the differences are in WSBs, the SN subpart, and the PBC subpart. Because SNs and PBC are connected with environmental education, this suggests that there are differences in environmental education between college students from S1 and S2. Meanwhile, this research found that the differences in environmental education lead to differences in WSBs. The results of this research are consistent with existing research [4,5,39] and the mechanism of the TPB [28].

However, the result suggesting that college students from S1 exhibited better WSBs is inconsistent with previous research [40]. The possible reason for this situation is that the classification standard of college students is different between previous research and this research. It is obvious that the opportunities for college students to receive environmental education from schools have an impact on their WSBs, but previous research [40] ignored this significance and used the major as the classification standard. In addition, this study found no differences between college students in the At subpart, which is contrary to the mechanism of the TPB [28]. This may be because personal attitudes are difficult to translate into actual WSBs. Thus, if college administrators want to improve the WSBs of college students, they need to focus on the degree of environmental education received by the students rather than their majors and their attitudes toward WSBs.

At the same time, the results of this study demonstrate that PBC was the main factor affecting WSBs. This indicates that the opportunities offered by schools to college students to obtain knowledge about water saving mainly affect the differences in WSBs among college students from different schools. Therefore, college management departments can conduct environmental education courses about water saving for college students. In this way, the WSBs of college students can be improved. However, although this study highlights the influence of different environmental education on differences in WSBs among college students, and the findings can be extended to society by improving people's understanding of water saving, this research only considered college students from different schools and ignored some social-psychological variables. As a result, researchers should consider such scenarios in subsequent research.

5. Summary and Conclusions

The objective of this research was to ascertain whether there were differences in WSBs among college students based on the differences in environmental education offered by different schools. Drawing upon the theoretical framework proposed by the TPB and utilizing data gathered from a study conducted at HUE, this research used contingency

table analysis to determine whether there are differences in WSBs and relevant variables of college students and then used factor analysis and gray relational analysis to discover the driving factors of these differences. Given the objectives, methodology, and results of this research, the conclusions are as follows:

1. There are differences in WSBs among college students based on the different environmental education they receive from different schools.
2. The differences in WSBs are mainly caused by the different understanding of water saving among college students from different schools.

6. Recommendations

According to the conclusions, there are three recommendations for college administrators to improve environmental education. These administrators are in departments related to course offerings, such as the Ministry of Education and the Office of Academic Affairs. The recommendations are as follows:

1. College administrators can conduct environmental education courses about water saving for college students, such as Water and Health, Social Circulation and Sustainable Development of Water, and so on.
2. College administrators can introduce policies to encourage college students with sufficient environmental education to spread water-saving knowledge to other students, such as increasing credit hours, setting scholarships for students who spread the knowledge, and so on.
3. College administrators can organize water-saving activities for college students, such as Beautiful Campus, Water-Saving Priority, and so on.

Through these recommendations, college administrators can more effectively improve the environmental education of colleges and enable college students with insufficient environmental education to learn more about water saving. In this situation, college students will exhibit better WSBs. Meanwhile, these administrators can also provide advice to other academic institutions. Therefore, if these administrators extend the recommendations to other institutions, the WSBs among the students at those schools will be improved.

Furthermore, there are two future research directions based on the conclusions, which are to explore how environmental education affects WSBs among other groups and to study the differences in other pro-environment behaviors among college students based on the framework of this paper.

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Appendix A. Questionnaire

This is an English translation of the questionnaire for this research.
Q1 What is your gender?
Male□ Female□
Q2 What is your school?
School of Water Conservancy and Hydroelectric Power (S1)□

School of Mathematics and Physics (S2)☐
Q3 What is your grade?
Junior☐ Senior☐ Postgraduate ☐

Q4 Do you agree to the following water-saving behaviors?

Water-Saving Behaviors	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The behavior of shutting off faucets quickly.	☐	☐	☐	☐	☐
The behavior of turning off faucets which are opened by someone else.	☐	☐	☐	☐	☐
The behavior of collecting waste water when the respondents washed their clothes by hands.	☐	☐	☐	☐	☐
The behavior of rinsing less frequently when the respondents washed their clothes by hands.	☐	☐	☐	☐	☐
The behavior of washing with basins when the respondents washed their faces and rinsed their mouths.	☐	☐	☐	☐	☐
The behavior of washing more clothes at once when the respondents wash their clothes by machines.	☐	☐	☐	☐	☐

Q5 Do you agree that the following contents affect your water-saving behaviors?

Indexes	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Responsibility consciousness about water-saving	☐	☐	☐	☐	☐
Perceived barriers about water-saving	☐	☐	☐	☐	☐
Perceived benefits about water-saving	☐	☐	☐	☐	☐
School environment	☐	☐	☐	☐	☐
Curriculum design of school	☐	☐	☐	☐	☐
Public water-saving	☐	☐	☐	☐	☐
Public opinion about water-saving	☐	☐	☐	☐	☐
School water-saving publicity	☐	☐	☐	☐	☐
School water-saving activities	☐	☐	☐	☐	☐
Understanding about the value of the local water resources	☐	☐	☐	☐	☐
Understanding about the impact on the environments from water-saving	☐	☐	☐	☐	☐
Understanding about the impact on the lives of each people from water-saving	☐	☐	☐	☐	☐

Q6 What is your opinion or suggestion on water-saving behaviors?

Table A1. Revisions to the questionnaire.

Questions	Original questionnaire	Questionnaire
What is your grade?	Freshman and sophomore were included as options in the original questionnaire.	Freshman and sophomore were not options in the questionnaire.
Do you agree to the following water-saving behaviors?	This question was not in the original questionnaire.	This question was in the questionnaire.

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