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## Article

# College Students' Attitude towards Waste Separation and Recovery on Campus

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**Abstract:** As large communities, the efficiency and effectiveness of waste management on university campuses are of concern. This study aims to verify the variable relationship, influence path, and regulating factors of college students' attitudes and behavior toward waste separation. A questionnaire survey was conducted at Henan Institute of Science and Technology, China, with 1300 respondents, among which 1213 questionnaires were valid. The SPSS software v23.0 was used to carry out the statistical analysis of the collected data by applying multiple analyses. The results showed that (i) females outperform males across attitudes and internal and external contextual factors, (ii) freshmen showed more positive waste separation behaviors, while upper-year students' behaviors were more susceptible to contextual factors, (iii) college students' attitudes, especially the knowledge factor, have a significant positive influence on behaviors, and (iv) the external contextual factors, as moderating variables, have a significant difference in the impact amplitude at different levels when attitudes affect behaviors. Our findings supplement the limited information available on the potential implications of applying the ABC model in exploring the factors influencing waste separation behaviors among college students. The provided insights can support college students, university administrators, policymakers, and government departments in more effectively optimizing, designing, and managing waste systems on campuses.

**Keywords:** circular economy; consumer behavior; contextual factor; consumer attitude; waste management



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## 1. Introduction

Effective waste management is key to tackling environmental concerns and supporting the transition from a linear economy to a circular economy [1], which faces various challenges and barriers [2,3]. Waste separation is recognized worldwide as an effective measure to achieve waste reduction, harmlessness, and resource recovery [4]. Since China officially started the construction of pilot cities for waste separation in 2000, no breakthrough has been made in urban waste separation [5,6]. Currently, public awareness of waste separation is generally high, while the actual behavior level is low [7–9].

Waste sorting plans within the waste management system in societies require accurate planning and cooperation of all residents. In particular, successful waste management programs for colleges and universities, as a large community, need the support and effective participation of residents [10]. College students are the most important part of college community residents, and their attitude and participation in campus waste separation practices play a key role in the successful implementation of college waste management projects [11]. Therefore, a better understanding of the attitudes of college students toward waste separation and the factors influencing their behaviors is greatly significant to contribute to the promotion of waste management programs in universities.

Educational interventions are essential to ensure students have the required knowledge and understanding, as well as positive attitudes towards waste separation on campus, such as environmental education [12], scientific activities [13], and training programs [14]. In terms of waste separation knowledge, Dai et al. justified that knowledge and attitude, as well as acceptance of waste education, significantly affect college students' willingness to separate waste [15]. The public generally shows different awareness of the new classification standard and inadequate correctness rate in the actual separation operation, which requires more time for them to learn and adapt [16]. The relevant studies show that there are differences in the accuracy of college students' perceptions of different categories of waste in the waste classification standards [17,18]. Although mandatory measures could improve students' knowledge of waste management, there are still different degrees of difficulties in concrete separating practices [19]. Earlier studies in China have found that there is a gap between the willingness and action of waste separation among university students [20]. Additionally, it is determined that demographic factors of college students have a significant impact on their waste separation behaviors, such as gender, age, grade, and major [21–23].

The extant studies reveal that the relationship between attitude and behavior and the influencing mechanism of waste separation among college students in China still lacks sufficient empirical evidence [15,17], especially whether the variable relationship in the ABC model (Attitude–Behavior–Context) is applicable to the issue of waste separation on campus. The characteristics, status, and environment of college students are different, and the moderating effects of external context variables are different from those of the public. Therefore, this study aims to verify the variable relationship, influence path, and regulating factors of college students' waste separation attitude and behavior. In this regard, a questionnaire survey is performed at Henan Institute of Science and Technology with 1213 respondents to shed light on the relationship between students' attitudes and behavior towards waste separation practices on campus (see Appendix A).

The remainder of the article is organized as follows. The theoretical background of the research conducted on waste management practices in universities, as the main base for developing the hypotheses of the current study, is presented in Section 2. The research method and material used are explained in Section 3. Section 4 provides the results of the conducted analyses using the SPSS software version 23.0, followed by a discussion of the main findings in Section 5. Finally, Section 6 concludes the remarks of the research.

## 2. Theoretical Background and Hypotheses Development

Theoretical and empirical studies on the determinants of waste separation intentions and behavior among university students have been conducted in many countries around the world. Lack of knowledge on waste separation is always considered to be a crucial factor in not separating waste or not being able to separate it properly [24].

A study among university students in the Netherlands found that although students have a positive attitude and are inclined to behave more environmentally friendly, there is a discrepancy between intention and actual behavior [25]. Also, it was verified that students at the University of Venda in South Africa are willing to participate in waste recycling projects, but their knowledge of solid waste management is low and inadequate [26]. A questionnaire study conducted in Sydney, Australia, found that university students have a serious lack of knowledge regarding collection points and the current recycling programs, resulting in an inability to properly dispose of e-waste [27].

The introduction of a new waste separation program in Malaysian university dormitories resulted in a significant increase in waste separation knowledge and recycling rates [28]. An awareness campaign at Universitat Rovira i Virgili in Spain improved the separate collection of municipal waste by 17.9% among university students [29]. Conversely, it was also shown that although students' theoretical knowledge improved, it was not sufficient to change behaviors established by cultural values or to encourage students to adequately separate waste [30,31]. Situmorang et al., identified that college students of environmen-

tal science majors with relevant expertise exhibit more pro-environmental behaviors in their daily lives [32]. It is necessary to consider that the new national waste classification standards in China were just issued in 2019, which cover four major categories (recyclable, hazardous waste, food Waste, and residual waste) and 11 sub-categories [33].

Moreover, a questionnaire survey of undergraduate students at the higher education mega center of Guangzhou showed that environmental awareness, personal responsibility, convenience, and economic cost had a significant positive effect on waste separation behavior [34]. The attitudes, situational factors, publicity, and education are justified as the main factors influencing students' willingness to separate waste through a survey of 16 universities in Chongqing [17]. Among the 62 universities surveyed in Zhengzhou, the factors influencing college students' waste separation behavior included locational convenience, willingness, knowledge, attitude, peer pressure, and the reward and punishment system [19]. Similarly, Zhou et al. highlighted that the convenience of recycling facilities, the convenience of sorting facilities, and education on sorting knowledge were the top three most significant factors influencing college students' waste separation behavior [18].

Regarding the theoretical basis, the theory of planned behavior has been frequently used to assess the determinants of college students' waste separation intentions and behaviors [12,30], which states that behavioral intentions and actual behaviors are influenced by "perceived behavioral control" in addition to "attitudes" and "subjective norms" [35]. Besides, Xia et al. used the technology acceptance model, theory of planned behavior, and norm activation model together to analyze college students' waste separation behavior [36]. Also, the extended parallel process model was applied to estimate waste separation beliefs and behaviors considering appropriate psychometric characteristics [37,38].

The ABC theory is a social psychological theory with environmental implications, which is one of the most significant efforts to overcome the internal-external dichotomy [39, 40]. According to the ABC theory, behavior is a function of the organism and its environment. That is, environmental behavior (B) is generated by the interaction of individuals' attitude variable (A) and contextual factors (C) toward environmental protection [41]. Previous studies have also confirmed that there is a significant positive correlation between individuals' environmental attitudes and their participation in environmental behaviors [42], and the public's environmental, attitudinal behavior path is affected by contextual factors; that is, contextual factors have a positive or negative regulating effect on environmental, attitudinal behavior paths, and will promote or inhibit environmental behavior accordingly [43].

Based on the ABC theory and previous research results, this study develops a conceptual framework to provide an interpretation of the expected relationship between the variables. It is expected that college students' waste separation attitude (independent variable) has a direct impact on their waste separation behavior (dependent variable). For example, positive attitudes towards waste separation can have a beneficial effect on the actual occurrence of waste separation behavior. Besides, we expect that the internal and external contextual factors (moderating variables) have a moderating effect on the relationship between attitude and behavior. Hence, the following hypotheses are formulated to be examined in this research:

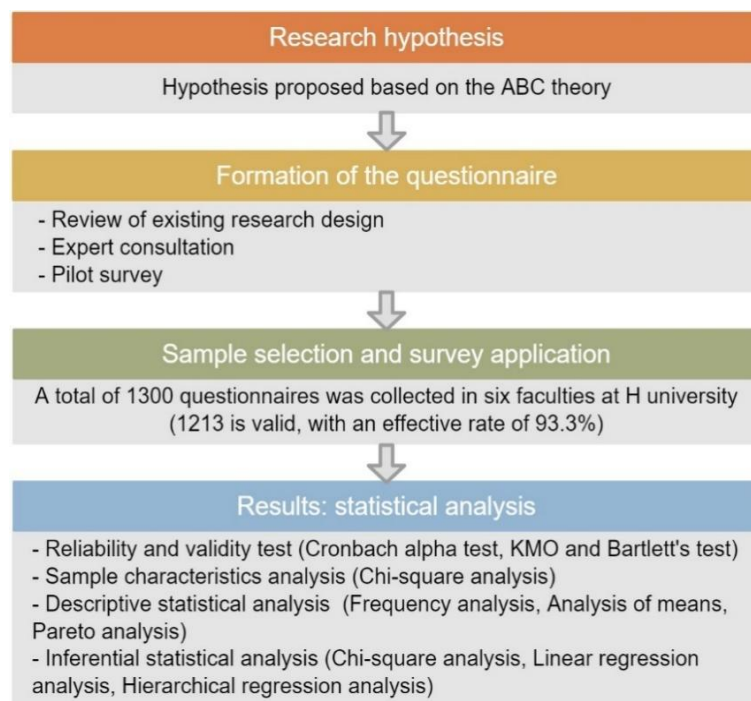
**Hypotheses 1. (H1)** *Students' attitudes toward waste separation directly impact their waste separation behavior.*

**Hypotheses 2. (H2)** *Students' internal contextual factors can moderate the attitude-behavior pathway of waste separation.*

**Hypotheses 3. (H3)** *External contextual factors on campus can moderate the pathway of attitude-behavior influence on waste separation.*

### 3. Materials and Methods

The methodology followed in this study is shown in Figure 1. First, through the review of the previous studies focused on student attitude and waste separation behaviors, the research hypotheses were put forwards. Second, a questionnaire was compiled with the consideration of the existing research design. Third, a representative sample was selected from several faculties at the Henan Institute of Science and Technology in China. Finally, the results obtained were statistically analyzed with various methods, as mentioned in Figure 1.



**Figure 1.** Methodology followed in this study.

#### 3.1. Preparation of the Questionnaire

The purpose of this study is to understand the attitude and behavior habits of Henan Institute of Science and Technology students toward household waste separation and recovery. Therefore, a questionnaire was prepared to ground on the research design of Stern et al. [39] and Fu et al. [44] and then adjusted according to the cultural background and behavioral situation of college students. In addition, interviews were conducted with some experts and representative students to understand the main factors contained in various variables and to design the original questionnaire.

In order to build a formal questionnaire that meets the research needs, the original questionnaire was trial-tested on a small scale before the formal survey and was repeatedly modified and adjusted according to the results of the item analysis and internal consistency testing. The Likert scale scoring method was adopted in the questionnaire, in which the points ranging from 1 to 5 represent the direction of respondents' attitudes and behaviors. The lowest score (score 1) indicates that respondents have a relatively negative attitude or behavior toward waste separation. On the contrary, the highest score (score 5) indicates that respondents are temporarily inert in attitude or behaviors toward waste separation.

#### 3.2. Sample Selection and Survey Application

There are a total of 24,202 full-time college students in the Xinxiang Campus of Henan Institute of Science and Technology. In view of this large overall population size, this study

calculated the size of the sample to be selected based on the sample content estimation method proposed by Uchida [45] with the following equation:

$$n \geq \left( \frac{k^2}{\alpha^2} \right) p(1 - p) \quad (1)$$

where  $n$  represents the sample size,  $\alpha$  stands for the margin of error or confidence interval ( $\alpha = 5\%$ ),  $k$  is the selected alpha level in normal typified distribution ( $k = 1.96$ ), and  $p$  is the percentage of respondents who selected a specific choice ( $p = 0.5$ ). After calculation, this study obtained  $n = 384$ .

Due to the COVID-19 pandemic, the school was suspended during the investigation period, and students were taking online classes at home. Therefore, the questionnaire was distributed, filled in, and recovered through the network platform. To improve the reliability of the survey results, this study expanded the sample as much as possible. In the survey, questionnaires were distributed to 1380 students from six faculties, of which a total of 1300 respondents made responses, with a recovery rate of 94.2%. Among the collected questionnaires, 1213 were valid, representing an effective rate of 93.3%. It is worthwhile highlighting that the representative sample size of 1213 is much larger than the 384-sample size required according to the calculation result.

### 3.3. Reliability and Validity Test

The Internal Reliability index Cronbach's alpha value was used to test the scale Reliability in the questionnaire. The questionnaire contained 16 scale items involving the attitude variable (5 items), behavior variable (4 items), internal context variable (3 items), and external context variable (4 items). A contradictory item was set in the items of the attitude variable, which was only intended for censoring invalid questionnaires and not for statistical analysis. As shown in Table 1, Cronbach's  $\alpha$  value of the scale was 0.866 ( $>0.8$ ), indicating that the scale had good reliability and could be used for further analysis.

**Table 1.** The reliability and validity test of the questionnaire.

Items	Sample Size	Cronbach Alpha Coefficient	KMO	Bartlett Test of Sphericity	Degrees of Freedom (df)	$p$
16	1213	0.866	0.880	10,473.071	120	0.000 **

\*\*  $p < 0.01$ .

In order to test content validity, the expert judgment method was used. First, the original questionnaire was built based on an interview with some experts in the field and representative students. Before the formal test, the original questionnaire was used to conduct a preliminary survey for further modification to meet the research needs. Second, the factor analysis method was used to test the construct validity, which is usually achieved by the KMO value and Bartlett's test of sphericity. Test results showed that the questionnaire was valid, indicating the research data is reliable for extracting information.

### 3.4. Statistical Analysis Method

Statistical analysis software SPSS 23.0 was used for the statistical processing of data at different levels. First, a statistical analysis of the socioeconomic characteristics of the sample was carried out. Second, descriptive statistics were carried out on the results of each item within the questionnaire. Finally, based on descriptive analysis, inference statistics were carried out on the attitudes, behaviors, and situations of college students toward waste separation and recycling in order to verify the proposed hypothesis.

On the one hand, it is necessary to analyze different relationships between the attitude and behavior of waste sorting and recycling among the classified people. That is, by combining socioeconomic variables with the responses to the scale questions, this study can understand the differences in attitudes and behaviors of different types of groups in waste sorting and recycling. On the other hand, it is necessary to analyze the influence



of college students' attitudes toward waste sorting and recycling on the corresponding behavior. Furthermore, it is necessary to analyze the moderating effect of contextual factor variables on the attitude-behavior influence path.

## 4. Results

### 4.1. Characteristics of the Sample

Through the analysis of the socio-economic characteristics of the respondents, it is found that the share of females from the respondents is higher than that of males, the group aged 18–20 years accounts for the largest proportion of the sample (66.03%), and the number of freshmen participating in the survey is the largest (42.54%).

The result reflects that females and lower-grade students have higher enthusiasm and willingness to participate in the survey, which is consistent with the actual context. The respondents met the quota sample control target of the study. A Chi-square test (cross-analysis) was carried out for the gender, age, and grade of the respondents. It was found that there was no significant difference in the number of males and females in different age stages and grades in the selected respondents ( $p > 0.05$ ), as shown in Table 2.

**Table 2.** Chi-square analysis between socioeconomic characteristics.

Items	Categories	Gender		Total	$\chi^2$	$p$
		Male	Female			
Age	<18	3.49%	3.05%	3.22%	6.034	0.110
	18–20	62.31%	68.30%	66.03%		
	21–23	33.12%	28.25%	30.09%		
	$\geq 24$	1.09%	0.40%	0.66%		
Grade	Freshman	43.14%	42.18%	42.54%	5.460	0.141
	Sophomore	26.80%	25.60%	26.05%		
	Junior	21.35%	19.23%	20.03%		
	Senior	8.71%	13.00%	11.38%		
Total		459 (37.84%)	754 (62.16%)	1213	-	-

### 4.2. Descriptive Analysis

To facilitate the analysis of the relationship between each pair of variables, it is necessary to generate new variables by combing the factors contained in each variable into a whole. In this study, exploratory factor analysis was performed to determine the weights of each factor in each variable. The results of all KMO and Bartlett's tests indicated that the data were appropriate for factor analysis. The titles and weights of the factors are presented in Table 3. Correlation analysis was conducted on the factors involved in attitude, behavior, and context variables, and the results showed that there was a positive correlation between the factors of each variable. The weighted summation method was employed for the factors of each variable to generate new variables X (attitude), Y (behavior), Z1 (internal contextual factors), and Z2 (external contextual factors).

**Table 3.** Titles and weights of the factors of each variable.

Variables	Titles and Weights of the Factors				Formulas
X (attitude)	X1 (value)	X2 (awareness)	X3 (knowledge)	X4 (responsibility)	$X = 0.2799 \times X1 + 0.3046 \times X2 + 0.1422 \times X3 + 0.2733 \times X4$
	27.99%	30.46%	14.22%	27.33%	

Table 3. Cont.

Variables	Titles and Weights of the Factors				Formulas
Y (behavior)	Y1 (publicity and promotion)	Y2 (waste separation and recovery)	Y3 (waste textiles recovery)	Y4 (express package recovery)	$Y = 0.2350 \times Y1 + 0.2592 \times Y2 + 0.2684 \times Y3 + 0.2374 \times Y4$
	23.50%	25.92%	26.84%	23.74%	
Z1 (internal contextual factors)	Z1.1 (recognition and material incentives)	Z1.2 (credit or scholarship incentives)	Z1.3 (incentives in further education or employment)	-	$Z1 = 0.3186 \times Z1.1 + 0.3427 \times Z1.2 + 0.3387 \times Z1.3$
	31.86%	34.27%	33.87%	-	
Z2 (external contextual factors)	Z2.1 (infrastructure construction)	Z2.2 (mission and curriculum)	Z2.3 (regulations and rules)	Z2.4 (culture and atmosphere)	$Z2 = 0.2442 \times Z2.1 + 0.2452 \times Z2.2 + 0.2558 \times Z2.3 + 0.2548 \times Z2.4$
	24.42%	24.52%	25.58%	25.48%	

Figure 2 displays the visual representation of each factor on the five-point Likert scale. In general, the respondents’ attitudes and behaviors toward waste separation are mostly positive. Specifically, the respondents showed the strongest consistency on the X4, while the lowest overall consistency was found for the X3.

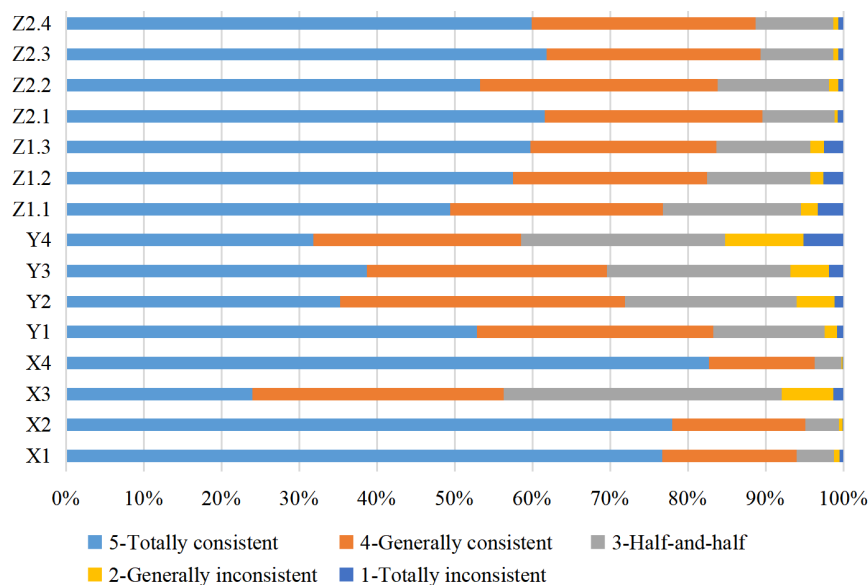
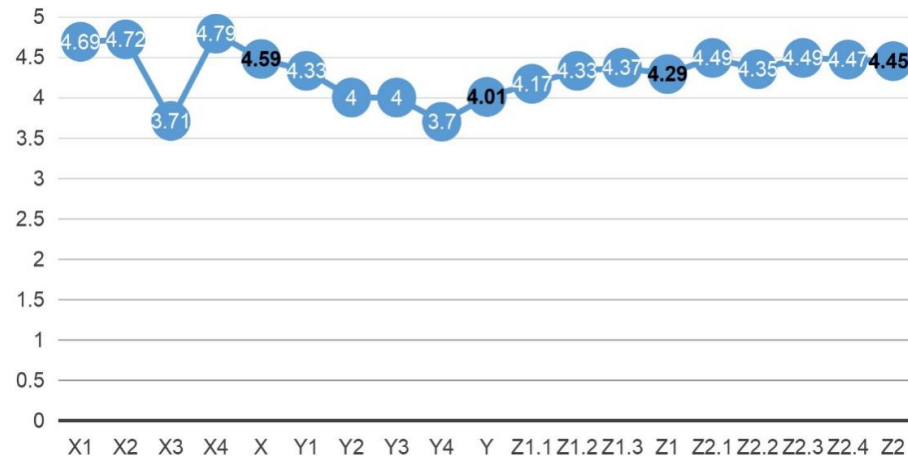


Figure 2. Comparison of the mean values of different variables. X1: value; X2: awareness; X3: knowledge; X4: responsibility; Y1: publicity and promotion; Y2: waste separation and recovery; Y3: waste textiles recovery; Y4: express package recovery; Z1.1: recognition and material incentives; Z1.2: credit or scholarship incentives; Z1.3: incentives in further education or employment; Z2.1: infrastructure construction; Z2.2: mission and curriculum; Z2.3: regulations and rules; Z2.4: culture and atmosphere.

The variable of college students’ attitude towards waste separation mainly includes the value (X1), awareness (X2), knowledge (X3), and responsibility (X4) factors. As shown in Figure 3, the overall mean value on the attitude scale was 4.59, indicating that the attitude of the respondents towards waste separation is relatively positive. The mean values of each factor from high to low are X4 > X2 > X1 > X3. This result reflects that college students are generally aware of the importance of waste separation and their responsibility in realizing waste separation and recovery but do not have adequate knowledge about waste separation.



This indicates that the attitudes of college students toward waste separation are only at the level of consciousness without learning the relevant knowledge of waste classification, so it is not enough to deal with the practical problems of waste separation and recovery.



**Figure 3.** Comparison of the mean values of different variables. X1: value; X2: awareness; X3: knowledge; X4: responsibility; X: attitude; Y1: publicity and promotion; Y2: waste separation and recovery; Y3: waste textiles recovery; Y4: express package recovery; Y: behavior; Z1.1: recognition and material incentives; Z1.2: credit or scholarship incentives; Z1.3: incentives in further education or employment; Z1: internal contextual factors; Z2.1: infrastructure construction; Z2.2: mission and curriculum; Z2.3: regulations and rules; Z2.4: culture and atmosphere; Z2: external contextual factors.

The behavioral variables of waste separation of college students mainly include publicity and promotion (Y1), waste separation and recovery (Y2), waste textiles recovery (Y3), and express package recovery (Y4). Statistical results of various factors in behavioral variables are also shown in Figure 3. The mean value of various factors from high to low is  $Y1 > Y2 = Y3 > Y4$ . This result reflects that college students are generally able to participate in the promotion activities of waste separation but are relatively ineffective in their waste separation behavior.

The context variables of waste separation of college students mainly include internal contextual factors (Z1) and external contextual factors (Z2). The former contains three factors, namely recognition and material incentives (Z1.1), credit or scholarship incentives (Z1.2), and incentives in further education or employment (Z1.3), while the latter contains four factors, namely infrastructure construction (Z2.1), mission and curriculum (Z2.2), regulations and rules (Z2.3) and culture and atmosphere (Z2.4). The overall mean scores of the internal context scale and the external context scale were 4.29 and 4.45, respectively. Among them, Z2.1 and Z2.3 had the highest mean score of 4.49, while Z1.1 had the lowest mean value of 4.17 (Figure 3).

In addition, by comparing the overall mean values of attitude, behavior, and contextual factors, this study found that the mean score was in the order of  $X (4.59) > Z2 (4.45) > Z1 (4.29) > Y (4.01)$ . It shows that college students' attitude toward waste separation does not correspond to their waste separation behavior. That is to say, the waste separation behaviors of college students are not as positive as their attitude toward waste separation. In addition, relatively speaking, in the corresponding context, the performance of waste separation behaviors of college students has been greatly improved, even close to the evaluation level of attitude.

### 4.3. Inferential Analysis

#### 4.3.1. Relationship between Socio-Economic Characteristics and Other Variables

One-way ANOVA was used to study the relationship between gender and X, Y, Z1, and Z2, and it was found that respondents with different genders showed significant differences with respect to X, Z1, and Z2 ( $p < 0.01$ ; see Table 4). The analysis also showed that the average value of males was significantly lower than that of females for the mentioned three variables.

**Table 4.** ANOVA of the sample's socioeconomic characteristics.

Variable	X	Y	Z1	Z2	
Gender ( $\bar{x} \pm S$ )	Male (n = 459)	4.53 $\pm$ 0.51	3.99 $\pm$ 0.83	4.20 $\pm$ 0.99	4.34 $\pm$ 0.77
	Female (n = 754)	4.62 $\pm$ 0.38	4.01 $\pm$ 0.74	4.35 $\pm$ 0.83	4.52 $\pm$ 0.60
	F	10.881	0.253	8.597	19.224
	p	0.001 **	0.615	0.003 **	0.000 **
Age ( $\bar{x} \pm S$ )	<18 (n = 39)	4.48 $\pm$ 0.49	3.99 $\pm$ 0.74	4.25 $\pm$ 0.96	4.36 $\pm$ 0.90
	18~20 (n = 801)	4.61 $\pm$ 0.44	4.05 $\pm$ 0.76	4.30 $\pm$ 0.89	4.49 $\pm$ 0.65
	21~23 (n = 365)	4.56 $\pm$ 0.43	3.92 $\pm$ 0.81	4.28 $\pm$ 0.90	4.38 $\pm$ 0.70
	$\geq$ 24 (n = 8)	4.39 $\pm$ 0.55	3.81 $\pm$ 0.64	4.67 $\pm$ 0.47	4.29 $\pm$ 0.45
	F	2.075	2.398	0.524	2.472
	p	0.102	0.066	0.666	0.060
Grade ( $\bar{x} \pm S$ )	Freshman (n = 516)	4.62 $\pm$ 0.41	4.06 $\pm$ 0.76	4.36 $\pm$ 0.86	4.54 $\pm$ 0.61
	Sophomore (n = 316)	4.57 $\pm$ 0.48	4.05 $\pm$ 0.76	4.14 $\pm$ 0.99	4.35 $\pm$ 0.77
	Junior (n = 243)	4.54 $\pm$ 0.44	3.91 $\pm$ 0.81	4.28 $\pm$ 0.84	4.37 $\pm$ 0.68
	Senior (n = 138)	4.57 $\pm$ 0.44	3.87 $\pm$ 0.80	4.42 $\pm$ 0.83	4.47 $\pm$ 0.65
	F	2.529	3.875	4.855	6.899
	p	0.056	0.009 **	0.002 **	0.000 **

\*\*  $p < 0.01$ .

Similarly, one-way ANOVA was used to study the effect of age and grade on X, Y, Z1, and Z2. The results showed that respondents of different ages show no statistical difference in terms of X, Y, Z1, and Z2 ( $p > 0.05$ ), which indicates that respondents of different ages show consistency in all the above variables without a significant difference.

As for grades, the analysis results showed that respondents from different grades showed no significant difference in terms of X ( $p > 0.05$ ). However, the grade of respondents showed significant differences in terms of Y, Z1, and Z2 ( $p < 0.01$ ). Furthermore, based on the analysis, the mean score comparison results of the groups with significant differences in Y in terms of grade are "freshman > sophomore > junior > senior". The comparison result of the mean score of grade groups with obvious differences in Z1 is "senior > freshman > junior > sophomore". The comparison result of the mean score of grade groups with obvious differences in Z2 is "freshman > senior > junior > sophomore". The research shows that waste separation behaviors tend to fade with the increase in grade. In addition, generally, the waste separation behavior of senior students is more susceptible to contextual factors. However, it should be noted that freshmen show a higher degree of activity under contextual factors; that is, freshmen show a higher willingness to waste separation under the influence of contextual factors.

#### 4.3.2. Relationship between Attitude and Behavior

To understand the impact of college students' attitudes towards waste separation on their waste separation behavior, X was taken as the independent variable, while Y was

taken as the dependent variable to conduct linear regression analysis. As can be seen in Table 5, the model equation is:

$$Y = 0.180 + 0.834 \times X \quad (2)$$

**Table 5.** Parameter estimates of linear regression analysis (n = 1213).

-	Unstandardized Coefficients		Standardized Coefficients	t	P	VIF	R <sup>2</sup>	Adj R	F
	B	Std. Error	Beta						
Constant	0.180	0.206	-	0.874	0.382	-	0.224	0.2223	F(1, 1211) = 349.039, p = 0.000 **
X	0.834	0.045	0.473	18.683	0.000 **	1.000			

Dependent Variable: Y. D-W: 1.933. \*\* p < 0.01.

As shown in Table 5, the R<sup>2</sup> value of the model is 0.224, which means that X can explain 22.4% of the changes of Y. The model passed the F test (F = 349.039, p = 0.000 < 0.01), indicating that X must have an impact on Y. Finally, the analysis showed that the regression coefficient value of X is 0.834 (t = 18.683, p = 0.000 < 0.01), which means that X has a significant positive influence on Y.

To further clarify the influence of each factor within the attitude variable on the behaviors, X1, X2, X3, and X4 were taken as independent variables, while Y was taken as dependent variables for linear regression analysis. As can be seen in Table 6, the model Equation is:

$$Y = 0.294 + 0.049 \times X1 + 0.126 \times X2 + 0.385 \times X3 + 0.304 \times X4 \quad (3)$$

**Table 6.** Parameter estimates of linear regression analysis of each factor (n = 1213).

-	Unstandardized Coefficients		Standardized Coefficients	t	p	VIF	R <sup>2</sup>	Adj R	F
	B	Std. Error	Beta						
Constant	0.294	0.197	-	1.495	0.135	-			
X1	0.049	0.033	0.041	1.485	0.138	1.386	0.349	0.347	F(4, 1208) = 162.091; p = 0.000 **
X2	0.126	0.039	0.093	3.197	0.001 **	1.562			
X3	0.385	0.019	0.470	19.827	0.000 **	1.044			
X4	0.304	0.041	0.199	7.444	0.000 **	1.325			

Dependent Variable: Y. D-W: 1.889. \*\* p < 0.01.

The R<sup>2</sup> value of the model is 0.349, indicating that X1, X2, X3, and X4 can explain 34.9% of the change in Y (see Table 6). The model passed the F test (F = 162.091, p = 0.000 < 0.01), confirming that at least one of the four elements of the X variable would have an impact on Y. In addition, the test of the model's multicollinearity showed that all VIF (Variance Inflation Factor) values in the model are less than 5, which means there is no collinearity problem. Moreover, the D-W value is near 2, showing that the model does not have autocorrelation and there is no correlation between sample data. Therefore, the model is good. The final concrete analysis shows that the regression coefficient value of X1 is 0.049 (t = 1.485, p = 0.138 > 0.05), meaning that X1 will not have a significant impact on Y. Also, the regression coefficient of X2 is 0.126 (t = 3.197, p = 0.001 \*\*), X3 is 0.385 (t = 19.827, p = 0.000 \*\*), X4 is 0.304 (t = 7.444, p = 0.000 \*\*), implying that these three factors have a significant positive influence on Y. Among them, X3 exhibited the greatest influence on the dependent variable Y.

#### 4.3.3. Analysis of Moderating Effect

Moderating effect analysis is to study whether the influence of independent variable X on dependent variable Y will be interfered with by the moderating variable Z. In the study, X and Z were first treated centrally, followed by hierarchical regression analysis.

In the study of the moderating effect of Z1, three models were involved in hierarchical regression analysis. Model 1 includes independent variables, X. In model 2, a moderating variable Z1 was added based on Model 1, and in Model 3, an interaction term (product term of the independent variable and moderating variable) was added based on Model 2. The dependent variable of the model is Y.

The purpose of model 1 was to study the influence of the independent variable X on the dependent variable Y without considering the interference of the moderating variable Z1. As can be seen from Table 7, X has a significant influence on Y.

**Table 7.** Parameter estimates of modulation analysis of Z1 (n = 1213).

	Model 1					Model 2					Model 3				
	B	S.E.	t	p	$\beta$	B	S.E.	t	p	$\beta$	B	S.E.	t	p	$\beta$
Constant	4.005	0.020	203.958	0.000 **	–	4.005	0.020	204.062	0.000 **	–	3.999	0.020	198.628	0.000 **	–
X	0.834	0.045	18.683	0.000 **	0.473	0.819	0.046	17.933	0.000 **	0.465	0.846	0.050	17.012	0.000 **	0.480
Z1	–	–	–	–	–	0.034	0.023	1.494	0.135	0.039	0.029	0.023	1.256	0.209	0.033
X × Z1	–	–	–	–	–	–	–	–	–	–	0.074	0.053	1.382	0.167	0.038
R <sup>2</sup>	0.224					0.225					0.226				
Adj. R <sup>2</sup>	0.223					0.224					0.224				
F	F(1, 1211) = 349.039, p = 0.000 **					F(2, 1210) = 175.813, p = 0.000 **					F(3, 1209) = 117.934, p = 0.000 **				
$\Delta R^2$	0.224					0.001					0.001				
$\Delta F$	F(1, 1211) = 349.039, p = 0.000 **					F(1, 1210) = 2.232, p = 0.135					F(1, 1209) = 1.911, p = 0.167				

Dependent Variable: Y. \*\*  $p < 0.01$ .

The moderating effect can be viewed in two ways. The first is to check the significance of the change in F value from Model 2 to Model 3. The second is to check the significance of the interaction term in Model 3. As shown in Table 7, the change in the R<sup>2</sup> value is only 0.001, which is very low. Moreover, the change in the F value is not significant ( $p = 0.167 > 0.05$ ). In addition, the regression coefficient B of interaction terms is 0.074, which does not show a significant value ( $t = 1.382, p = 0.167 > 0.05$ ). This indicates that interaction terms are not significant, which further implies that there is no regulatory effect. In other words, when X affects Y, the moderating variable Z1 has a similar influencing range at different levels.

When studying the moderating effect of external factors on Z2, the moderating effect was similarly divided into three models, and the independent variable X was included in Model 1. In model 2, moderating variables Z2 were added based on Model 1, and in Model 3, interaction terms (product terms of independent variables and moderating variables) were added based on Model 2.

It can be seen that in model 1, X has a significant influence on Y. The  $\Delta F$  showed significance ( $F = 86.518, p = 0.000 **$ ) when moving from model 2 to model 3 (see Table 8). Moreover, the interaction term between X and Z2 exhibited that it was significant ( $t = 2.436, p = 0.015 < 0.05$ ). This all implies that the magnitude of the effect of the moderating variable Z2 differs significantly at different levels when X has an effect on Y. The value of the regression coefficient of the interaction term is 0.139, which suggests that the moderating variable acts as a positive moderator of the effect of X on Y.

**Table 8.** Parameter estimates of modulation analysis of Z2 (n = 1213).

-	Model 1					Model 2					Model 3				
	B	S.E.	t	p	$\beta$	B	S.E.	t	p	$\beta$	B	S.E.	t	p	$\beta$
Constant	4.005	0.020	203.958	0.000 **	-	4.005	0.019	211.037	0.000 **	-	3.987	0.020	196.417	0.000 **	-
X	0.834	0.045	18.683	0.000 **	0.473	0.643	0.048	13.474	0.000 **	0.365	0.709	0.055	12.961	0.000 **	0.402
Z2	-	-	-	-	-	0.289	0.031	9.302	0.000 **	0.252	0.287	0.031	9.254	0.000 **	0.250
X × Z2	-	-	-	-	-	-	-	-	-	-	0.139	0.057	2.436	0.015 *	0.070
R <sup>2</sup>	0.224					0.276					0.279				
Adj. R <sup>2</sup>	0.223					0.274					0.277				
F	F(1, 1211) = 349.039, p = 0.000 **					F(2, 1210) = 230.103, p = 0.000 **					F(3, 1209) = 156.007, p = 0.000 **				
$\Delta R^2$	0.224					0.052					0.004				
$\Delta F$	F(1, 1211) = 349.039, p = 0.000 **					F(1, 1210) = 86.518, p = 0.000 **					F(1, 1209) = 5.936, p = 0.015 *				

Dependent Variable: Y. \*  $p < 0.05$ , \*\*  $p < 0.01$ .

The results of simple slope analysis showed that in high external contexts, high levels of college students' attitudes toward waste separation and recovery significantly predicted high levels of corresponding behaviors. Meanwhile, in the low external context, the low level of college students' attitudes also effectively predicted their low level of behaviors (see Table 9).

**Table 9.** Results of the simple slope analysis.

Levels of the Moderating Variables	B	S.E.	t	p	95% CI	
Mean value	0.709	0.055	12.961	0.000	0.602	0.816
High level (+1 SD)	0.803	0.081	9.909	0.000	0.644	0.962
Low level (−1 SD)	0.614	0.049	12.506	0.000	0.518	0.711

## 5. Discussion

College students are a special group that plays an important role in leading society, so it is particularly important to cultivate their awareness and behavior of waste separation. The relationship between attitudes and behaviors is controversial [15,25,46]; that is, attitudes are capable of influencing the development of behaviors to a certain extent but not determining the occurrence of behaviors. This study confirms that college students' attitude towards waste separation has a positive influence on their behavior, which is consistent with the previous studies [47,48]. Meanwhile, this study found that college students' knowledge of waste separation is relatively insufficient. Obtaining waste separation knowledge is the basis and guarantee for waste separation, which can exert a subtle influence on improving students' consciousness of the circular economy. Thus, college students should master the common sense of waste separation and the specific separation methods in practice. Further, it is found that college students have a high awareness of environmental participation but lag in action because they are highly dependent on the government [49]. This highlights that college students should go beyond their thinking and take the initiative to shoulder their social responsibilities as citizens. Moreover, the way of life focused on the consumption of resources in the past caused damage to the environment. Hence, college students should actively practice a green lifestyle and improve their living environment.

Administrators of higher education institutions are the direct decision-makers who can determine the campus contextual factors. This study found that contextual factors could play a moderating role in the waste separation behavior of college students. Therefore, university administrators should strengthen the popularization and education of college students' waste separation knowledge and increase students' awareness of social

responsibility. According to the results, attention should be paid to the performance of male college students and the differentiation of different grades during education.

Besides, although China has clearly defined the classification standard of domestic waste and the standard identification of waste facilities, many colleges and universities have not yet been able to improve the construction of facilities on campus simultaneously [50]. Previous studies have also shown that the system and policy measures have a strong binding force and can effectively regulate and restrain students' daily life behavior [51]. Therefore, university administrators should improve the construction of supporting facilities for waste separation and improve the constraints of the waste separation system. In addition, university administrators should guide and encourage campus pro-environmental activities, actively organize and carry out waste separation practice activities, expand the influence range of campus publicity, and strengthen the cultural atmosphere of the circular economy on campus.

Government departments are the dominant players affecting the external context of waste separation at the social level, which could essentially solve some dilemmas at universities through policy formulation and implementation. At present, the back-end separation, collection, and transportation system of urban waste treatment in China is in a relatively backward state, which directly leads to the low enthusiasm of college students for front-end separation and delivery. Thus, the government must establish a complete domestic waste separation and treatment system of "separated delivery, separated collection, separated transportation, and separated disposal." Besides, only a few pilot cities in China have established effective laws and regulations, incentive mechanisms, and mandatory restraint policies for the management of domestic waste separation and recovery at present [52]. As the producers of waste, the participation of most urban residents in the waste separation mainly depends on their initiative and willingness and is not subject to laws and regulations [53]. Therefore, government departments need to strengthen the binding and incentivized laws and regulations to ensure all residents participate in living waste separation and recovery.

## 6. Conclusions

College students' attitudes and behavior towards waste separation could greatly influence the efficiency of campus waste management. This study aimed at verifying the variable relationship, influence path, and regulating factors of college students' waste separation attitude and behavior. The results of the statistical analysis showed that the attitude of respondents towards waste separation is relatively positive. Specifically, college students are generally aware of the importance of waste separation and their responsibility in realizing waste separation and recovery but lack sufficient knowledge about waste separation. Regarding waste separation behaviors, college students are generally able to participate in the promotion activities of waste separation, but their waste separation behaviors are relatively inadequate in practice. Contextual factors can positively influence waste separation behaviors to varying degrees, among which the infrastructure construction and the regulations and rules have the most significant impact.

The results of the further analysis showed that different gender respondents are significantly different in terms of attitudes and internal and external contextual factors. Moreover, the mean value of males was significantly lower than that of females for the above variables. The respondents of different grades showed significant differences in behavior and internal and external contextual factors. Generally, freshmen showed the highest degree of waste separation behaviors. Waste separation behaviors of senior students are more susceptible to contextual factors.

The results of structural equation modeling suggested that attitude has a significant positive influence on behavior, especially the knowledge factor shows the greatest degree of influence. It was verified that the moderating variable 'internal contextual factors' has a similar influence range at different levels when attitude affects behavior. On the contrary, the moderating variable 'external contextual factors' has a significant difference



in the impact amplitude at different levels when attitude affects behavior. Based on the analysis, appropriate suggestions and countermeasures were proposed for college students, university administrators, policymakers, and government departments, respectively.

The findings of this study reveal the logical relationship between the attitudes and behaviors of Chinese college students on waste separation and recovery, which facilitates the design and optimization of college waste management policies. Nevertheless, it is also needed to acknowledge that there are still certain limitations in this study. The sample selected mainly consisted of college students from one university, and the sampling was relatively concentrated. In future studies, the group of respondents can be expanded to involve more universities in the region. Additionally, some regions in China have implemented mandatory economic policies such as quantity-based fees for domestic waste and financial penalties for failure to separate waste accurately. An empirical study of the effect of these measures on waste separation behavior could be a promising future research direction to upgrade campus waste management performance.

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## Appendix A Questionnaire of Waste Separation and Recovery Status at Henan Institute of Science and Technology

It would be our great pleasure if you could join this scientific survey!

The purpose of our study is to identify the primary elements affecting the achievement of waste management at the Henan Institute of Science and Technology.

We would like to emphasize that the survey is anonymous, all data received is strictly confidential, and your answers will not be passed on to third parties.

The survey is conducted online and will take approximately 5 min. There are no right or wrong answers, and it is just your vision. Your opinion is important to us!

Many thanks for your time and interest!

### Part 1. Please choose the most appropriate option depending on your situation.

1. Your gender: A. Male B. Female
2. Your age: A. <18 years old B. 18–20 years old C. 21–23 years old D.  $\geq$ 24 years old
3. Your grade: A. Freshman B. Sophomore C. Junior D. Senior

### Part 2. Please choose the most appropriate option according to your practical actions and thoughts in daily life.

1. Do you agree that the mass generation and unreasonable disposal of waste will have a negative impact on your life and health?
  - A. Totally agree B. Generally agree C. Neutral D. Generally disagree E. Totally disagree
2. Do you agree that waste separation and recovery at universities is significantly meaningful for solving resource scarcity and environmental problems?
  - A. Totally agree B. Generally agree C. Neutral D. Generally disagree E. Totally disagree

3. Do you know the national standards for domestic waste classification (four major categories, including Recyclable Waste, Hazardous Waste, Food Waste, and Residual Waste, and 11 sub-categories)?  
A. Very clear B. Generally clear C. Half-and-half D. Not very clear E. Totally no idea
4. Do you agree that it is the responsibility of every citizen to separate waste?  
A. Totally agree B. Generally agree C. Neutral D. Generally disagree E. Totally disagree
5. You always participate in the publicity and education activities on waste separation organized by the university.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
6. You always take the initiative to separate the generated waste in your daily life.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
7. You always drop off your old and unwanted clothes at the special textile recycling bins on campus.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
8. You always return the carton/box to the courier for recycling when you receive the parcel.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
9. Do you agree that waste separation is mainly the responsibility of the government and has little to do with individuals?  
A. Totally agree B. Generally agree C. Neutral D. Generally disagree E. Totally disagree
10. If there is a recognition or material reward mechanism at your university, you will separate the waste.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
11. If you can get extra points in the evaluation of merit and scholarship, you will separate the waste.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
12. If you can have priority in the entrance examination and job application, you will actively participate in waste separation and the relevant practical activities.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
13. If there are standard waste classification bins and special waste collection points on campus, you will separate the waste.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
14. If your university has mandatory rules and requirements on waste separation, you will comply with the rules.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
15. If all your acquaintances around you carry out waste separation and recovery, you will separate the waste, too.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent
16. The publicity campaign and courses on waste separation will make you more enthusiastic about involving in waste separation activities.  
A. Totally consistent B. Generally consistent C. Half-and-half D. Generally inconsistent E. Totally inconsistent

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