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# MODELING SUSTAINABLE ENVIRONMENTAL RESPONSIBILITY BEHAVIOR OF STUDENTS IN PRIVATE UNIVERSITY

Shaohua BEN[1, 2]✉, Wenjun ZHENG[2], Mohamad Bin BILAL ALI[2]

[1]*School of Finance and Economics, Guangxi Science & Technology Normal University, 546199 Lai Bin, China*
[2]*Faculty of Social Sciences and Liberal Arts, UCSI University, 56000 Kuala Lumpur, Malaysia*

**Highlights:**

- our study explores the interplay between environmental knowledge, attitudes, and responsibility in shaping environmentally responsible behavior among university students;
- employing a robust structural equation modeling (PLS-SEM) approach, this research contributes to the growing field of environmental education for sustainable development;
- this study integrates Environmental Literacy Theory (ELT) and the Theory of Planned Behavior (TPB) to explore how environmental attitudes and responsibility mediate environmentally responsible behavior.

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**Abstract.** Using a novel integration of Environmental Literacy Theory, the Theory of Planned Behavior, and Sustainable Development Theory, this study models the determinants of environmentally responsible behavior (often termed organizational citizenship behavior for the environment [OCBE]) among undergraduates at private universities in Malaysia. Data were collected via stratified random sampling of 450 students and analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings show that environmental attitudes and a sense of responsibility partially mediate the effect of environmental knowledge on OCBE, highlighting their pivotal roles. These results suggest that educational interventions should not only impart environmental knowledge but also foster pro-environmental attitudes and responsibility. The framework provides guidance for educators and policymakers to design curricula and policies that align with Malaysia's Sustainable Development Goals (SDGs) and national environmental education targets. By highlighting these mediating factors, the study offers actionable insights for universities and policymakers aiming to advance Malaysia's sustainability education agenda and SDGs.

**Keywords:** environmental knowledge, environmental attitude, environmentally responsible behavior.

✉Corresponding author. E-mail: ***benshaohua922@gmail.com***

## 1. Introduction

As humanity confronts accelerating climate change, biodiversity loss, and pollution, the urgency of achieving sustainable development intensifies. Global policymakers and educators emphasize that cultivating environmentally responsible behavior is essential to equipping citizens with the knowledge and skills needed to mitigate environmental degradation (Liao et al., 2021). In Malaysia, rapid industrialization and economic growth have reduced poverty but at the cost of significant environmental degradation, creating an urgent need for educational strategies that promote sustainable practices (Vollset et al., 2020). Despite governmental initiatives, environmental literacy among Malaysian students remains relatively low, constraining their capacity to contribute effectively to sustainability goals (Al-Jubari, 2019). Furthermore, while many students express positive environmental attitudes, their knowledge and actions often fail to align with these sentiments, revealing a persistent attitude–behavior gap that targeted education must address (Al-Jubari et al., 2019).

Existing research on environmentally responsible behavior offers diverse theoretical perspectives. Some studies emphasize cognitive factors such as knowledge and attitudes, while others stress social influences and personal responsibility (Suryawati et al., 2020; Strandberg, 2024). Evidence suggests that increased environmental knowledge can foster pro-environmental attitudes and behaviors (Müderrisoglu & Altanlar, 2011), yet other scholars argue that knowledge alone is insufficient without a strong sense of personal responsibility (Li et al., 2024). There is also debate over whether behavior change is driven mainly by external policies or by intrinsic values and attitudes (Kuruppuarachchi et al., 2021; Gatan et al., 2021; Cincera

et al., 2023). Although these studies offer valuable insights, most examine direct relationships between knowledge and behavior and do not consider how attitudes or responsibility might mediate this link. Moreover, few studies have integrated Environmental Literacy Theory, the Theory of Planned Behavior, and Sustainable Development Theory in a Malaysian higher-education context, leaving questions about why knowledge does not consistently translate into action.

This study addresses these gaps by testing a comprehensive model that combines Environmental Literacy Theory, the Theory of Planned Behavior, and Sustainable Development Theory. We propose that environmental attitudes and a sense of responsibility partially mediate the relationship between environmental knowledge and environmentally responsible behavior among university students. By focusing on these mediating pathways, the research contributes novel insights into how knowledge can be converted into action—an aspect often overlooked in previous work.

Our objectives are threefold: (1) to assess the direct effect of environmental knowledge on university students' environmental attitudes, sense of responsibility, and environmentally responsible behavior; (2) to evaluate whether and how environmental attitudes and responsibility mediate these relationships; and (3) to develop a holistic theoretical framework that links global environmental crises with Malaysia's local educational context. Integrating these constructs not only advances theoretical understanding by uniting disparate perspectives but also yields practical guidance for educators and policymakers. By showing that educational interventions should cultivate pro-environmental attitudes and responsibility alongside knowledge, this study offers actionable strategies for aligning university curricula with Malaysia's sustainable development goals and contributes a new model for examining environmental behavior in similar contexts.

## 2. Theoretical background

Environmental knowledge, attitudes, and a sense of responsibility are increasingly recognized as pivotal determinants of environmentally responsible behavior in higher education contexts (Robertson & Barling, 2017). Environmental knowledge serves as a foundation for fostering pro-environmental attitudes and responsible actions among students (Ipikasari et al., 2020). Research has shown that knowledge alone, while influential, may not directly translate into responsible behavior unless complemented by positive attitudes and a strong sense of responsibility (Heredia et al., 2023; Confente & Scarpi, 2021). Hence, the relationship between these factors and environmentally responsible behavior forms the basis of our study's hypotheses (Chuah et al., 2020).

Drawing from the Environmental Literacy Theory (ELT) (Roth, 1992), the Theory of Planned Behavior (TPB) (Ajzen, 2020), and Sustainable Development Theory (SDT) (Sonetti, 2019), this study examines how environmental attitudes, and a sense of responsibility mediate the relationship between environmental knowledge and environmentally responsible behavior among university students (Marcinkowski et al., 1990; Hollweg et al., 2011). According to TPB, behavioral intention is influenced by attitudes, subjective norms, and perceived behavioral control, while ELT posits that environmental knowledge leads to responsible behavior through positive attitudes and responsibility (Brundtland, 1987).

## 3. Hypothesis development

Environmental knowledge is widely acknowledged as a fundamental driver of pro-environmental outcomes, shaping individuals' attitudes, responsibility, and behaviors toward environmental sustainability. According to Environmental Literacy Theory, enhanced environmental knowledge significantly influences individuals' attitudes toward environmental issues, promoting positive perceptions of ecological stewardship (Roth, 1992; Pasek et al., 2022). Empirical studies support that an increase in environmental knowledge leads directly to more favorable environmental attitudes, suggesting individuals who are better informed about ecological concerns exhibit stronger environmental awareness and responsibility (Dunlap et al., 2000; Li et al., 2024). Furthermore, environmental knowledge is considered instrumental in cultivating a sense of responsibility among students, influencing their ethical stance and commitment toward environmental protection and sustainability (Ren et al., 2023). Importantly, extensive literature also illustrates that environmental knowledge can directly foster environmentally responsible behavior by empowering individuals with the necessary skills and understanding to engage in sustainable practices (Robertson & Barling, 2017; Müderrisoglu & Altanlar, 2011). Therefore, based on this theoretical and empirical background, the following hypotheses are formulated (see Figure 1).

H1: Environmental knowledge (EK) has a significant direct effect on environmental attitude (NEP).

H2: Environmental knowledge (EK) has a significant direct effect on environmentally responsible behavior (OCBE).

H3: Environmental knowledge (EK) has a significant direct effect on students' sense of responsibility (CCSPR).

Environmental attitude plays a critical role in predicting environmentally responsible behavior. Grounded in the Theory of Planned Behavior (Ajzen, 2020), attitudes toward the environment shape behavioral intentions and actual engagement in ecological practices. Individuals with strong pro-environmental attitudes are more likely to demonstrate sustainable behaviors in daily life, including waste reduction, recycling, and energy conservation (Kollmuss & Agyeman, 2002; Liu et al., 2022). Environmental attitude reflects an individual's overall evaluation and concern for environmental issues, which translates into action when such concern is deeply internalized (Dunlap et al., 2000). Moreover, environmental attitude has been found to mediate the relationship between environmental knowledge

and environmentally responsible behavior. According to Environmental Literacy Theory, knowledge influences behavior indirectly by shaping attitudes, which serve as motivational drivers toward sustainable actions (Tuncer Teksoz et al., 2014; Lee et al., 2015). In this regard, environmental knowledge enhances awareness and understanding, which subsequently reinforces pro-environmental attitudes and promotes responsible behavior.

Therefore, the following hypotheses are proposed (see Figure 1).

H4: Environmental attitude (NEP) has a significant direct effect on environmentally responsible behavior (OCBE).

H5: Environmental attitude (NEP) has a mediating effect of environmental knowledge (EK) toward environmentally responsible behavior (OCBE).

A strong sense of personal and social responsibility has been identified as a crucial determinant of environmentally responsible behavior. Responsibility reflects individuals' internalized ethical obligation to act in favor of environmental preservation, encompassing values such as accountability, moral reasoning, and civic duty (Ren et al., 2023). Research suggests that students with a heightened sense of environmental responsibility are more likely to engage in pro-environmental behaviors, such as resource conservation and waste management, due to their intrinsic motivation to contribute positively to society (Miller et al., 2020; Huang et al., 2021). Moreover, responsibility is often shaped by knowledge—individuals equipped with environmental understanding are more likely to perceive environmental issues as morally salient, thus reinforcing responsible attitudes and subsequent behavior (Müderrisoglu & Altanlar, 2011; Pasek et al., 2022). Within the framework of Environmental Literacy Theory, responsibility thus serves as a mediating mechanism through which environmental knowledge is translated into sustainable action. Therefore, the following hypotheses are proposed (see Figure 1).

H6: Responsibility (CCSPR) has a significant direct effect on environmentally responsible behavior (OCBE).

H7: Responsibility (CCSPR) has a mediating effect of environmental knowledge (EK) to-ward environmentally responsible behavior (OCBE).

These hypotheses aim to explore the multifaceted relationships among knowledge, attitudes, responsibility, and environmentally responsible behavior, providing valuable insights into fostering sustainable behaviors among university students. By investigating these dynamics, this study seeks to support sustainable development goals through enhanced educational interventions that encourage students to engage in pro-environmental actions both within and beyond academic settings.

## 4. Methods and procedure

### 4.1. Participants and data collection

A strategic stratified random sampling approach was employed to proportionally allocate the total population of 110,327 undergraduate students across eight leading private universities in Malaysia, based on student enrollment figures officially disclosed by each institution. The number of participants selected from each university was determined by its actual student population, not by its global QS ranking. The population distribution was as follows: Taylor's University (24,517 students), UCSI University (21,452 students), Universiti Teknologi PETRONAS (18,388 students), Sunway University (15,323 students), INTI International University (12,259 students), Management and Science University (9,194 students), Asia Pacific University of Technology & Innovation (6,129 students), and Universiti Tunku Abdul Rahman (3,065 students).

Based on this population structure, a proportional stratified sampling approach was used to determine the final sample size of 450 students, exceeding the minimum recommended sample size of 384 (Krejcie & Morgan, 1970). Accordingly, the sample included 100 students from Taylor's University, 87 from UCSI University, 75 from Universiti Teknologi PETRONAS, 62 from Sunway University,

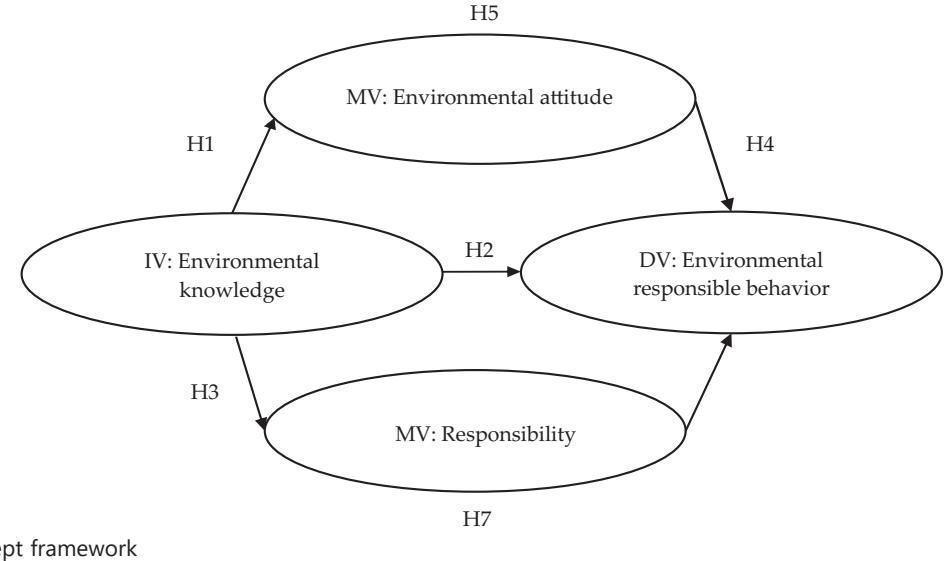


**Figure 1.** Concept framework

50 from INTI International University, 38 from Management and Science University, 25 from Asia Pacific University of Technology & Innovation, and 13 from Universiti Tunku Abdul Rahman. This proportional allocation ensured institutional representativeness and enhanced the external validity of the findings.

Further stratification by academic year and field of study was applied within each institution, and participants were randomly selected within each stratum. Selection criteria required participants to be full-time undergraduate students currently enrolled in one of the eight universities and willing to participate voluntarily. No exclusions were made based on gender, ethnicity, or discipline, ensuring inclusivity (see Table 1). This combined approach of stratification and randomization accurately reflects the demographic and institutional characteristics of the target population, thereby strengthening the generalizability and credibility of the study's results.

The data collection involved obtaining initial authorization and cooperation from university administrative offices and respective faculty coordinators. Upon approval, participants were recruited via institutional WhatsApp and WeChat groups and in-class announcements. Prospective respondents were informed about the study objectives, eligibility criteria, and provided with a secure link to an online questionnaire hosted on 'Questionnaire Star.' Participants voluntarily accessed the questionnaire, provided informed consent emphasizing confidentiality and anonymity, and completed the survey online. Periodic reminders were sent through messaging platforms to enhance response rates and ensure timely completion of data collection.

### 4.2. Measures

The study focuses on four primary constructs: environmental knowledge, environmental attitudes, environmental responsibility, and environmentally responsible behavior. Environmental knowledge was measured using the Environmental Education Scale developed by Pasek et al. (2022), consisting of 30 items across six dimensions: animals, pollution, general environmental issues, water, energy, and recycling (Cronbach's $\alpha$ = 0.72). Environmental attitudes were assessed through Dunlap et al.'s (2000) New Ecological Paradigm Scale, comprising 15 items designed to capture students' perspectives on environmental sustainability (Cronbach's $\alpha$ = 0.81). Environmental responsibility was evaluated using Ren's (2023) College Students' Commitment to Personal and Social Responsibility Scale, consisting of 13 items that reflect students' ethical and social considerations regarding environmental issues (Cronbach's $\alpha$ = 0.79). Lastly, environmentally responsible behavior was measured using Robertson and Barling's (2017) Organizational Citizenship Behavior for the Environment Scale, which includes 13 items focusing on students' individual pro-environmental actions within academic contexts (Cronbach's $\alpha$ = 0.89).

### 4.3. Data analysis

This study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) as the primary analytical method to examine the relationships among environmental knowledge, attitudes, responsibility, and environmentally responsible behavior. PLS-SEM is particularly suited for this research as it emphasizes prediction and exploratory analysis, aligning with the study's objective of understanding the direct and indirect effects of various factors on environmentally responsible behavior. Its ability to maximize explained variance ($R^2$) in the dependent variable makes it a robust choice for this context. Additionally, the flexibility of PLS-SEM to handle small sample sizes and non-normal data ensures reliability given the characteristics of the dataset (Hair et al., 2017, 2021).

The measurement model involves both reflective and formative constructs, which require a method capable of addressing this complexity. PLS-SEM is equipped to handle such mixed measurement models while providing comprehensive outputs, including path coefficients, effect sizes, and predictive relevance. These outputs validate the theoretical framework and offer practical insights into the influence of environmental knowledge and attitudes on behavior. The choice of PLS-SEM is therefore justified by its alignment with the study's objectives, its suitability for the data characteristics, and its ability to yield detailed and actionable results (Malmqvist et al., 2019; Bujang et al., 2024).

## 5. Results

### 5.1. Demographic informatics analysis

In terms of gender distribution, the gender distribution of undergraduates is roughly equal. In terms of age, undergraduates under 30 years old account for about 79.56%. In terms of grade distribution is balance, the third-year undergraduates account for the least, about 19.33% (see Table 1).

**Table 1.** Respondent background analysis results

| Items | Options | Percentage |
|---|---|---|
| Gender | Male | 48.44% |
| | Female | 51.56% |
| Age | Under 18 | 19.56% |
| | 18–21 | 20.22% |
| | 22–25 | 20.00% |
| | 26–30 | 19.78% |
| | Over 30 | 20.44% |
| Current school year | Year 1 | 26.22% |
| | Year 2 | 27.78% |
| | Year 3 | 19.33% |
| | Year 4 | 26.67% |

## 5.2. Measurement model assessment

Table 2 shows that all constructions are reliability, convergent and discriminant validity. The outer loadings range from 0.738 to 0.879, get a good quantify. The Cronbach a coefficient (CA) ranges from 0.906 to 0.955, get a good quantify. The consistency reliability (CR) ranges from 0.93 to 0.96, get a good quantity. According to Table 2, the AVE is more than 0.748 and has a minimum value of 0.605. Thus, it was confirmed that the structure has good convergent validity. The discriminant validity was also assessed using the Fornell-larcker criterion and the Heterotrait-monotrait ratio (HTMT) approach. According to Fornell and Larcker, the square root of the AVE for each latent variable should be larger than its correlation with the other latent variables. As shown in Table 3, all constructs satisfied the Fornell-Larcker criterion. When all of the construct values are less than 0.9, the study satisfies the HTMT requirement, based on the results in Table 4, HTMT criteria were met, thus indicating that discriminant validity was confirmed (Taber, 2018). It can be seen from Table 5 that the VIF values are all below 5, indicating that there is no serious collinearity problem in the data.

**Table 2.** Reliability and validity results

| Second-order Factors | First-order Factors | Item | Outer loadings | CA | CR | AVE |
|---|---|---|---|---|---|---|
| EK | AK | AK1 | 0.862 | 0.91 | 0.933 | 0.736 |
| | | AK2 | 0.862 | | | |
| | | AK3 | 0.853 | | | |
| | | AK4 | 0.844 | | | |
| | | AK5 | 0.867 | | | |
| | PK | PK1 | 0.861 | 0.908 | 0.931 | 0.731 |
| | | PK2 | 0.84 | | | |
| | | PK3 | 0.856 | | | |
| | | PK4 | 0.855 | | | |
| | | PK5 | 0.862 | | | |
| | KO | KO1 | 0.867 | 0.916 | 0.937 | 0.748 |
| | | KO2 | 0.863 | | | |
| | | KO3 | 0.879 | | | |
| | | KO4 | 0.846 | | | |
| | | KO5 | 0.87 | | | |
| | WK | WK1 | 0.858 | 0.912 | 0.934 | 0.739 |
| | | WK2 | 0.85 | | | |
| | | WK3 | 0.866 | | | |
| | | WK4 | 0.852 | | | |
| | | WK5 | 0.872 | | | |
| | EKs | EK1 | 0.848 | 0.906 | 0.93 | 0.726 |
| | | EK2 | 0.852 | | | |
| | | EK3 | 0.858 | | | |
| | | EK4 | 0.855 | | | |
| | | EK5 | 0.848 | | | |
| | RK | RK1 | 0.859 | 0.913 | 0.935 | 0.742 |
| | | RK2 | 0.871 | | | |
| | | RK3 | 0.851 | | | |
| | | RK4 | 0.869 | | | |
| | | RK5 | 0.858 | | | |
| | NEP | NEP1 | 0.778 | 0.955 | 0.96 | 0.614 |
| | | NEP2 | 0.793 | | | |
| | | NEP3 | 0.753 | | | |
| | | NEP4 | 0.821 | | | |
| | | NEP5 | 0.759 | | | |
| | | NEP6 | 0.774 | | | |
| | | NEP7 | 0.781 | | | |
| | | NEP8 | 0.789 | | | |
| | | NEP9 | 0.789 | | | |
| | | NEP10 | 0.763 | | | |
| | | NEP11 | 0.772 | | | |
| | | NEP12 | 0.806 | | | |
| | | NEP13 | 0.786 | | | |
| | | NEP14 | 0.795 | | | |
| | | NEP15 | 0.788 | | | |
| | CCSPR | CCSPR1 | 0.816 | 0.947 | 0.954 | 0.614 |
| | | CCSPR2 | 0.778 | | | |
| | | CCSPR3 | 0.787 | | | |
| | | CCSPR4 | 0.809 | | | |
| | | CCSPR5 | 0.769 | | | |
| | | CCSPR6 | 0.773 | | | |
| | | CCSPR7 | 0.761 | | | |
| | | CCSPR8 | 0.805 | | | |
| | | CCSPR9 | 0.792 | | | |
| | | CCSPR10 | 0.757 | | | |
| | | CCSPR11 | 0.716 | | | |
| | | CCSPR12 | 0.81 | | | |
| | | CCSPR13 | 0.804 | | | |
| | OCBE | OCBE1 | 0.814 | 0.945 | 0.952 | 0.605 |
| | | OCBE2 | 0.781 | | | |
| | | OCBE3 | 0.758 | | | |
| | | OCBE4 | 0.778 | | | |
| | | OCBE5 | 0.776 | | | |
| | | OCBE6 | 0.738 | | | |
| | | OCBE7 | 0.765 | | | |
| | | OCBE8 | 0.808 | | | |
| | | OCBE9 | 0.746 | | | |
| | | OCBE10 | 0.754 | | | |
| | | OCBE11 | 0.805 | | | |
| | | OCBE12 | 0.782 | | | |
| | | OCBE13 | 0.799 | | | |

*End of Table 2*

**Table 3.** Discriminant Validity: Fornell-Larcker Criterion

| | AK | CCSPR | NEP | EKs | KO | OCBE | PK | RK | WK |
|---|---|---|---|---|---|---|---|---|---|
| AK | 0.858 | | | | | | | | |
| CCSPR | 0.481 | 0.783 | | | | | | | |
| ENP | 0.469 | 0.45 | 0.783 | | | | | | |
| EKs | 0.577 | 0.544 | 0.543 | 0.852 | | | | | |
| KO | 0.626 | 0.533 | 0.467 | 0.648 | 0.865 | | | | |
| OCBE | 0.511 | 0.546 | 0.542 | 0.474 | 0.505 | 0.778 | | | |
| PK | 0.664 | 0.536 | 0.511 | 0.641 | 0.656 | 0.497 | 0.855 | | |
| RK | 0.618 | 0.47 | 0.505 | 0.601 | 0.62 | 0.544 | 0.642 | 0.861 | |
| WK | 0.63 | 0.459 | 0.499 | 0.614 | 0.592 | 0.483 | 0.633 | 0.617 | 0.86 |

**Table 4.** Discriminate Validity: Heterotrait-Monotrait Ratio (HTMT)

| | AK | CCSPR | NEP | EKs | KO | OCBE | PK | RK | WK |
|---|---|---|---|---|---|---|---|---|---|
| AK | | | | | | | | | |
| CCSPR | 0.518 | | | | | | | | |
| NEP | 0.502 | 0.471 | | | | | | | |
| EKs | 0.635 | 0.586 | 0.584 | | | | | | |
| KO | 0.686 | 0.57 | 0.499 | 0.711 | | | | | |
| OCBE | 0.55 | 0.574 | 0.568 | 0.511 | 0.541 | | | | |
| PK | 0.73 | 0.577 | 0.549 | 0.706 | 0.719 | 0.535 | | | |
| RK | 0.677 | 0.504 | 0.541 | 0.661 | 0.678 | 0.584 | 0.705 | | |
| WK | 0.691 | 0.493 | 0.535 | 0.676 | 0.647 | 0.519 | 0.695 | 0.675 | |

**Table 5.** Collinearity Statistic (VIF)

| | OCBE | NEP | CCSPR | EK |
|---|---|---|---|---|
| OCBE | | | | |
| NEP | 1.597 | | | |
| CCSPR | 1.616 | | | |
| EK | 2.023 | 1 | 1 | |

## 5.3. Structural model assessment

In order to meet the assumption of user-defined estimation and run a statistically robust model, we analyzed it with 5000 bootstraps and 95% confidence intervals. Figure 2 shows the $R^2$ of the user-tested model in SmartPLS software (NEP = 0.363, CCSPR = 0.370, OCBE = 0.455), indicating that the model has a moderate explanatory power for environmental responsibility behavior (Hair et al., 2021).

The structural model results (Table 6) show that all hypothesized direct effects (H1, H2, H3, H4, H6) were significant and positive. For H1, the path from environmental knowledge (EK) to environmental attitude (NEP) was strong ($\beta = 0.602$, $t = 16.893$, $p < 0.001$), indicating that students with higher environmental knowledge tend to report more pro-environmental attitudes. Similarly, H2 was supported: EK had a significant positive direct effect on sense of responsibility (CCSPR) ($\beta = 0.608$, $t = 18.188$, $p < 0.001$), meaning that greater knowledge is associated with a stronger sense of personal responsibility for the environment. For H3, the direct effect of EK on environmentally responsible behavior (OCBE) was also significant ($\beta = 0.307$, $t = 4.933$, $p < 0.001$), suggesting that knowledge contributes directly (though more modestly) to students' self-reported responsible behaviors. H4 predicted that environmental attitude (NEP) would directly influence behavior, and this was confirmed: the NEP→OCBE path was significant ($\beta = 0.245$, $t = 4.258$, $p < 0.001$). In practical terms, students who hold stronger pro-environmental attitudes engage in more responsible actions. Finally, H6 was supported: the direct effect of responsibility (CCSPR) on behavior (OCBE) was significant ($\beta = 0.250$, $t = 4.281$, $p < 0.001$), indicating that a higher sense of personal responsibility leads to more environmentally responsible behavior. In summary, each tested hypothesis yielded a statistically significant positive direct effect, confirming that higher environmental knowledge enhances attitudes and responsibility, and that both attitude and responsibility, as well as knowledge itself, positively predict students' responsible environmental behavior.

The *p*-values for both indirect paths of H5 and H7 (EK → NEP → OCBE and EK → CCSPR → OCBE) are less than 0.05, indicating that the mediating effects proposed in H5 and H7 are supported (Hair et al., 2021; Piaw et al., 2025). NEP and CCSPR are partial mediator that enhances the relationship between EK and OCBE. NEP mediates the relationship between EK and OCBE (mediate effect = 0.2426), while CCSPR mediates the relationship between EK and OCBE (mediate effect = 0.2508). This shows that the research model has a good explanatory effect.

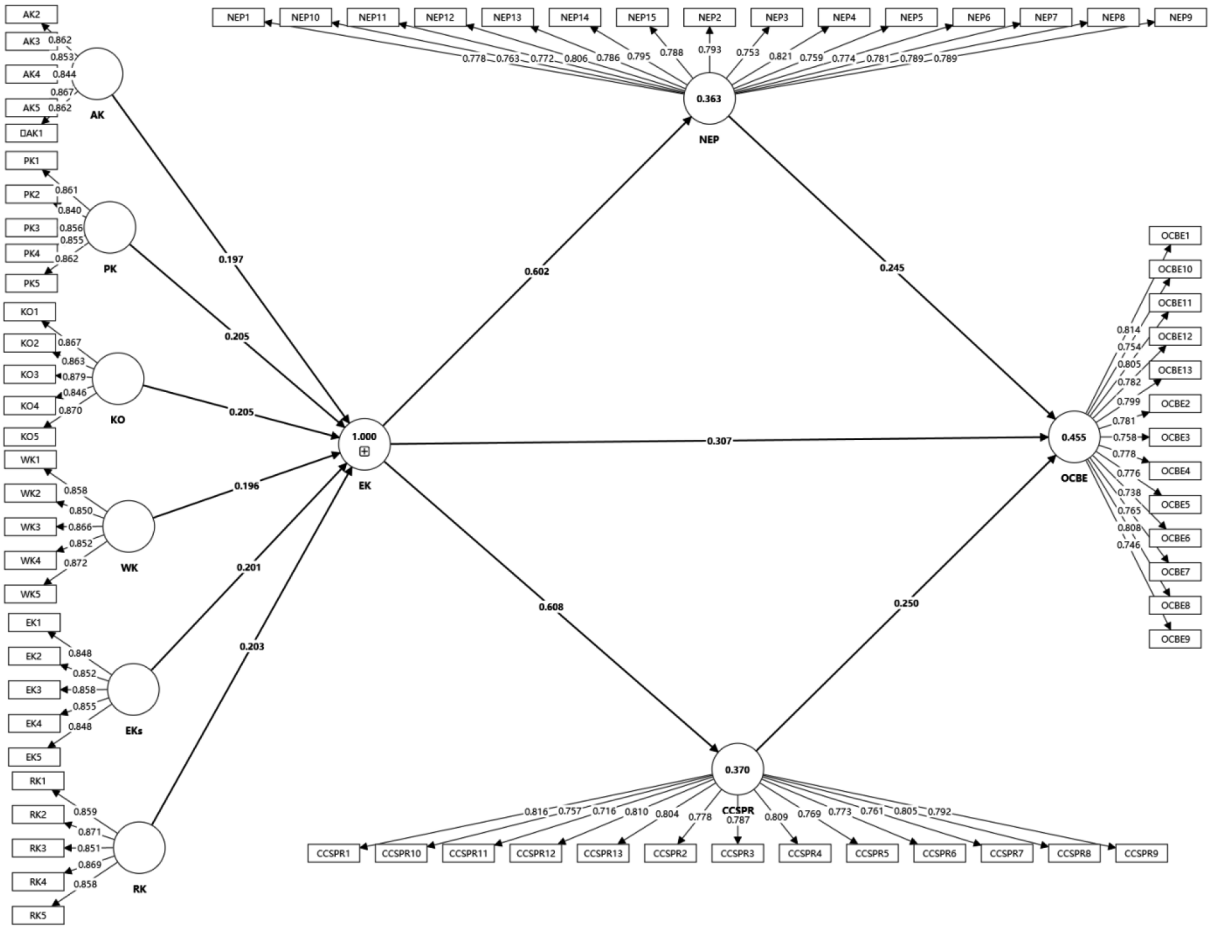


**Figure 2.** PLS-SEM path coefficients and significance testing results of the structural model

**Table 6.** Structural model analysis

| | Path | Coefficient | Standard deviation | *t* statistics | *p* values | Effect ratio |
|---|---|---|---|---|---|---|
| H1 | EK → NEP | 0.602 | 0.036 | 16.893 | 0.000 | none |
| H2 | EK → OCBE | 0.307 | 0.062 | 4.933 | 0.000 | none |
| H3 | EK → CCSPR | 0.608 | 0.033 | 18.188 | 0.000 | none |
| H4 | NEP → OCBE | 0.245 | 0.057 | 4.258 | 0.000 | none |
| H5 | EK → NEP → OCBE | 0.147 | 0.035 | 4.176 | 0.000 | 24.26% |
| H6 | CCSPR → OCBE | 0.250 | 0.058 | 4.281 | 0.000 | none |
| H7 | EK → CCSPR → OCBE | 0.152 | 0.036 | 4.182 | 0.000 | 25.08% |

## 6. Discussion

Previous research on environmentally responsible behavior has often been limited to single-theory perspectives. For example, some studies examine environmentally responsible behavior through the lens of sustainable development theory (SDT) (Pasek et al., 2022), others through environmental literacy theory (ELT) (Dunlap et al., 2000; Bujang et al., 2024), and still others through the theory of planned behavior (TPB) (Ren et al., 2023; Olawuyi, 2024). These siloed approaches capture only part of the broader behavioral process. To address this limitation, we integrated all three perspectives into a unified environmental education model in which environmental knowledge is treated as an antecedent and environmental attitude and personal responsibility as mediating variables. This integrated framework aligns with calls for more holistic approaches (Corbos et al., 2023; Corboș et al., 2024) and explicitly tests how pro-environmental attitudes and a sense of duty channel the influence of knowledge into behavior. Our analysis confirms that both attitudes and responsibility partially mediate the effect of knowledge on environmentally responsible behavior, highlighting their pivotal roles in shaping behavior. This perspective provides a more nuanced understanding than earlier studies that largely examined only direct or pairwise causal paths (e.g., knowledge → attitude, attitude → behavior) without modeling mediation.

A persistent debate in the literature concerns how directly environmental knowledge translates into action.

Some researchers contend that simply increasing knowledge can directly foster pro-environmental behavior, while others argue that knowledge alone is insufficient and must be coupled with supportive attitudes and a sense of personal responsibility (Dunlap et al., 2000). Our findings strongly support this latter view. We find that the positive influence of environmental knowledge on environmentally responsible behavior emerges primarily when individuals also hold strong pro-environmental attitudes and a heightened sense of responsibility. In other words, knowledge appears to drive behavior chiefly through its effects on these internal motivators. This underscores the importance of environmental attitudes and responsibility as mediating mechanisms: they serve as the affective and moral filters through which cognitive knowledge is translated into concrete sustainable actions (Pasek et al., 2022; Olawuyi, 2024).

## 7. Implications

### 7.1. Theoretical implications

The proposed model synthesizes Sustainable Development Theory, the Theory of Planned Behavior, and Environmental Literacy Theory into an integrated framework for environmentally responsible behavior. It posits that environmental knowledge influences action indirectly via two mediators: students' environmental attitudes and their sense of responsibility. In other words, learners must internalize environmental values and a duty of stewardship to translate knowledge into sustainable practices. This perspective aligns with Roth's (1992) view that environmental literacy grows when knowledge is coupled with positive attitudes and moral commitment, and with Ajzen's (2020) emphasis on attitudes as drivers of intention. By centering on attitudes and responsibility, the framework highlights the affective and ethical dimensions of learning. It situates environmental education in the contemporary educational context influenced by digitalization and sustainability challenges (Corboș et al., 2024), thereby extending beyond traditional knowledge-centered approaches.

Modeling these mediating pathways offers theoretical insight into why knowledge alone may not yield lasting behavioral change (Roth, 1992; Ajzen, 2020; Corboș et al., 2024). It reveals that cognitive knowledge leads to action only when filtered through positive attitudes and a sense of responsibility. This perspective extends Roth's environmental literacy thesis and Ajzen's theory by explicitly identifying responsibility as a parallel mediator. By emphasizing these affective and ethical drivers, the model departs from unidimensional knowledge-centered models. This dual focus is especially pertinent in today's educational landscape, which is increasingly shaped by digitalization and sustainability challenges (Corbos et al., 2023). In sum, the framework transcends traditional knowledge-centered paradigms, providing new theoretical understanding of how environmental education can effectively inspire sustainable behavior.

### 7.2. Practical implications

In the formulation of educational policies, we explain the intermediate role of environmental attitude and environmental responsibility on environmentally responsible behavior, providing support for the implementation of the next step of environmental education policy. It provides a framework for policymakers to understand how attitudes and responsibilities interact with knowledge to promote sustainable behavior. This knowledge can guide the formulation of policies that support environmental education programs that focus on these mediating factors.

The first mediation path underscores that environmental attitude plays a critical mediating role in translating environmental knowledge into sustainable behavior, accounting for 24.26% of the total effect. This finding suggests that merely enhancing students' cognitive understanding of environmental issues is insufficient to ensure behavioral change. Educational interventions must also cultivate pro-environmental attitudes, which serve as affective filters that motivate learners to act upon their knowledge. Incorporating emotionally resonant content, nature immersion programs, and reflective learning activities can help foster these attitudes. This aligns with the Theory of Planned Behavior (Ajzen, 2020), which posits that attitudes toward behavior significantly influence behavioral intentions. In practice, curriculum designers should embed values-oriented content that bridges factual knowledge with affective engagement, thereby enhancing learners' readiness to engage in environmentally responsible action (Kollmuss & Agyeman, 2002; Otto & Pensini, 2017).

The second mediation path reveals that responsibility independently mediates the relationship between environmental knowledge and behavior, contributing 25.08% to the total effect. This highlights the importance of moral development and ethical responsibility in promoting sustainable behaviors. Environmental knowledge must be coupled with a sense of personal and collective responsibility to activate behavioral intention. Educational practices such as service learning, community-based environmental projects, and deliberative ethical discussions can reinforce the internalization of responsibility among learners. This is consistent with the principles of Education for Sustainable Development (UNESCO, 2017), which emphasize empowering learners to act as responsible agents of change in their communities and ecosystems.

Together, these two mediating mechanisms—attitude and responsibility—account for nearly half (49.34%) of the total effect of environmental knowledge on behavior, providing strong empirical support for a holistic approach to environmental education. To effectively foster environmentally responsible behavior, educational strategies must move beyond unidimensional knowledge transmission and instead integrate affective and normative dimensions of learning. Teachers and policymakers should design interdisciplinary interventions that simultaneously develop ecological literacy, emotional connection to nature, and ethical agency. This integrated pedagogical approach aligns

with contemporary frameworks in transformative learning and ecological citizenship, ultimately equipping learners with the competencies needed for sustainable decision-making and long-term behavioral change (Orr, 1992).

## 8. Recommendations

The four scales used in the study (the ecological knowledge scale; the new ecological paradigm scale; university student personal responsibility scale; organizational environmental citizenship behavior scale) limit their ability to capture the diversity of student experiences. The degree of internationalization of students in private universities in Malaysia is higher than that of public universities in Malaysia. Therefore, more psychological scales are needed to explain the diversity of student experiences in private universities.

Future research should consider longitudinal studies, adding the variables of self-efficacy and self-determination to knowledge, attitude, and responsibility, and studying how they evolve over time and how these changes affect students' environmentally responsible behavior in different situations. Extending this research to psychological research, self-efficacy scales and self-determination scales can be added to allow self-efficacy and self-determination to serve as mediating variables between environmental knowledge and environmentally responsible behavior and studying how they affect the understanding of sustainable behavior.

## 9. Conclusions

Environmental attitudes and responsibility served as partial mediators in the relationship between environmental knowledge and environmentally responsible behavior. These findings underscore the importance of both attitudes and responsibility as mechanisms through which knowledge influences behavior. The PLS-SEM results confirm the critical roles of environmental knowledge, attitudes, and responsibility in fostering environmentally responsible behavior among students. Knowledge positively impacts attitudes and responsibility, which in turn promote environmentally responsible behavior. These findings offer empirical support for designing educational interventions that not only impart knowledge but also foster responsible attitudes and behaviors, aligning with sustainable development goals.

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