Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-024-32384-0

RESEARCH ARTICLE

Impacts of education and perception on Vietnamese high school students' behaviors regarding plastic waste: the mediating role of attitude

Hien Thi Nguyen[1] · Thi Truc Quynh Ho[2] · Ba Loc Hoang[3] · Thi Cam Tu Le[4]

Received: 25 May 2023 / Accepted: 4 February 2024

Abstract
This study analyzed the impact of educational, perception, and attitudinal factors on the plastic waste behavior of high school students in Vietnam. A cross-sectional research design and questionnaire survey method were used to collect data from 573 high school students. All the statistical analyses and hypothesis tests were performed using SPSS 26 and AmoS 20 software. Research results show that perception does not directly affect students' behavior toward the plastic waste problem ($B = 0.051$, $p = 0.201 > 0.05$, CI = [− 0.027; 0.130]) but has an indirect impact through attitude mediation, with an impact coefficient of $B = 0.107$ ($p = 0.016 < 0.05$, CI = [0.042; 0.177]). Educational factors positively impact students' behavior toward plastic waste through both direct effects, with an impact coefficient of $B = 0.546$ ($p = 0.00 < 0.05$, CI = [0.473; 0.620], and indirect effects, mediated by attitude, with an impact coefficient of $B = 0.017$ ($p = 0.007 < 0.05$, CI = [0.003; 0.037]). These findings are new compared to previous studies, contributing to enriching theories related to behavior toward the plastic waste problem and bringing practical significance to Vietnam. The findings of this study provide the basis for proposing measures to improve plastic waste behaviors for Vietnamese high school students.

Keywords Plastic waste · Education · Perception · Attitude · Behavior · Vietnamese high school students

Introduction

Plastic is a material that is durable, flexible, lightweight, flexible, impermeable, and inexpensive so that it can produce convenient products for consumers and, at the same time, bring high economic value to businesses so that plastics are produced, distributed, and used commonly in everyday life around the globe (Baierl and Bogner 2021). Humans have produced an enormous amount of plastic worldwide, estimated at 9.2 billion tons between 1950 and 2017, equivalent to more than a ton of plastic for every living person today (Williams and Rangel-Buitrago 2022). However, after being disposed of, plastic will become a dangerous waste that seriously pollutes the ecosystem, biodiversity, and climate change and negatively impacts livelihoods and human health (Barnes et al. 2009; Bläsing and Amelung 2018; Heidbreder et al. 2019; Horton et al. 2017; Li et al. 2016; World Bank 2022b). Plastic pollution has become an urgent problem worldwide, with approximately 300 million tons of plastic waste released into the environment annually and increasing exponentially (Chandran et al. 2020).

Vietnam is currently one of the countries with the highest amount of plastic consumption in daily life, ranking fourth globally in ocean plastic waste (Bidegain and Paul-Pont 2018; Chau et al. 2020; Lahens et al. 2018). According to the World Bank's Analysis Report on Plastic Waste Pollution in Vietnam, it is estimated that each year, Vietnam generates 3.1 million tons of plastic waste, of which at least 10% is discharged into the sea (World Bank 2022a). The amount of plastic waste dumped into the sea in Vietnam accounts for about 6% of the total plastic waste discharged into the

Responsible Editor: Philippe Garrigues

✉ Hien Thi Nguyen
nthien.dhsp@hueuni.edu.vn

[1] Department of Geography, University of Education, Hue University, 34 Le Loi, Hue City, Vietnam

[2] Department of Psychology-Education, University of Education, Hue University, 34 Le Loi, Hue City, Vietnam

[3] Department of Foreign Languages and Tourism, Phu Xuan University, 176 Tran Phu Str, Hue City, Vietnam

[4] Department of Physics, University of Education, Hue University, 34 Le Loi, Hue City, Vietnam

Published online: 15 February 2024

world's sea, but only 27% is recycled (Jambeck et al. 2015). In 2018, the average Vietnamese consumed up to 41.3 kg of plastic products yearly (Milne 2019). The pollution of plastic waste and plastic bags in Vietnam was severe, with plastic waste accounting for 8–12% of domestic waste (Schwenkel 2018). Plastic waste pollution has become a serious environmental problem and a significant burden for developing economies such as Vietnam.

The most basic and severe cause of plastic waste pollution lies in the limited environmental culture of humans, which is caused by widespread actions today such as littering without sorting, abuse of nylon bags and disposable plastic items because of their low cost and convenience, despite the very hardly decomposing properties of plastic (Vương 2021). Environmental quality depends heavily on human behavior, and appropriate behavioral changes can reduce negative environmental impacts (Steg and Vlek 2009). Therefore, studying the behavior of individuals in the community toward the plastic waste problem is necessary to discover the influencing factors and create a basis for proposing appropriate solutions to reduce plastic waste and use plastic for each country's and humanity's sustainable development.

Previous studies have investigated the plastic waste behavior of subjects from many countries. Research subjects, such as people and households (Afroz et al. 2017; Allison et al. 2022; Nguyen et al. 2022; Uehara et al. 2023; Van et al. 2021), university students (Abd Hamid and Wan Yahaya 2020; Boca and Saraçli 2023; Choi et al. 2022; Robertson and Walkington 2009; Situmorang et al. 2020; Yusuf and Fajri 2022), and elementary and middle school students (Dalu et al. 2020; Ferdous and Das 2014; Oturai et al. 2022), are very diverse. However, there are few related studies on the factors affecting the plastic waste behavior of high school students worldwide. In our search efforts, we only discovered two studies on the relationship between knowledge, attitudes, and behaviors related to plastic waste management among high school students in Bangkok, Thailand (Patricia Arttachariya 2022), and survey research on the awareness and attitudes of high school students related to plastic pollution in Sharjah city, UAE (Hammami et al. 2017). Exploratory research in Thailand has shown that knowledge and media factors impact students' attitudes, and that these attitudes also significantly influence their plastic waste management behavior (Patricia Arttachariya 2022). Moreover, research in Sharjah, UAE (Hammami et al. 2017), showed that students' awareness and attitudes about plastic pollution are influenced by age, gender, and mother's education levels. Knowledge strongly impacts students' attitudes toward plastic consumption, and education is vital in improving environmentally friendly behavior.

In Vietnam, no research has been conducted on the factors affecting high school students' behavior toward the plastic waste problem. This vast gap needs to be researched because the number of high school students in Vietnam is relatively large, up to 2.89 million people, accounting for 2.84% of Vietnam's population in 2022 (Vietnam General Statistics Office 2022). Vietnam is one of the top countries in the world for consuming plastic and discharging plastic into the ocean (Chau et al. 2020). Students not only are a factor in worsening plastic waste pollution but can also participate in protecting the environment and reducing plastic waste (Kusumawati et al. 2020).

There are significant differences in the results of previous studies on the relationship between perception and behavior toward the plastic waste problem. Research shows that perception factors positively and directly impact behavior toward plastic waste (Anggraini et al. 2019; D'Astous and Legendre 2009). However, many studies find that perception has no direct impact on and has little influence on human behavior related to the plastic waste problem (Hammami et al. 2017; Heidbreder et al. 2019; Van et al. 2021). This contradiction raises the following question: Does perception strongly impact the behavior of high school students in Vietnam regarding the plastic waste problem?

Education is considered a feasible, sustainable, and low-cost solution for reducing plastic waste and improving the current plastic pollution problem (Liu et al. 2023). Education to reduce plastic waste has been mentioned in many studies in many countries, such as in research on the role of environmental education in reducing plastic waste pollution (Hammami et al. 2017; Hungerford and Volk 1990; Liu et al. 2023), in research on plastic waste recycling education in the USA (Bennett and Alexandridis 2021); in plastic waste management education and programs in Japan, Taiwan, the UK, and Hong Kong (Chow et al. 2017), and in experimentally measuring the increase in students's knowledge after being educated about plastic use and the harmful effects of plastic in Pakistan (Abid et al. 2020). However, these studies mainly address theories about the role of environmental education, educational programs, educational methods, and the effectiveness of increasing knowledge after experiments. Very few studies have quantitatively explored the impact of education on student behavior toward the plastic waste problem.

In the current context in Vietnam, education about plastic waste is not focused on high schools. A study surveying the current status of education on plastic waste conducted on 2183 students in 10 provinces and cities in Vietnam in December 2022 showed that education about plastic waste is only occasionally implemented in high schools through environmental education activities or integrated into related subjects. Educational effectiveness has not met expectations because high school students' knowledge and behavior related to plastic waste are still limited (Hien and Bay 2023). This practice also raises the question: How does education impact the behavior of high school students in

Vietnam regarding the issue of plastic waste? Do strengthening educational measures contribute to improving the plastic use reduction behavior of high school students in Vietnam?

Many studies have demonstrated the influence of attitudes on environmental behavior. Typically, research on students in Henan, China, shows that attitudes positively impact students' waste classification behavior (Qu et al. 2023). Attitudes toward environmentally friendly products influence the zero plastic waste behavior of university students in Korea (Choi et al. 2022). Conversely, attitudes toward plastic waste can also be influenced by other factors, such as education and perception. Education can influence consumer attitudes toward plastic waste management (Chauhan and Punia 2022). Perception also clearly impacts students' attitudes and willingness to change toward the issue of plastic pollution (Hammami et al. 2017). The above studies all point to a direct impact of attitude on behavior or from education and perception to attitude on different aspects of the plastic waste problem. However, additional research is needed to explore the mediating role of attitudes in these relationships, especially among high school students.

To address the above gaps, research has been conducted to investigate the direct and indirect impacts of attitudes toward the plastic waste problem through educational and perception factors on the behavior of high school students in Vietnam. The research results will provide the basis for us to propose appropriate educational measures to increase perceptions, change attitudes, and lead to behaviors that reduce plastic use in daily life for high school students in Vietnam.

Theoretical foundations and research models

Underpinning theory

When studying behavior toward environmental issues, many theories including the Theory of Planned Behavior (TPB), have been considered. The TPB states that behavioral intention is the central premise for forming human behavior (De Groot and Steg 2007). According to TPB, three factors predict individuals' behavioral intentions: attitudes, subjective norms, and perceived behavioral control (Ajzen 2012). This approach is considered a robust theoretical framework with high predictive ability for discovering factors that influence human social behavior (Van et al. 2021). The TPB and studies extending various components of the TPB are increasingly widely used to identify determinants of environmental protection behavior (Yuriev et al. 2020). In a study on the factors affecting behavioral intention to reduce single-use plastic use in Malaysia, the authors developed the TPB, using "environmental perception" to replace "perceived behavioral control" and adding "legal" factors to predict people's behavior to reduce single-use plastic (Van et al. 2021). In a study on the factors affecting the behavioral intention to classify solid waste among high school students in China (Liao and Li 2019), researchers expanded the impact of knowledge factors on the environment and of environmental education on students' solid waste classification behavior.

Based on the TPB and the research expanding the TPB mentioned above, this study was conducted to test the impact of educational factors, perceptions, and attitudes on behavior on the plastic waste problem of high school students in Vietnam.

The relationship between education and behavior toward the plastic waste problem

Education plays an essential role in sustainable development (Filho et al. 2015). In addition to economic and legal interventions, psychological interventions such as education to raise awareness and encourage behavioral change have a significant impact on the plastic waste problem (McCoy et al. 2018; Thompson et al. 2009). Hammami et al. (2017) argue that education is the only tool that can be used in this critical time to combat social indifference to the war on plastic waste and that environmental problems are under threat, especially among students (Hammami et al. 2017). Situmorang et al. also noted that increased involvement in environmental education activities increases the risk of contracting environmental issues, including plastic waste problems (Situmorang et al. 2020). The 1977 Intergovernmental Conference on Environmental Education in Tbilisi also affirmed that education could change behavior by providing social groups and individuals with opportunities for active participation at all levels toward solving environmental problems (Chow et al. 2017; Hungerford and Volk 1990).

On that basis, we propose the following hypothesis:

Hypothesis 1 (H1). Education directly impacts the behavior of Vietnamese high school students regarding the problem of plastic waste.

The mediating role of attitudes in the relationship between education and behavior toward the plastic waste problem

The relationships among education, attitudes and behaviors related to the problem of plastic waste have long been of research interest. On the one hand, several previous studies have shown that the level of formal education a person receives is directly correlated with the amount of environmental knowledge and the formation of positive attitudes toward the environment in the person's own life (Chow et al. 2017). Education is seen as a powerful weapon for forming a positive attitude toward a healthier living environment

and a greater quality of life (Avan et al. 2011; Nagra 2010). The goal of environmental education in general and plastic waste education, in particular, is to change people's attitudes by "helping social groups and individuals acquire a set of values and feelings of concern for the environment and motivation for actively participating in environ-mental improvement and protection" (Chow et al. 2017; Hungerford and Volk 1990). In addition, educating students about environmental issues is beneficial for the establishment and maintenance of environmentally responsible behaviors by students now and into the future as they mature (Damerell et al. 2013).

On the other hand, attitude is the fundamental driver of human behavior toward the environment as it determines the stimuli with which the individual will approach or avoid environmental problems (Steg and Vlek 2009). Some studies show that individuals' attitudes impact their plastic waste reduction behavior. People with a positive attitude toward the environment will avoid using plastic products or increase the reuse and recycling of plastic (Jeżewska-Zychowicz and Jeznach 2016; Lea and Worsley 2008; Yeow et al. 2014).

A study in China (Sun et al. 2017) has shown that attitudinal factor is one factor that positively influences people's intention to use plastic bags. Research on factors affecting the behavior of reducing plastic use in Malaysia also shows that the factor that has the most significant influence on people's intention to reduce single-use plastic is the attitude toward the plastic waste problem (Van et al. 2021). Research by Ajzen (2012) also confirms that attitude is one of the decisive factors in human behavior (Ajzen 2012).

Therefore, we propose the following hypothesis:

Hypothesis 2 (H2). Attitudes mediate the relationship between education and behavior toward the plastic waste problem in Vietnamese high school students.

The relationship between perception and behavior toward the plastic waste problem

The perception of environmental issues (including plastic waste) includes the perception of the problem's current state, causes, contributors, and impacts (Hammami et al. 2017). The perception of a problem contributes to changes in people's behavior because perception clearly affects people's attitude and willingness to change (Hammami et al. 2017). If consumers are fully aware of the impact of plastic waste on the environment, their plastic consumption behavior will decrease, especially that of single-use plastic (D'Astous and Legendre 2009). Anggraini et al. also said that the key to educating communities about the management and use of plastic is to increase their perception of the direct impact of plastic pollution on their health (Anggraini et al. 2019).

Therefore, we propose the following hypothesis:

Hypothesis 3 (H3). Perception directly impacts behavior on the plastic waste problem of Vietnamese high school students.

The mediating role of attitudes in the relationship between perceptions and behaviors related to the plastic waste problem

Like in terms of the relationships among education, attitudes and behaviors related to the plastic waste problem, in terms of the relationships between perceptions, attitudes and behaviors related to the plastic waste problem, these relationships have also attracted the attention of researchers. First, perception is seen as a prerequisite for forming a positive attitude toward the environment of each individual (Mobley et al. 2010). Raising perceptions about environmental issues will change individuals' attitudes toward the environment, thereby strongly influencing environmental behaviors and reducing people's irresponsible behavior toward the natural environment (Kollmuss and Agyeman 2002). Research results on secondary school students in the UAE also confirm that students' perceptions have an evident influence on their attitudes and willingness to change toward the plastic pollution problem (Hammami et al. 2017). Moreover, attitudes toward plastic waste problems were found to be positively associated with individuals' behavior (Ajzen 2012; Jeżewska-Zychowicz and Jeznach 2016; Lea and Worsley 2008; Sun et al. 2017; Yeow et al. 2014). From the above analysis, we propose the following hypothesis:

Hypothesis 4 (H4). Attitudes mediate the relationship between perception and behavior toward the plastic waste problem in Vietnamese high school students.

Based on the theory mentioned above, we propose the following research model shown in Fig. 1.

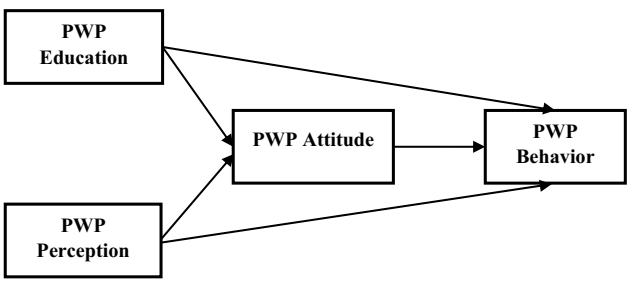

Fig. 1 The proposed research framework

Research methodology

Research procedure

The research process was carried out through the following steps:

- Step 1: Determine the purpose and research problem. This research originates from the current situation of plastic waste pollution in Vietnam and the need to implement solutions to change people's behavior (including that of high school students) toward the plastic waste problem. We wanted to determine the factors that affect the behavior of high school students regarding plastic waste to propose appropriate educational measures.
- Step 2: Research documents. We reviewed relevant international and domestic research to support our hypotheses and arguments.
- Step 3: Proceed to build a conceptual framework and hypotheses.
- Step 4: We designed the questionnaire and tested its reliability.
- Step 5: Choose a survey sample and conduct the survey process to collect the data
- Step 6: Synthesizing and processing survey results using mathematical–statistical methods on 573 valid samples via SPSS 26.0 and AmoS 20.0 software.
- Step 5: Analyze the results and discuss and conclude the research problem.

Sample

In this study, we have conducted measures to measure the perception, attitude, behavior, and level of educational access to the plastic waste problem of 600 Vietnamese high school students based on reference sample size in several studies (Hair et al. 2019; Raykov and Widaman 1995). After removing invalid questionnaires, the number of valid questionnaires remaining is 573 (accounting for 95.5%). Table 1 presents the characteristics of the study sample.

Table 1 Survey sample characteristics

		No	%
Sex	Male	238	41.5
	Female	335	58.5
Grade	Grade 10	244	42.6
	Grade 11	165	28.8
	Grade 12	164	28.6
Total		573	100.0

Data collection methods

The study used a cross-sectional design and utilized online and in-person surveys conducted from September to November 2022. The study applied a convenience sampling technique. To encourage high school students to participate in the online survey, we enlisted the help of principals and homeroom teachers at six high schools. After receiving approval from the principals and homeroom teachers, the homeroom teachers helped us inform the parents and students who participated in the survey of the following information: survey content and participation in the survey were voluntary; all the information provided was used for research purposes only; and personal information was kept confidential.

We invited 600 students to participate in the study, and informed consent was obtained from the 600 students and their parents. Afterward, the homeroom teacher helps us send the participating students paper survey forms or online survey links and funding. After completing the survey, each participating student received 30,000 VND. However, out of 600 survey response samples, there were only 573 valid responses, so we conducted data analysis on these 573 questionnaires.

Measures

This study aimed to measure the impact of educational and cognitive factors on the behavior of Vietnamese high school students regarding the plastic waste problem and the mediating role of attitude factors. To accomplish this purpose, we built the scale ourselves based on a reference to the scale in previous studies (Table 2). Our scale is designed with 28 observed variables and four factors: perception of the plastic waste problem (PWP Perception), attitude toward the plastic waste problem (PWP Attitude), level of education access to the plastic waste problem (PWP Education), and behavior toward the plastic waste problem (PWP Behavior). The scale is designed as a 5-point Likert scale, from 1 (never) to 5 (always) and from 1 (strongly disagree) to 5 (strongly agree). The specific levels of the scale and reference sources used to construct the scale are shown in Table 2.

The scale was tested on 192 students, and the Cronbach's alpha coefficient of the whole scale reached 0.953 (for which the PWP Perception factor was 0.946, the PWP Attitude was 0.931, the PWP Education was 0.938, and the PWP Behavior was 0.916). These findings show that the scale has high reliability for inclusion in the official survey.

Data analysis

In this study, we used SPSS software version 26.0 and Amos software version 22.0 to analyze descriptive

Table 2 Questionnaire's reference sources and five point Likert scale

Component	Items	Reference sources	5-point Likert scale
PWP Perception	**07**	(O'Brien and Thondhlana 2019) (Abd Hamid and Wan Yahaya 2020) (Oturai et al. 2022) (Hammami et al. 2017) (Heidbreder et al. 2019) (Widayat et al. 2022)	1. Strongly disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly agree
PWP Attitude	**06**	(Avan et al. 2011) (Afroz et al. 2017) (Hammami et al. 2017)	
PWP Behavior	**07**	(Partono et al. 2020) (Abd Hamid and Wan Yahaya 2020) (Heidbreder et al. 2019) (Nguyen et al. 2022) (Oturai et al. 2022) (Van et al. 2021) (Widayat et al. 2022)	1. Never 2. Rarely 3. Sometimes 4. Often 5. Always
PWP Education	**08**	(Hammami et al. 2017) (Chow et al. 2017)	

statistics, test the reliability of the scale, analyze exploratory factor analysis (EFA), and perform confirmatory factor analysis (CFA) using the Structural equation modeling (SEM) method to test the proposed research hypotheses H1, H2, H3, and H4 in the model. Finally, the normalized regression coefficient was used to show the different degrees of influence between each pair of hypotheses to clarify the analytical contents of the study.

Results

Reliability and validity of research instruments

Exploratory factor analysis EFA

The results of the study indicated the reliability and validity of the measurement scale. The KMO coefficient of 0.927 demonstrated that the EFA results were consistent with the research data. Bartlett's test sig value is $0.00 < 0.05$, indicating that the observed variables were significant. The total variance explained is $64.121\% > 50\%$; that is, the standard part is more significant than the partial variance and the error are, meeting these conditions, and the EFA model is suitable. The results of the factor loading coefficient through the analysis of the rotation matrix (pattern matrix) are all > 0.50, showing that the observed variable has good statistical significance. The factor loading factors are shown in detail in Table 3.

Table 3 Factor loadings

Items	Factor loading			
	Factor 1	Factor 2	Factor 3	Factor 4
PWP Education 4	0.828			
PWP Education 2	0.814			
PWP Education 3	0.807			
PWP Education 1	0.779			
PWP Education 5	0.729			
PWP Education 6	0.714			
PWP Education 7	0.671			
PWP Education 8	0.635			
PWP Perception 2		0.848		
PWP Perception 4		0.847		
PWP Perception 1		0.834		
PWP Perception 3		0.789		
PWP Perception 5		0.760		
PWP Perception 6		0.735		
PWP Perception 7		0.723		
PWP Behavior 4			0.777	
PWP Behavior 6			0.773	
PWP Behavior 5			0.757	
PWP Behavior 2			0.750	
PWP Behavior 3			0.737	
PWP Behavior 1			0.735	
PWP Behavior 7			0.697	
PWP Attitude 5				0.811
PWP Attitude 4				0.791
PWP Attitude 3				0.774
PWP Attitude 1				0.772
PWP Attitude 6				0.762
PWP Attitude 2				0.721

Table 4 Assessment of the reflective measurement model

Factor	Cronbach's alpha	Composite reliability	AVE
PWP Perception	0.918	0.919	0.621
PWP Attitude	0.897	0.898	0.594
PWP Education	0.904	0.907	0.552
PWP Behavior	0.894	0.894	0.548

CFA for confirmatory factor analysis

To measure the fit of the model and evaluate the reliability of the scales, the study conducted confirmatory factor analysis (CFA). First, the overall fit of the data was evaluated based on the model metrics (model fit). In this study, the indexes chi-square/df = 2.575 < 5, CFI = 0.943 > 0.80, NFI = 0.911 > 0.80, GFI = 0.893 > 0.85, AGFI = 0.874 > 0.80, and RMSEA = 0.053 < 0.08 were used; all the indexes met the required thresholds. The research model fits the data well. Second, to evaluate the scale's reliability, this study used the following indicators: composite reliability (CR), total extracted variance (AVE), and Cronbach's alpha coefficient. All the values are above the minimum CR requirements of 0.7, AVE of 0.5, and Cronbach's alpha of 0.8 (as shown in Table 4), which can confirm that the scales meet the requirements. Third, the convergence value is tested. The results of the CFA test show that the estimated coefficients of the observed variables are more significant than 0.5, and all p-values are less than 0.05, which is statistically significant.

Correlation analysis among factors

Table 5 presents the mean scores, standard deviations, and correlation coefficients between the perceptions, attitudes, and education and behaviors of high school students toward plastic waste. The data in Table 5 shows that the scores of perception, attitude, and education and behavior of high school students toward the problem of plastic waste were 4.173 (SD = 0.769), 4.061 (SD = 0.78549), 3.5598 (SD = 0.82203), and 3.4468 (SD = 0.86191), respectively. Perception is positively correlated with attitude ($r = 0.523$; $p < 0.01$) and positively correlated with education ($r = 0.110$; $p < 0.01$) and behavior ($r = 0.103$; $p < 0.05$). Attitude was positively correlated with education ($r = 0.168$; $p < 0.01$) and behavior ($r = 0.187$; $p < 0.01$). Education was positively correlated with behavior ($r = 0.526$; $p < 0.01$).

Moderated mediation analyses

This study used structural equation modeling (SEM) to test the proposed research hypotheses, and the results showed the appropriateness of the structural model compared with the data. The indexes chi square/df = 2.575 < 5, CFI = 0.943 > 0.80, NFI = 0.911 > 0.80, GFI = 0.893 > 0.85, AGFI = 0.874 > 0.80, and RMSEA = 0.052 < 0.08 are all satisfactory.

Table 6 and Fig. 2 present the direct and indirect effects of education and perception on the behavior of plastic waste among Vietnamese high school students. The results showed that the direct impact of education on behavior was statistically significant ($B = 0.546$, $p = 0.00 < 0.05$, CI = [0.473; 0.620]); and that the indirect impact of education on behavior through attitude was statistically significant ($B = 0.017$, $p = 0.007 < 0.05$, CI = [0.003; 0.037]). The above results

Table 5 Mean score, standard deviation, and correlation matrix between variables

Factor	Mean	SD	PWP Perception	PWP Attitude	PWP Education
PWP Perception	4.1730	0.76999	1		
PWP Attitude	4.0611	0.78549	0.523**	1	
PWP Education	3.5598	0.82203	0.110**	0.168**	1
PWP Behavior	3.4468	0.86191	0.103*	0.187**	0.526**

Table 6 Direct and indirect effects of education and perception on plastic waste behavior

Effects	B	Sig. (p-values)	95% CI
PWP Education → PWP Behavior	0.546	0.000 < 0.05	[0.473; 0.620]
PWP Education→PWP Attitude	0.107	0.002 < 0.05	[0.040; 0.174]
PWP Attitude→PWP Behavior	0.205	0.000 < 0.05	[0.117; 0.294]
PWP Education→PWP Attitude→PWP Behavior	0.017	0.007 < 0.05	[0.003; 0.037]
PWP Perception → PWP Behavior	0.051	0.201 > 0.05	[−0.027; 0.130]
PWP Perception →PWP Attitude	0.521	0.000 < 0.05	[0.450; 0.593]
PWP Perception→PWP Attitude→PWP Behavior	0.107	0.016 < 0.05	[0.042; 0.177]

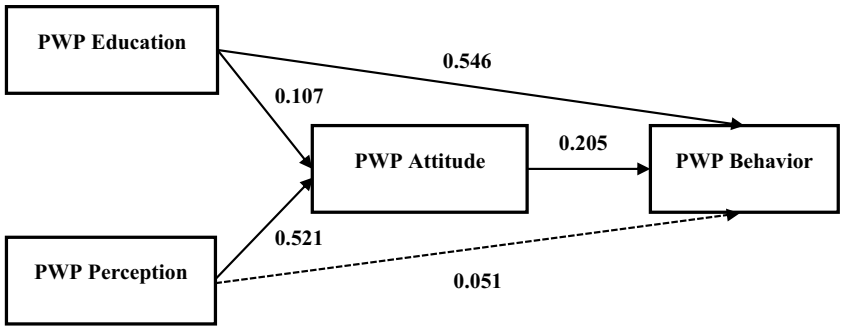

Fig. 2 Summary of SEM model estimation results

show that attitude partly mediates the relationship between education and the behavior of Vietnamese high school students regarding the plastic waste problem. The direct effect of perception on behavior was not statistically significant ($B = 0.051$, $p = 0.201 > 0.05$, CI = [−0.027; 0.130]); the indirect impact of perception on behavior through attitude was also statistically significant ($B = 0.107$, $p = 0.016 < 0.05$, CI = [0.042; 0.177]). The above results show that attitude completely mediates the relationship between perception and behavior on the plastic waste problem among high school students in Vietnam.

The results of the research model are presented as follows:

Discussion

This section will discuss the extent to which the research objectives have been achieved and the appropriateness of the hypotheses, contributions, and limitations of the research.

This study has two main goals. First, to evaluate the impact of educational and perception factors on the plastic waste behavior of high school students in Vietnam. Second, we evaluated the mediating role of the attitude factor in that relationship. Research results show that education strongly influences student behavior toward the plastic waste problem through direct and indirect effects. Moreover, perception does not influence students' behavior on the issue of plastic waste. Attitude partially mediates the relationship between education and students' behavior toward the plastic waste problem. Moreover, attitude also plays a vital role as a complete mediator in the relationship between perception and behavior toward the plastic waste problem among high school students in Vietnam. The statistical results have clarified the research's objectives.

Hypothesis H1 states, "Education directly impacts behavior toward the plastic waste problem of Vietnamese high school students." The research results prove that hypothesis H1 is appropriate and accepted. This was also shown in several previous studies demonstrating that education has an impact on changing the waste management practices of students (Grodzińska-Jurczak et al. 2003); education is a measure of interventions that need to be made to reduce the amount of plastic waste that is not adequately managed (Cordier et al. 2021). In a study of Spain and the USA (Vicente-Molina et al. 2013), Vicente and colleagues calculated that a 1% increase in environmental knowledge would increase environmental behavior further by 0.40%, and environmental education is a promising solution to the plastic waste problem. Other studies (such as Chow et al. 2017; Damerell et al. 2013; McCoy et al. 2018) have confirmed the positive role of education in directly improving individuals' behavior toward plastic waste, which contributes to their environmental responsibility.

Consistent with hypothesis H2, our research results showed that education indirectly impacts the behavior of Vietnamese high school students regarding plastic waste through the medium of students' attitudes toward the plastic waste problem. The statistical results prove that hypothesis H2 is appropriate and accepted. This result is consistent with many previous studies suggesting that education contributes to changing students' attitudes toward a more positive and healthy way when facing the problem of plastic waste (Desa et al. 2011), that attitude plays a predictor role in plastic consumption behavior of individuals in the community (Sun et al. 2017), and that attitudes form the basis for individuals to perform environmentally beneficial behaviors (Afroz et al. 2017; Ajzen 2012). However, previous studies have not explored whether this mediating relationship is partial or complete. In this study, statistical indicators showed that attitudinal factors play a partial mediating role in the relationship between education and the behavior of high school students regarding the plastic waste problem.

Regarding the relationship between awareness and behavior toward plastic waste, our research results show that the direct impact of perception on behavior is not statistically significant. This rejects hypothesis H3, "Awareness has a direct impact on the behavior of the plastic waste problem of Vietnamese high school students," of the study. This can be explained by the fact that many high school students in Vietnam know that plastic is not suitable and that the increasing amount of plastic waste produced in Vietnam harms the environment. However, students do not know

about the long-term decomposition time of plastic, the serious harmful effects of plastic and plastic waste on human health and the environment, the problematic current situation of plastic pollution in Vietnam, or the causes of plastic pollution that come from people's use of plastic in their daily lives. Therefore, many students ignore this issue and still use plastic daily. Although the statistical results contradict the hypothesis proposed in this study, they are consistent with the results of some previous studies; for example, there is no correlation between perception and behavior toward plastic waste (Rayon-Viña et al. 2018), and the perception of the harmful effects of plastic has no direct impact on plastic use behavior (Hammami et al. 2017; Heidbreder et al. 2019). The factor that has the most negligible impact on people's behavioral intention to reduce single-use plastic is the perception factor (Van et al. 2021). Van et al. also confirmed that a person with an excellent environmental perception and plastic waste does not believe that they will implement behaviors to reduce plastic use (Van et al. 2021). Moreover, although many students have a good perception of the harmful effects of plastic and plastic waste, they still use plastic on a regular basis.

Consistent with hypothesis H4, the research results showed that attitude fully mediated the relationship between the perception and behavior of high school students toward the plastic waste problem. Therefore, hypothesis H4 is suitable and accepted. This result can be explained as follows: when students are highly aware of the issue of plastic waste, they have certain knowledge about the harmful effects of plastic, the reality of plastic waste pollution, and the responsibility of individuals in the community for plastic waste management. In addition, students will tend to be more concerned about this issue. Attention will increase the willingness to participate in activities to reduce plastic waste, forming a positive attitude toward environmental protection. A positive attitude will influence students' daily actions toward plastic, such as limiting plastic cups and nylon bags when shopping, using cloth bags to replace nylon bags, using glass bottles for water instead of plastic cups, and recycling plastic into valuable items. This result is consistent with previous studies, such as a study on a sample of 400 high school students in the UAE showed that students' perception of plastic pollution clearly affects their attitudes and willingness to change their change in plastic consumption, thereby contributing to behavior change toward environmentally responsible (Hammami et al. 2017); Attitude is the primary determinant of consumer plastic recycling behavior (Heidbreder et al. 2019).

This research contributes to enriching theories about high school students' behavior toward the plastic waste problem. A new contribution of this study is to explore the specific impact of education and perception on behavior related to the plastic waste problem and the mediating role of attitude. Research has demonstrated the critical role of education in changing behavior toward the plastic waste problem among high school students in Vietnam. Moreover, the study revealed the full mediating role of attitude in the relationship between students' perceptions and behavior toward the plastic waste problem. Attitude also partially mediates the relationship between education and behavior toward the plastic waste problem among high school students in Vietnam. These findings are new compared to those of previous studies.

The research findings have practical value in the current Vietnamese context. Vietnam is a country with a high level of plastic consumption in daily life, and a large amount of plastic waste is discharged into the ocean. Research has shown that if we strengthen educational measures on the plastic waste problem for high school students, improving students' perceptions and attitudes about this issue will increase students' responsible behaviors for using and managing plastic daily. According to the National Action Plan on Marine Plastic Waste Management for 2030, Vietnam aims to reduce ocean plastic waste by 50% by 2025 and 75% by 2030. To achieve that goal, education needs to become an essential solution to change plastic consumption habits, and at the same time, it is necessary to develop positive attitudes among students toward the problem of plastic waste through interest and willingness to practice actions to reduce plastic use in daily life. Although perception does not directly impact behavior, it affects attitudes, and attitudes affect behavior; thus, raising students' perceptions about the plastic waste problem is also necessary. Improving the behavior of high school students in Vietnam in terms of using plastic and managing plastic waste can be accomplished in many ways, such as by integrating into relevant high school subjects pine; organizing experiential activities on the topic of plastic waste management and reducing plastic waste in schools; developing and providing valid documents on plastic waste management for students; organizing communication activities about the harmful effects of plastic waste and the need to reduce plastic use; educating about plastic reuse and recycling practices; coordinating education on plastic waste issues between families, schools, and localities; and strengthening communication channels such as radio, television, and the Internet in propagating the issue of plastic waste. Research results provide additional understanding and valuable scientific basis for the government, the Ministry of Education and Training, and policymakers in Vietnam when proposing educational measures to reduce plastic waste for high school students.

Although specific results were obtained, this study has several limitations. First, the new study tested this hypothesis with high school students in one city but did not extend to other cities in Vietnam. Second, factors affecting students' behavior toward plastic waste problems, such as knowledge,

habits, intentions, social norms, motivation, and interests, were not included. To simplify the model, this study selects the prominent factors proposed by some studies as awareness, attitude, and education. Third, the study has yet to show the differences in perceptions, attitudes, and levels of educational access and behaviors related to the plastic waste problem among male and female students across all grades. Fourth, due to the cross-sectional study design, this study does not allow us to infer a causal relationship between the research variables. These limitations suggest the need for follow-up research by expanding the research's scale, scope, and subjects.

Conclusion

Plastic waste pollution has become one of the most severe environmental problems for Vietnam and many other countries worldwide. To reduce plastic waste for sustainable development, it is necessary to learn about the factors that influence the behavior of individuals in the community toward the plastic waste problem to propose appropriate measures.

This study explored the impact of educational and perception factors on the behavior of Vietnamese high school students toward the plastic waste problem and the mediating role of attitude. The analysis of 573 Vietnamese high school students showed that educational factors positively and directly impact Vietnamese high school students' plastic waste problem behavior. In addition, education indirectly affects the behavior of Vietnamese high school students through mediating attitudes. Although the perception factor does not directly impact students' behavior toward the plastic waste problem, it does have an indirect impact through attitude mediation. Compared to the findings of previous studies, this is a new finding because it confirms the mediating role and specific impact of attitude factors on the relationships among education, perceptions, and behaviors of high school students toward plastic waste problems. The research results contribute to enriching theories related to human behavior toward plastic waste, confirming the significant role of education and attitudes toward plastic waste reduction behavior in high school students. At the same time, this research has practical value in the current Vietnamese context. This study provides information for the government, education management agencies, and educators in Vietnam to develop appropriate policies, programs, and activities to educate high school students to reduce plastic waste.

In addition to the results achieved, the spatial scope and research subjects still need to be improved, the use of cross-sectional research methods is limited in interpreting the results, and the limitations in the content have partly affected the research results. Expanding the research space, adding other influencing factors to cover more variables that affect students' behavior toward the plastic waste problem, and applying PLS software to the analysis statistics will constitute our next research direction.

Acknowledgements We thank all participants and their parents for their cooperation.

Author contribution All authors contributed to the study conception and design. Conceptualization: Hien Thi Nguyen; methodology: Hien Thi Nguyen and Thi Truc Quynh Ho; software: Ba Loc Hoang; validation: Hien Thi Nguyen and Ba Loc Hoang; formal analysis: Hien Thi Nguyen and Thi Truc Quynh Ho; investigation: Hien Thi Nguyen and Thi Cam Tu Le; resources: Hien Thi Nguyen and Thi Truc Quynh Ho; data curation: Hien Thi Nguyen and Ba Loc Hoang; writing—original draft preparation: Hien Thi Nguyen; writing—review and editing: Thi Truc Quynh Ho and Thi Cam Tu Le; visualization: Thi Truc Quynh Ho, Thi Cam Tu Le, and Hien Thi Nguyen; supervision: Hien Thi Nguyen; project administration: Hien Thi Nguyen and Thi Truc Quynh Ho; funding acquisition: Hien Thi Nguyen. All authors read and approved the final manuscript.

Funding This research was funded by Hue University (Vietnam) under grant number DHH2022-03–167.

Data Availability Research data are not shared.

Declarations

Ethical approval All procedures performed in studies involving human participants were by the ethical standards of the institutional and national research committee.

Consent to participate Informed consent was obtained from all participants in this study.

Consent for publication All authors have read and agreed to the published version of the manuscript.

Competing interests The authors declare no competing interests.

References

Abd Hamid I, Wan Yahaya WA (2020) Zero-waste campaign: assessment on university student's behaviour, awareness, and impact on plastic products. Malaysian J Social Sci Human (MJSSH), 5(3), 24–29. https://doi.org/10.47405/mjssh.v5i3.371

Abid R, Hussain M, Majeed I, Afzal M, Parveen K, Gilani SA (2020) Effectiveness of health education session on knowledge of high school students regarding plastic use and its health hazards. J Health Med Nurs, 12(13year), 4–5. https://doi.org/10.7176/jhmn/72-09

Afroz R, Rahman A, Masud MM, Akhtar R (2017) The knowledge, awareness, attitude and motivational analysis of plastic waste and household perspective in Malaysia. Environ Sci Pollut Res 24(3):2304–2315. https://doi.org/10.1007/s11356-016-7942-0

Ajzen I (2012) The theory of planned behavior. Handbook of Theories of Social Psychology: Volume 1, 50(2), 438–459. https://doi.org/10.4135/9781446249215.n22

Allison AL, Baird HM, Lorencatto F, Webb TL, Michie S (2022) Reducing plastic waste: a meta-analysis of influences on behaviour and interventions. J Clean Prod 380:134860

Anggraini W, Karyanto P, Sarwanto, & Prihantomo. (2019) School and teachers' role to empowerment of environmental literacy in prominent middle school based on Adiwiyata Program. J Phys: Conf Ser 1233(1):12084. https://doi.org/10.1088/1742-6596/1233/1/012084

Avan C, Aydinli B, Bakar F, Alboga Y (2011) Preparing attitude scale to define students' attitudes about environment, recycling, plastic and plastic waste. Intl Electron J Environ Educ, 1(3), 179–191. www.iejeegreen.com

Baierl T-M, Bogner FX (2021) Plastic pollution. Am Biol Teach 83(5):320–324. https://doi.org/10.1525/abt.2021.83.5.320

Barnes DKA, Galgani F, Thompson RC, Barlaz M (2009) Accumulation and fragmentation of plastic debris in global environments. Philos Trans Royal Society b: Biol Sci 364(1526):1985–1998. https://doi.org/10.1098/rstb.2008.0205

Bennett EM, Alexandridis P (2021) Informing the public and educating students on plastic recycling. Recycling 6(4):69

Bidegain G, Paul-Pont I (2018) Commentary: plastic waste associated with disease on coral reefs. Front Marine Sci, 5(JUL), 460–462. https://doi.org/10.3389/fmars.2018.00237

Bläsing M, Amelung W (2018) Plastics in soil: analytical methods and possible sources. Sci Total Environ 612:422–435. https://doi.org/10.1016/j.scitotenv.2017.08.086

Boca GD, Saraçli S (2023) Effects of Romanian student's awareness and needs regarding plastic waste management. Sustainability 15(8):6811

Chandran M, Tamilkolundu S, Murugesan C (2020) Characterization studies: waste plastic oil and its blends. Energy Sources, Part a: Recovery, Util Environ Effects 42(3):281–291. https://doi.org/10.1080/15567036.2019.1587074

Chau MQ, Hoang AT, Truong TT, Nguyen XP (2020) Endless story about the alarming reality of plastic waste in Vietnam. Energy Sources, Part A: Recovery, Utilization and Environmental Effects, 1–9. https://doi.org/10.1080/15567036.2020.1802535

Chauhan NS, Punia A (2022) Role of education and society in dealing plastic pollution in the future. Plastic and Microplastic in the Environment: Management and Health Risks, 267–281. https://doi.org/10.1002/9781119800897.ch14

Choi E-H, Lee H, Kang M-J, Nam I, Moon H-K, Sung J-W, Eu J-Y, Lee H-B (2022) Factors affecting zero-waste behaviours of college students. Int J Environ Res Public Health 19(15):9697

Chow CF, So WMW, Cheung TY, Yeung SKD (2017) Plastic waste problem and education for plastic waste management. In Emerging Practices in Scholarship of Learning and Teaching in a Digital Era (pp. 125–140). Springer. https://doi.org/10.1007/978-981-10-3344-5_8

Cordier M, Uehara T, Baztan J, Jorgensen B, Yan H (2021) Plastic pollution and economic growth: the influence of corruption and lack of education. Ecol Econ 182:106930. https://doi.org/10.1016/j.ecolecon.2020.106930

D'Astous A, Legendre A (2009) Understanding consumers' ethical justifications: a scale for appraising consumers' reasons for not behaving ethically. J Bus Ethics 87(2):255–268. https://doi.org/10.1007/s10551-008-9883-0

Dalu MTB, Cuthbert RN, Muhali H, Chari LD, Manyani A, Masunungure C, Dalu T (2020) Is awareness on plastic pollution being raised in schools? Understanding perceptions of primary and secondary school educators. Sustainability (switzerland) 12(17):6775. https://doi.org/10.3390/SU12176775

Damerell P, Howe C, Milner-Gulland EJ (2013) Child-orientated environmental education influences adult knowledge and household behaviour. Environ Res Lett 8(1):15016. https://doi.org/10.1088/1748-9326/8/1/015016

De Groot J, Steg L (2007) General beliefs and the theory of planned behavior: the role of environmental concerns in the TPB. J Appl Soc Psychol 37(8):1817–1836. https://doi.org/10.1111/j.1559-1816.2007.00239.x

Desa A, Ba'yah Abd Kadir N, Yusooff F (2011) A study on the knowledge, attitudes, awareness status and behaviour concerning solid waste management. Procedia - Social Behav Sci, 18, 643–648https://doi.org/10.1016/j.sbspro.2011.05.095

Ferdous T, Das T (2014) A study about the attitude of grade eight students for the use of plastic in Gwarko, Balkumari, Lalitpur district. Procedia Soc Behav Sci 116:3754–3759

Filho WL, Manolas E, Pace P (2015) The future we want key issues on sustainable development in higher education after Rio and the UN decade of education for sustainable development. Int J Sustain High Educ 16(1):112–129. https://doi.org/10.1108/IJSHE-03-2014-0036

Grodzińska-Jurczak M, Bartosiewicz A, Twardowska A, Ballantyne R (2003) Evaluating the impact of a school waste education programme upon students' parents' and teachers' environmental knowledge, attitudes and behaviour. Intl Res Geog Environm Educ 12(2):106–122. https://doi.org/10.1080/10382040308667521

Hair JF, Anderson RE, Tatham RL, Black WC (2019) Multivariate Data Analysis. Book 87(4):611–628

Hammami MBA, Mohammed EQ, Hashem AM, Al-Khafaji MA, Alqahtani F, Alzaabi S, Dash N (2017) Survey on awareness and attitudes of secondary school students regarding plastic pollution: implications for environmental education and public health in Sharjah city. UAE Environ Sci Pollut Res 24(25):20626–20633. https://doi.org/10.1007/s11356-017-9625-x

Heidbreder LM, Bablok I, Drews S, Menzel C (2019) Tackling the plastic problem: a review on perceptions, behaviors, and interventions. Sci Total Environ 668:1077–1093. https://doi.org/10.1016/j.scitotenv.2019.02.437

Hien NT, Bay VD (2023) Research on the behavior and level of approach to education on the issue of plastic waste among high school students No Title. Educ Manage Sci 4(40):36–48

Horton AA, Walton A, Spurgeon DJ, Lahive E, Svendsen C (2017) Microplastics in freshwater and terrestrial environments: evaluating the current understanding to identify the knowledge gaps and future research priorities. Sci Total Environ 586:127–141. https://doi.org/10.1016/j.scitotenv.2017.01.190

Hungerford HR, Volk TL (1990) Changing learner behavior through environmental education. J Environ Educ 21(3):8–21. https://doi.org/10.1080/00958964.1990.10753743

Jambeck JR, Geyer R, Wilcox C, Siegler TR, Perryman M, Andrady A, Narayan R, Law KL (2015) Plastic waste inputs from land into the ocean. Science 347(6223):768–771. https://doi.org/10.1126/science.1260352

Jeżewska-Zychowicz M, Jeznach M (2016) Consumers' behaviours related to packaging and their attitudes towards environment. J Agribusiness Rural Dev, *9*(3), 447–457. https://doi.org/10.17306/jard.2015.47

Kollmuss A, Agyeman J (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ Educ Res 8(3):239–260. https://doi.org/10.1080/13504620220145401

Kusumawati I, Setyowati M, Dharma Syakti A, Fahrudin A (2020) Enhancing millennial awareness towards marine litter through environmental education. E3S Web of Conferences, 147, 2019. https://doi.org/10.1051/e3sconf/202014702019

Lahens L, Strady E, Kieu-Le TC, Dris R, Boukerma K, Rinnert E, Gasperi J, Tassin B (2018) Macroplastic and microplastic contamination assessment of a tropical river (Saigon River, Vietnam) transversed by a developing megacity. Environ Pollut 236:661–671. https://doi.org/10.1016/j.envpol.2018.02.005

Lea E, Worsley A (2008) Australian consumers' food-related environmental beliefs and behaviours. Appetite 50(2–3):207–214. https://doi.org/10.1016/j.appet.2005.07.012

Li WC, Tse HF, Fok L (2016) Plastic waste in the marine environment: a review of sources, occurrence and effects. Sci Total Environ 566–567:333–349. https://doi.org/10.1016/j.scitotenv.2016.05.084

Liao C, Li H (2019) Environmental education, knowledge, and high school students' intention toward separation of solid waste on campus. Int J Environ Res Public Health 16(9):1659. https://doi.org/10.3390/ijerph16091659

Liu J, Hu Z, Du F, Tang W, Zheng S, Lu S, An L, Ding J (2023) Environment education: a first step in solving plastic pollution. Front Environ Sci 11:1130463

McCoy K, Oliver JJ, Borden DS, Cohn SI (2018) Nudging waste diversion at Western State Colorado University: application of behavioral insights. Int J Sustain High Educ 19(3):608–621. https://doi.org/10.1108/IJSHE-05-2017-0063

Milne GQ (2019) Plastics a growing concern-a Vietnam perspective. Ipsos|Plastic A Growing Concern, https://www.ipsos.com/sites/default/files/2019-09/. www.ipsos.com

Mobley C, Vagias WM, DeWard SL (2010) Exploring additional determinants of environmentally responsible behavior: the influence of environmental literature and environmental attitudes. Environ Behav 42(4):420–447. https://doi.org/10.1177/0013916508325002

Nagra V (2010) Environmental education awareness among school teachers. Environmentalist 30(2):153–162. https://doi.org/10.1007/s10669-010-9257-x

Nguyen XC, Dao DC, Nguyen TT, Tran QB, Huyen Nguyen TT, Tuan TA, Phuong Nguyen KL, Nguyen VT, Nadda AK, Thanh-Nho N, Chung WJ, Chang SW, Nguyen DD (2022) Generation patterns and consumer behavior of single-use plastic towards plastic-free university campuses. Chemosphere 291:133059. https://doi.org/10.1016/j.chemosphere.2021.133059

O'Brien J, Thondhlana G (2019) Plastic bag use in South Africa: perceptions, practices and potential intervention strategies. Waste Manage 84:320–328. https://doi.org/10.1016/j.wasman.2018.11.051

Oturai NG, Pahl S, Syberg K (2022) How can we test plastic pollution perceptions and behavior? A feasibility study with Danish children participating in "the Mass Experiment." Sci Total Environ 806:150914. https://doi.org/10.1016/j.scitotenv.2021.150914

Partono B, Karsidi R, Yusuf M, Sutarno (2020) Investigation on the urban and rural students' behavior for plastic waste management in solo region. Humanities & Social Sciences Reviews, 8(3 SE-Education & Assessment), 686–694. https://doi.org/10.18510/hssr.2020.8373

Patricia Arttachariya (2022) Knowledge, attitude and behaviour related to plastic waste management : a study on high school students in Bangkok, Thailand. Indian J Environ Protect, 42(3). https://www.e-ijep.co.in/42-3-342-349/

Qu D, Shevchenko T, Esfandabadi ZS, Ranjbari M (2023) College students' attitude towards waste separation and recovery on campus. Sustainability (Switzerland), 15(2). https://doi.org/10.3390/su15021620

Raykov T, Widaman KF (1995) Issues in applied structural equation modeling research. Struct Equ Modeling 2(4):289–318. https://doi.org/10.1080/10705519509540017

Rayon-Viña F, Miralles L, Gómez-Agenjo M, Dopico E, Garcia-Vazquez E (2018) Marine litter in south Bay of Biscay: local differences in beach littering are associated with citizen perception and awareness. Mar Pollut Bull 131:727–735. https://doi.org/10.1016/j.marpolbul.2018.04.066

Robertson S, Walkington H (2009) Recycling and waste minimisation behaviours of the transient student population in Oxford: results of an on-line survey. Local Environ 14(4):285–296

Schwenkel C (2018) Waste infrastructure breakdown and gendered apathy in Vietnam. In In The routledge handbook of & anthropology and the City (Eds.), The Routledge Handbook of Anthropology and the City. New York: Routledge.

Situmorang ROP, Liang TC, Chang SC (2020) The difference of knowledge and behavior of college students on plastic waste problems. Sustainability (switzerland) 12(19):7851. https://doi.org/10.3390/SU12197851

Steg L, Vlek C (2009) Encouraging pro-environmental behaviour: an integrative review and research agenda. J Environ Psychol 29(3):309–317. https://doi.org/10.1016/j.jenvp.2008.10.004

Sun Y, Wang S, Li J, Zhao D, Fan J (2017) Understanding consumers' intention to use plastic bags: using an extended theory of planned behaviour model. Nat Hazards 89(3):1327–1342. https://doi.org/10.1007/s11069-017-3022-0

Thompson RC, Moore CJ, Saal FSV, Swan SH (2009) Plastics, the environment and human health: current consensus and future trends. Philos Trans Royal Society b: Biol Sci 364(1526):2153–2166. https://doi.org/10.1098/rstb.2009.0053

Uehara T, Asari M, Sakurai R, Cordier M, Kalyanasundaram M (2023) Behavioral barrier-based framework for selecting intervention measures toward sustainable plastic use and disposal. J Clean Prod 384:135609

Unnikrishnan VK, Choudhari KS, Kulkarni SD, Nayak R, Kartha VB, Santhosh C (2013) Analytical predictive capabilities of laser induced breakdown spectroscopy (LIBS) with principal component analysis (PCA) for plastic classification. RSC Adv 3(48):25872–25880. https://doi.org/10.1039/c3ra44946g

Van L, Hamid NA, Ahmad MF, Aizat Ahmad AN, Ruslan R, Muhamad Tamyez PF (2021) Factors of single use plastic reduction behavioral intention. Emerg Sci J, 5(3), 269–278. https://doi.org/10.28991/esj-2021-01275

Vicente-Molina MA, Fernández-Sáinz A, Izagirre-Olaizola J (2013) Environmental knowledge and other variables affecting pro-environmental behaviour: comparison of university students from emerging and advanced countries. J Clean Prod 61:130–138. https://doi.org/10.1016/j.jclepro.2013.05.015

Vietnam General Statistics Office. (2022). Education-Vietnam Statistics Yearbook 2022. https://www.gso.gov.vn/wp-content/uploads/2023/06/Sach-Nien-giam-TK-2022-final.pdf

Vương Q-H (2021) Western monopoly of climate science is creating an eco-deficit culture-ELCI. Economy, Land & Climate Insight. https://elc-insight.org/western-monopoly-of-climate-science-is-creating-an-eco-deficit-culture/

Widayat W, Praharjo A, Putri VP, Andharini SN, Masudin I (2022) Responsible consumer behavior: driving factors of pro-environmental behavior toward post-consumption plastic packaging. Sustainability (switzerland) 14(1):425. https://doi.org/10.3390/su14010425

Williams AT, Rangel-Buitrago N (2022) The past, present, and future of plastic pollution. Mar Pollut Bull 176:113429. https://doi.org/10.1016/j.marpolbul.2022.113429

World Bank (2022a) Analysis of plastic waste pollution in Vietnam. https://documents1.worldbank.org/curated/en/099731506282258321/pdf/P167307016be7609b087c101a167c06027a.pdf

World Bank (2022b) Where is the value in the chain?: Pathways out of plastic pollution. In Where Is the Value in the Chain?: Pathways out of Plastic Pollution. World Bank. https://doi.org/10.1596/978-1-4648-1881-3

Yeow P, Dean A, Tucker D (2014) Bags for life: the embedding of ethical consumerism. J Bus Ethics 125(1):87–99. https://doi.org/10.1007/s10551-013-1900-2

Yuriev A, Dahmen M, Paillé P, Boiral O, Guillaumie L (2020) Pro-environmental behaviors through the lens of the theory of planned behavior: a scoping review. Resour Conserv Recycl 155:104660

Yusuf R, Fajri I (2022) Differences in behavior, engagement and environmental knowledge on waste management for science and social students through the campus program. Heliyon, 8(2)