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Environmental Research Communications

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RECEIVED
27 March 2026

REVISED
20 May 2026

ACCEPTED FOR PUBLICATION
22 May 2026

PUBLISHED
2 June 2026

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PAPER

Development and validation of the responsible recycling behavior scale: a multidimensional assessment of university students' recycling practices

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Keywords: recycling, responsible behavior, scale development, university students

Supplementary material for this article is available online

Abstract

Despite increasing emphasis on sustainability, existing instruments for assessing recycling behavior often rely on single indicators or attitudinal measures, limiting their ability to capture the multidimensional nature of responsible recycling practices. Addressing this gap, this study aims to develop and validate the Responsible Recycling Behavior Scale, a theory-driven, multidimensional instrument to assess responsible recycling behavior among university students. A mixed-method design was employed. Item generation was based on a literature review and qualitative data, followed by expert evaluation. The scale was tested using data from three independent samples of university students ($N = 1105$). Exploratory factor analysis and confirmatory factor analysis were conducted to examine the factor structure, and reliability and validity analyses were performed. The findings support a 24-item, five-factor structure consisting of ecomanagement/physical action, consumer/economic action, individual/public persuasion action, political action, and legal action. The model demonstrated good fit indices, along with satisfactory reliability, convergent validity, and discriminant validity. These results indicate that responsible recycling behavior is multidimensional, extending beyond routine practices to include social, economic, and institutional forms of engagement. The study contributes to the literature by providing a behavior-focused, multidimensional measurement tool that enables a comprehensive assessment of responsible recycling behavior among university students.

1. Introduction

The continuous increase in global environmental problems has intensified the need for effective sustainability practices. The Sustainable Development Goals, adopted by the United Nations (UN) in 2015, emphasize responsible consumption, climate action, and ecosystem protection (United Nations 2015, Batalinide Macedo *et al* 2022). Recycling plays a critical role in this context by contributing to resource conservation and waste reduction, while environmental education (EE) supports the development of ecological awareness and sustainable consumption habits (UNEP 2020). Together, recycling and EE constitute key mechanisms for advancing sustainability goals. However, consistent and responsible recycling behavior at the individual level remains uneven, reflecting a persistent gap between sustainability objectives and actual practice (Liu *et al* 2026). Addressing this gap, the present study develops and validates the Responsible Recycling Behavior Scale (REBES), a theory-driven and multidimensional instrument designed to assess responsible recycling behavior. This indicates that raising awareness alone is insufficient to ensure effective behavioral change. In this context, university students represent a particularly relevant population, as they are both active consumers and future decision-makers whose behaviors will shape long-term sustainability outcomes. Moreover, universities provide structured environments for EE

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and behavioral interventions, making them highly suitable settings for examining responsible recycling behavior (Ugulu 2013a, 2013b).

EE research has long emphasized behavior change as a central outcome, and numerous studies have demonstrated a strong relationship between environmental awareness and pro-environmental behavior (Hoffmann and Muttarak 2020). Nevertheless, this relationship often remains inconsistent in practice, particularly in the context of recycling, where individuals may express positive attitudes but fail to engage in responsible and sustained behaviors. At the same time, existing approaches to assessing recycling behavior remain limited, often relying on simplified or unidimensional indicators that do not adequately capture the complexity of real-world practices (Kollmuss and Agyeman 2002, Larson *et al* 2015). As a result, current measurement approaches constrain both empirical research and the design of effective educational and policy interventions.

Research across psychology, sociology, and environmental science has produced a wide range of theoretical models explaining pro-environmental behavior (Tian and Liu 2022). While these models provide valuable insights into the determinants of behavior, their translation into robust and context-sensitive measurement frameworks remains limited. Accordingly, there is a clear need for a theory-driven and multidimensional instrument capable of assessing responsible recycling behavior in a comprehensive manner. The following section reviews key theoretical perspectives that inform this conceptualization and underpin the development of the REBES.

1.1. Theoretical framework on pro-environmental behavior and reflections on recycling

Research on pro-environmental behavior has been shaped by multiple theoretical perspectives emphasizing the roles of cognition, social influence, and contextual factors (Batool *et al* 2024, Liao 2024). Social Learning theory (Bandura and Walters 1977) introduced the role of observational learning and social reinforcement in shaping behaviors, including environmentally responsible actions. Another early pro-environmental behavior research model developed was the knowledge-attitude-behavior model, which argued that pro-environmentally knowledgeable individuals will develop prosocial attitudes toward the environment, hence the likelihood of them carrying out pro-environmental behaviors (Hines *et al* 1987). However, subsequent research has demonstrated that this linear relationship is often disrupted by external barriers, social influence, and habitual practices (Bamberg and Moser 2007).

In the late 20th century, researchers sought to explain the gap between environmental concern and actual behavior. Fishbein and Ajzen's (1975) theory of reasoned action suggested that behavior is directly influenced by an individual's intention, which is shaped by attitudes and subjective norms. This model was later extended by Ajzen (1991) into the theory of planned behavior (TPB), incorporating perceived behavioral control as a key determinant of action. Schwartz's (1977) norm activation model (NAM) highlighted the role of moral norms and personal responsibility in pro-environmental decision-making. These models emphasized individual agency but also acknowledged external social influences. Building on these foundations, Stern *et al* (1999) proposed the value-belief-norm (VBN) theory, which integrated personal values, environmental beliefs, and moral obligations into a single framework. Collectively, these models demonstrate that pro-environmental behavior is shaped by attitudinal, normative, and control-related factors, rather than simple linear processes.

The transtheoretical model of behavior change, developed by Prochaska and DiClemente (1983), depicted behavior change as being comprised of a series of several interconnected stages. Also, Verplanken and Aarts (1999) developed a habit disruption model that emphasized that in order to be successful in becoming environmentally responsible, individuals must break old habits and form new sustainable behaviors. These approaches highlight the dynamic and habitual nature of environmental behavior. On the other hand, Schultz's (2001) environmental identity model, built on these earlier theories, explores how individuals' self-concept and their identification with nature affect the way they behave towards the environment.

Overall, these theoretical perspectives indicate that pro-environmental behavior is influenced by a complex interaction of cognitive, social, and contextual factors and cannot be adequately explained through single-variable models (Tan *et al* 2025). Importantly, they also support the view that environmentally responsible behavior (ERB) is inherently multidimensional. In line with this perspective, ERB has been conceptualized as comprising multiple forms of action, including eco-management (physical action), consumer/economic action (CEA), persuasion, political action (PA), and legal action (LA) (Hsu 1997, Erdogan *et al* 2012). These dimensions are particularly relevant for understanding recycling behavior, as they extend beyond routine practices to include consumption choices, social influence, and civic engagement. Therefore, the present study draws on these theoretical foundations to conceptualize responsible recycling behavior as a multidimensional construct, which forms the basis for the development of the REBES.

1.1.1. Recycling behavior

Recycling plays a critical role in ensuring environmental sustainability, conserving natural resources, and reducing waste generation (Zakhilwal *et al* 2024). However, individuals' active participation in the recycling process is influenced by various psychological, social, and structural factors (Barr *et al* 2005). Within the broader concept of ERB, individuals' attitudes and actions that support ecological sustainability have been examined (Nigbur *et al* 2010, Ugulu and Erkol 2013). ERB generally includes various actions such as energy conservation, waste reduction, sustainable consumption, and recycling. Over time, theoretical models developed to understand ERB have been applied to more specific domains. Initially, broad theories aimed at explaining environmental behavior have been refined to better understand how individuals adopt recycling behaviors specifically. This transition highlights the importance of narrowing the focus from general environmental concerns to targeted behavioral domains, allowing for a deeper understanding of the motivational and contextual factors influencing recycling behavior (Tian and Liu 2022).

Several theoretical frameworks have been developed to understand recycling behavior (Kassim *et al* 2023). Some of the most well-known theoretical frameworks include the TPB (Ajzen 1991), which posits that a person's intention to recycle is influenced by their attitudes toward recycling, social norms associated with recycling, and their ability to recycle; the NAM (Schwartz 1977), which connects recycling to personal norms and moral obligations; the Integrated Behavior Model (Hornik *et al* 1995), which includes social and structural influences on recycling behavior; and the Habits and Routines Theory (Verplanken and Aarts 1999), which focuses on developing a habit of recycling to encourage more sustainable long-term practices with respect to recycling.

1.1.2. Five categories of ERB

To understand and promote ERB, various models have been proposed over time, each contributing to a more comprehensive understanding of sustainability-oriented actions (Ram and Bhagat 2026). One of the earliest contributions to ERB research was made by Hungerford and Peyton (1977), who developed a five-category model to describe ERBs. The five categories were ecological study, environmental study, environmental management, environmental activism, and persuasive advocacy. This model included an emphasis on education and involvement, meaning that an individual's engagement with environmental problems and issues would range from being a passive student to being a proactive activist or advocate for environmental causes and change through policy and legislation.

Building upon these foundations, Ramsey *et al* (1981) expanded on this model and categorized ERB into six distinct types: ecomanagement (physical action), CEA, persuasion, PA, LA, and interaction. This model provides a structured framework for analyzing and fostering sustainable behaviors in diverse contexts. Ecomanagement involves direct physical actions such as recycling, conserving resources, and participating in reforestation efforts. CEAs focus on making environmentally conscious purchasing decisions, reducing waste, and supporting sustainable businesses. Persuasion encompasses efforts to raise awareness and educate others about environmental issues, utilizing social media, community discussions, and educational initiatives. Political and LAs highlight the importance of systemic change. PA includes participation in environmental activism, policy advocacy, and supporting sustainable governance (Bowen *et al* 2017). LA includes using legal systems to keep people accountable for harming the environment, and includes filing lawsuits or lobbying for more stringent regulations. Finally, interaction includes engaging with environmental organizations, attending sustainable events, and supporting community-based environmental initiatives (Tian and Liu 2022).

Later, Champeau (1982, as cited in Hsu 1997) modified one of these categories, renaming consumerism as economic action. Champeau's definition of economic action referred to behaviors related to responses to economic threats, consumption habits, and monetary contributions. More recently, these categories and descriptions have been slightly modified (Simmons 1995, Hsu 1997, Erdogan *et al* 2012), leading to the removal of the 'interaction' category. Since 1995, many scholars have accepted and used these five categories of ERB: ecomanagement/physical action (EPA), CEA, individual/public persuasion action (IPPA), PA, and LA (Hsu 1997). These modifications reflect a refinement in the conceptualization of ERB, aligning with contemporary environmental challenges and policy changes.

1.2. Research on recycling behavior and the need for a new instrument

Several international researchers have studied how components of recycling habits are determined in their respective cultures (Aboelmaged 2021). Juliana *et al* (2022) studied the recycling values of households in the country of Malaysia and found that factors such as cost, convenience, and ethical beliefs

had a positive effect on recycling habits when using the extended TPB. Similarly, Strydom (2018) investigated recycling behavior in South Africa and found that individuals' attitudes, perceived behavioral control, and subjective norms significantly impacted their participation in recycling. In Taiwan, Chao *et al* (2023) studied recycling behavior among university students and revealed that environmental concern, motivation, interpersonal altruism, and place attachment strengthened their tendency to recycle. Wu *et al* (2021) focused on university students in China, highlighting that environmental knowledge and personal norms play a crucial role in fostering positive recycling habits. Collectively, these studies demonstrate that recycling behavior is influenced not only by individual intentions but also by social norms, moral values, and environmental awareness.

Despite increasing environmental awareness and numerous policy initiatives aimed at promoting sustainable waste management, individual participation in recycling remains insufficient (Ugulu 2019). Current research shows that while people may exhibit positive attitudes toward recycling, these attitudes do not always translate into responsible recycling behaviors (Schultz 2001, Barr *et al* 2005). This discrepancy highlights the critical need for more sensitive and behavior-oriented assessment tools that can capture the complexity of individual recycling practices, particularly in diverse cultural and socio-economic contexts.

However, a critical limitation persists in how recycling behavior is currently measured. Many existing instruments assess recycling either as a single behavioral indicator (e.g. frequency of recycling) or as a subdimension within broader pro-environmental behavior scales (Larson *et al* 2015). While such approaches are useful for general assessments, they fail to capture the multidimensional and context-dependent nature of responsible recycling behavior.

More specifically, widely used environmental behavior scales tend to aggregate diverse actions under a single construct, thereby overlooking qualitative differences between types of recycling-related behaviors (Larson *et al* 2015). As a result, these instruments do not adequately distinguish between routine participation in recycling and behaviors that reflect a deeper, more consistent, and contextually informed commitment (Kollmuss and Agyeman 2002). Furthermore, very few tools account for important behavioral nuances such as contamination avoidance, sorting accuracy, contextual barriers, and recycling motivational sources (e.g. social, normative, or informational), which are essential components of responsible recycling practices (Barr *et al* 2005).

Importantly, although several instruments have been developed to assess environmental and pro-environmental behavior, very few scales explicitly focus on recycling as a distinct and multidimensional construct (Ugulu 2015a). Existing measures typically incorporate recycling as a minor component within broader behavioral inventories, thereby limiting their ability to capture the full scope of responsible recycling behavior (Erdogan *et al* 2012, Ugulu *et al* 2013). To the best of our knowledge, no existing instrument systematically operationalizes responsible recycling behavior across behavioral, social, economic, and civic dimensions within a unified measurement framework. These limitations indicate that current measurement approaches are insufficient for capturing the full complexity of responsible recycling behavior. Consequently, there is a clear need for a theoretically grounded and psychometrically robust instrument that conceptualizes recycling behavior as a multidimensional construct.

Consequently, a psychometrically valid, theoretically based scale to exclusively measure responsible recycling behavior is lacking in the literature. In response to this gap, the present study develops the REBES, which is grounded in ERB theory and conceptualizes recycling across five distinct dimensions: EPA, CEA, IPPA, PA, and LA. By explicitly incorporating these dimensions, REBES moves beyond traditional single-behavior measures and provides a more comprehensive and behaviorally sensitive framework for assessing responsible recycling behavior.

Such a tool enables environmental psychologists, educators, researchers, and decision-makers to better assess recycling behaviors, identify place-based interventions for improvement, and develop more effective educational and behavioral interventions around recycling behavior. With the recent international emphasis on circular economies and zero-waste initiatives, this type of scale will not only be timely but essential. Therefore, REBES contributes to the literature by offering a multidimensional, theory-driven, and empirically validated instrument for assessing responsible recycling behavior.

1.3. Research objectives

The present study aims to develop and validate a multidimensional instrument for assessing responsible recycling behavior among university students. Specifically, the study seeks to establish a theoretically grounded scale that captures recycling behavior across the five dimensions of ERB: EPA, CEA, IPPA, PA, and LA.

In line with this aim, the study pursues three main objectives. First, it aims to generate and refine scale items based on theoretical foundations and empirical evidence. Second, it seeks to examine the

underlying factor structure of the proposed scale through exploratory factor analysis (EFA), with the expectation that a five-factor structure corresponding to the ERB framework will emerge. Third, the study aims to validate this structure using confirmatory factor analysis (CFA) and to evaluate the reliability, convergent validity, and discriminant validity of the instrument. Through these objectives, the study intends to provide a psychometrically robust and theoretically grounded tool for assessing responsible recycling behavior.

2. Method

2.1. Research design

A mixed-method approach was employed in the study, integrating both quantitative and qualitative techniques to ensure methodological triangulation and enhance the validity of findings. While each method possesses inherent strengths and limitations, their combined use in mixed-method research helps mitigate individual shortcomings and facilitates the development of contextually grounded measurement tools (McKim 2017).

The scale development process began with a comprehensive literature review aimed at deepening the conceptual understanding of the factors underpinning responsible recycling behavior. Insights gained from the review informed the initial drafting of the measurement instrument. This preliminary version was critically reviewed and refined in collaboration with experts in science and EE to ensure content relevance and clarity. Subsequently, a pilot study was conducted to assess the instrument's initial psychometric properties. Based on pilot results and expert feedback, necessary modifications were made. A full-scale survey was then administered, and the resulting data were subjected to a series of rigorous statistical analyses. These included tests for normality, EFA, CFA, and assessments of convergent and discriminant validity to establish the construct validity and reliability of the instrument. Following these steps, a validated instrument comprising 24 items was finalized. The entire scale development process adhered to Hinkin's (1998) methodological framework, as outlined in figure 1.

2.2. Sample

In this study, three different samples were used to develop and validate the REBES. Participants in all three samples were recruited using a convenience sampling strategy. In Sample 1, students were enrolled in different academic disciplines and had varying levels of prior exposure to EE courses or activities. The inclusion of students from diverse academic backgrounds was intended to capture a broad range of perspectives on recycling behavior.

Sample 1 was used for building an item pool. *The first sample* consisted of sixty-three female (38) and male (25) university students who were in their last year. Their ages ranged between 22 and 24 years. They were administered five open-ended items to get their responses in relation to recycling. This sample was from two universities in Izmir and Usak. A total of 63 students within these universities (38 females, 25 males) volunteered to take part in this initial step.

Parallel analyses were conducted for scale development using EFA and CFA. According to Hinkin's criteria (Hinkin 1998), the overall data were divided into two subsamples. In this context, data collected from 1042 university students were used for EFA and CFA in two sample groups of 521 individuals each. *The second sample* consisted of 521 university students (363 females, 158 males) from three universities in Izmir and Usak Provinces. Their ages ranged between 19 and 24 years. This sample was administered in the initial version of the REBES, built from the responses of the first sample. The responses gathered from Sample 2 were used for EFA. *The third sample,* the main sample of the research, consisted of 521 university students (378 females, 143 males) from three universities in Izmir and Usak Provinces. Their ages ranged between 19 and 24 years. The sample was administered using the revised version of the REBES to validate and confirm the factor structure emerging from EFA. CFA using Jamovi 2.6.25 was employed to confirm the initial structure.

2.3. Scale development

2.3.1. PHASE 1: literature review and item generation

Before the development of the item pool, an extensive literature review of recycling, EE, and ERB was carefully performed and examined. Although different types of ERB structures were reported (Ramsey *et al* 1981), many scientists agree on five main structures underlying ERB: eco-management, CEA, persuasion, PA, and LA (Simmons 1995, Hsu 1997, Erdogan *et al* 2012). In this study, responsible recycling behavior is operationally defined through five dimensions of ERB: EPA, CEA, IPPA, PA, and LA. Each



Figure 1. Steps in the development and validation of the REBES.

dimension represents a distinct but related form of engagement in responsible recycling, and these definitions constitute the conceptual and measurement framework of the REBES. These dimensions are used consistently throughout the study, and all interpretations of results are based on this operationalization.

After deciding on the five dimensions, five open-ended items were developed to correspond to each of the five dimensions of the ERB in order to create the item pool. These open-ended questions were reviewed by two faculty members specializing in science education. They were evaluated for comprehensibility and suitability for the study's objectives. The five open-ended items whose responses were included in the item pool are given in table SM1 as supplementary material.

Content analysis was used to analyze the data obtained from open-ended questions (Miles and Huberman 1994). The answers given by the students to the questions were listed as a result of content analysis. Before the content analysis of the responses, an analysis table was created to better present and describe the students' responses. In the table, the responses were grouped according to the grade and presented in frequency (table SM2, supplementary material). For constructing this table, the responses were first coded, and then common codes were brought together to result in broader themes. The codes that were not grouped into any themes were named as 'others'. Two independent researchers conducted the coding process, and intercoder agreement was calculated using percentage agreement, yielding a high level of agreement (92%). Discrepancies were resolved through discussion until consensus was reached.

As presented in table SM2, a total of 36 themes were found to be associated with five dimensions of ERB. The selection of themes for item generation was based on both frequency of occurrence and conceptual relevance to the ERB framework. The themes with the most frequent responses within the overall sample were selected for inclusion in the item pool. Of the total number of 36 themes, 30 themes were selected as possible items in the REBES. Less frequent or conceptually redundant themes were excluded during this process. After the selection, they were transformed into a sentence format.

In addition to these items, a few items relating to recycling were reviewed from environmental attitude, recycling attitude, and responsible environmental behavior instruments that were already developed and used in other studies to improve the intelligibility of the items and the content validity of the REBES. In this direction, three items adopted from 'Environmental Attitude Scale' (Ugulu *et al* 2013), three items adopted from 'Recycling Attitude Scale' (Ugulu 2015a), two items modified from 'Children's Responsible Environmental Behavior Scale' (Erdogan *et al* 2012), an item modified from 'Recycling attitude questionnaire for high school students' (Mrema 2008) and an item modified from 'Questionnaire on attitudes toward recycling and container deposit system' (Lorgunpai and Lertchaiworakul 2010). Finally, the initial draft of the REBES, consisting of 40 items, was constituted.

2.3.2. PHASE 2: Item refinement and content validity

Sixteen experts from different fields of expertise (science education, EE, educational psychology, science teachers, and curriculum specialists) were invited to evaluate the content of the materials and their compatibility with the relevant dimensions. The experts were asked to examine items about their relevance to the purpose of the instrument, content, understandability, and consistency. Each item was evaluated at three levels: 'fully representative', 'partially representative', and 'not representative' (Lin and Hsieh 2011). Content validity ratios (CVR) were calculated for each item based on expert ratings, ranging from .65 to 1.00, and evaluated against established thresholds (Almanasreh *et al* 2019). Items with lower CVR values or conceptual inconsistencies were removed or revised. Based on expert feedback, nine items were removed, resulting in a 31-item scale for pilot testing. The scale was structured as a five-point Likert-type instrument ranging from 'strongly agree' to 'strongly disagree'. These procedures provided evidence for the content validity of the REBES (Almanasreh *et al* 2019).

2.3.3. PHASE 3: test of normality

SPSS v.24 was used for the statistical analysis of the collected data. Before EFA, the data were cleaned considering the following analyses: normality of each variable (as measured by skewness and kurtosis), outliers, and missing data. Normality of each variable (item) was ensured with skewness and kurtosis values at the accepted level (± 1.5) (Tabachnick and Fidell 2013). Then, missing data analysis was performed to preserve the dataset and minimize case loss. This statistical procedure is a type of assignment method that allows replacing the missing value with the mean if at least 5% of each variable has missing values (Tabachnick and Fidell 2013). It was observed that each of the cases had missing values, but less than 5% of the given responses. Therefore, each missing value was replaced with the mean. After that, outlier analysis was performed with data containing 521 cases. Univariate outliers were examined using a scatter plot. A univariate outlier was detected and removed from the dataset (Ugulu *et al* 2008, Yorek *et al* 2010, Yorek and Ugulu 2015).

2.3.4. PHASE 4: EFA (factor structure)

Construct validity is essentially used to determine whether an instrument measures the hypothetical psychological construct it is being tested (Fraenkel and Wallen 2006). EFA was conducted to examine the underlying structure of the initial form of the 31-item REBES scale. The varimax rotation method was used to determine the structure of the scale factors, and principal component factor analysis was applied to the scores obtained from the responses of 520 students on the scale. The suitability of the data for factor analysis can be tested using the Kaiser–Mayer–Olkin (KMO) coefficient and the Bartlett Sphericity Test. If the KMO value is higher than 0.60 and the Bartlett Test is significant, the data is suitable for factor analysis (Field 2005).

2.3.5. PHASE 5: CFA (factorial validity) and model specification

To validate the factor structure revealed in the EFA performed using the data from *Sample 2*, a CFA was performed on the data from *Sample 3* using the statistical package program for moment structure analysis (Jamovi 2.6.25). The suitability of CFA models was evaluated using a variety of goodness-of-fit indices (Hu and Bentler 1999). If the $\chi 2/df$ value is less than 2, the chi-square statistic shows an excellent fit; if it is less than 3, it shows an acceptable fit (Kelloway 1998). CFA uses many goodness-of-fit tests and indices, such as the root mean square error approach (RMSEA), normed fit index (NFI), and

comparative fit index (CFI). The inclination to take into account a single fit index in a large sample is known as the NFI, or NFI. According to Byrne (2010), CFI examines the shift in fit between the independence model and the assumed model. In contrast to the assumed model, the independence model makes the assumption that the variables in the model are uncorrelated. CFI displays the model's overall common variation. A good fit to the data is indicated by NFI and CFI values greater than 0.90. The analysis of residuals is the foundation of RMSEA (Kelloway 1998). When the RMSEA index value is less than 0.08, a good model-data fit is anticipated (Kline 2015). The other model fit indices values, such as Tucker–Lewis index (TLI; target = >.90), and standardized root mean square residual (SRMR; target = <.08) were also found just close to the recommended value (Kline 2015).

2.3.6. PHASE 6: discriminant and convergent validity

The scale's convergent validity and discriminant validity were also examined. Convergent validity was assessed using average variance extracted (AVE) and composite reliability (CR), while discriminant validity was evaluated using the heterotrait–monotrait ratio (HTMT). Internal consistency was examined using Cronbach's α and McDonald's ω.

3. Results

3.1. Results of EFA

The EFA was conducted to examine the underlying structure of the initial form of the 31-item REBES scale. The KMO value was found to be 0.844, indicating sampling adequacy for principal component factor analysis. The Bartlett sphericity test was used to test the null hypothesis that the variables in the population correlation matrix are unrelated. A significant chi-square ($\chi 2$) value obtained in this test indicates the correlation matrix is not an identity matrix and that there are sufficient correlations among variables to proceed with factor analysis. In this study, Bartlett's sphericity test produced a value of 5471.92 at a significance level lower than 0.01, demonstrating the suitability of the factor model for the data.

Factor analysis performed on REBES revealed five factors with eigenvalues exceeding 1.0. These factors explained 56.18% of the variance in the results. The scree plot shows that the five factors exhibit a sharp decline followed by flattening (figure 2). This pattern supports the retention of a five-factor structure rather than indicating the necessity of rotation. Overall, the five factors were represented by one item each with a factor loading greater than 0.40. Item retention decisions were based on a minimum factor loading threshold of 0.40 and the absence of substantial cross-loadings. Five items (Items 3, 7, 12, 18, and 25) were removed because their loadings were lower than 0.40 or because they exhibited cross-loading across multiple factors (Ugulu 2015a). In summary, five items were removed from the 31-item dataset, and the factor analysis for rotation was rerun on the dataset containing 26 items. Varimax rotation was used. Thus, the factor analysis resulted in five independent factors with factor loadings greater than 0.40. Table 1 presents the factor loadings and factor structures of the items. These five factors explain 59.09% of the total variance and are named according to the common characteristics of the items loaded onto the same factor. This value is appropriate considering that other studies focusing on behaviors have shown lower explained variance (Erdogan *et al* 2012: 53.56%). The eigenvalues of the five factors are 4.818, 4.074, 2.916, 2.168, and 1.388, respectively. Table 2, which gives the factors, eigenvalues, and total variance, is explained.

3.2. Results of CFA

To determine the fit between the default model of 26 items and the data, a CFA was first performed using Jamovi 2.6.25. Three indices, NFI, CFI, and RMSEA, were considered to assess this fit. However, while RMSEA and CFI showed acceptable fit values (RMSEA = .061, CFI = .912), the NFI in the first CFA did not yield a satisfactory fit index (NFI = .892). The CFA output showed that the regression pathways (modification indices) were extremely high for two pairs of items (EPA3–IIPA6 and EPA2–IPPA2). The nature and content of the items were assessed, and a degree of overlap was observed; therefore, one of the items in each pair (EPA3 and IPPA2) was removed from the second CFA.

After removing these two REBES items, a 24-item CFA was rerun to determine the model. This second CFA showed that five factors emerged and confirmed the structure, which exhibits an excellent fit for the data in Sample 3 (fit indices: $\chi 2/df$ = 1.632, NFI = .983, CFI = .993, TLI = .992, RMSEA = .035, SRMR = .044). All path coefficients were found to be significant at the $p < .001$ level, indicating that each item makes a significant contribution to the relevant factor. Figure 3 illustrates the five dimensions of the five-factor measurement model of REBES.

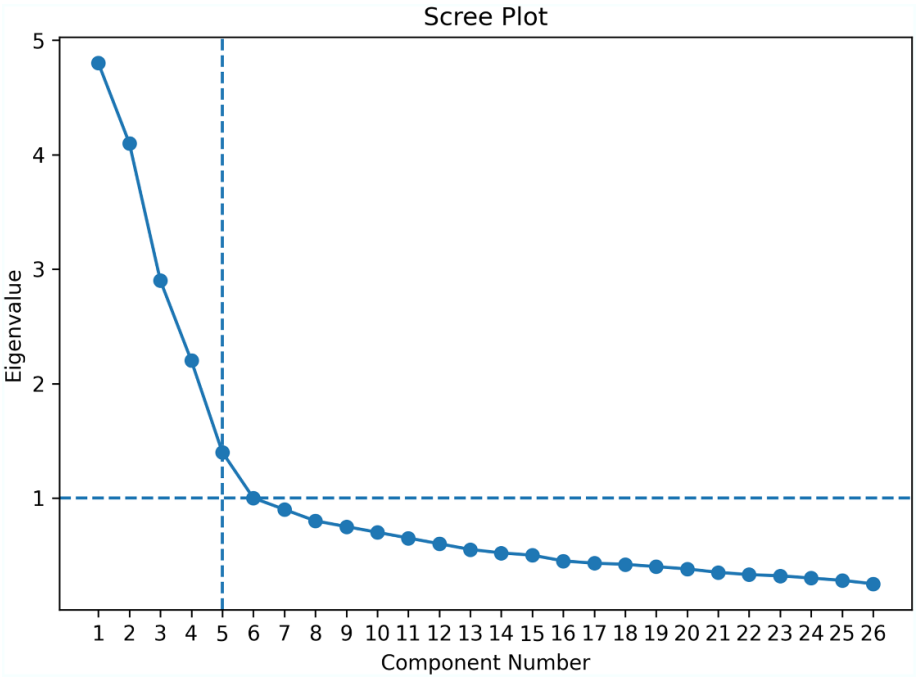

Figure 2. Scree plot indicating factor retention. The vertical dashed line represents the number of retained factors based on the scree test, and the horizontal line indicates the Kaiser criterion (eigenvalue = 1).

Table 1. Factor structures and loadings of REBES items.

	Factor loadings					
Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communality
PA1	.797					.753
PA2	.744					.675
PA3	.835					.555
PA4	.766					.363
PA5	.695					.666
CEA1		.594				.702
CEA2		.812				.690
CEA3		.837				.510
CEA4		.825				.638
CEA5		.710				.751
LA1			.763			.757
LA2			.812			.566
LA3			.833			.477
LA4			.723			.454
EPA1				.680		.422
EPA2				.666		.551
EPA3				.552		.286
EPA4				.737		.562
EPA5				.511		.562
EPA6				.730		.610
IPPA1					.744	.618
IPPA2					.769	.627
IPPA3					.757	.651
IPPA4					.723	.674
IPPA5					.791	.753
IPPA6					.820	.675

Extraction method: principal component analysis.
Rotation method: varimax with Kaiser normalization.

Table 2. Factor names, eigenvalues and variance of factors.

Factor names	Eigenvalues	% of Variance explained
Political action (PA)	4.818	14.424
Consumer/economic action (CEA)	4.074	12.495
Legal action (LA)	2.916	11.207
Eco-management/physical action (EPA)	2.168	10.537
Individual/public persuasion actions (IPPA)	1.388	10.429

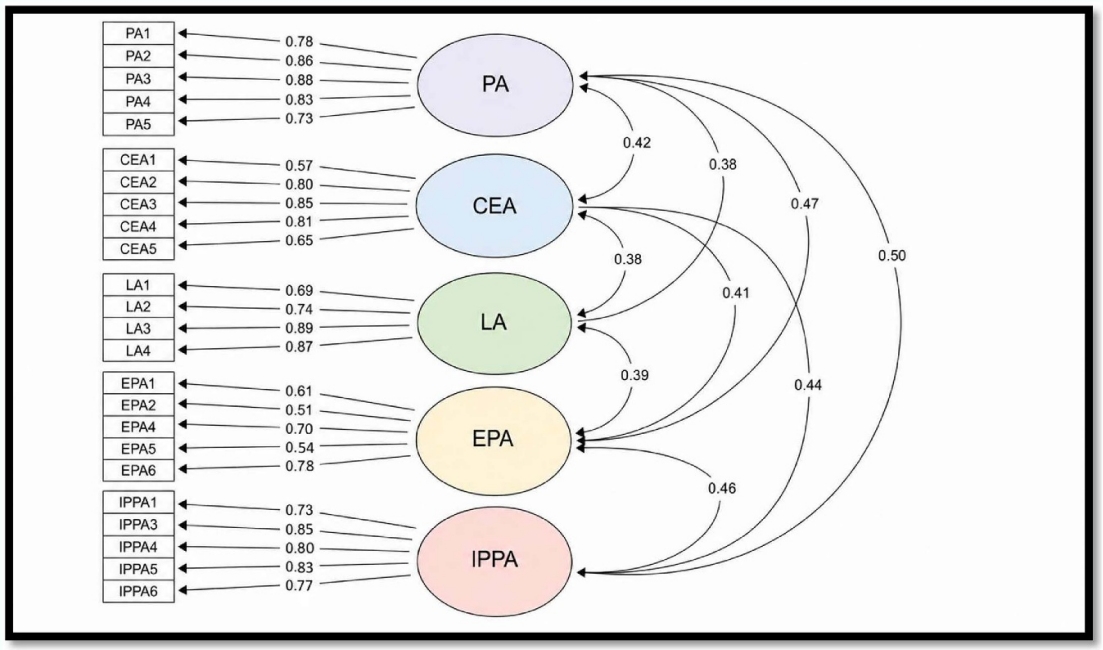

Figure 3. Standardized coefficients for the five-factors model for REBES based on CFA through JAMOVI. All coefficients are significant at $p < .001$. ($\chi 2/df = 1.632$, NFI = .983 CFI = .993, TLI = .992, RMSEA = .035, SRMR = .044). PA: political action, CEA: consumer/economic action, LA: legal action, EPA: eco-management/physical action and IPPA: individual/public persuasion action.

Table 3. Convergent validity and discriminant validity of each dimension.

	Convergent validity		Discriminant validity (HTMT)				
Dimension	AVE	CR	PA	CEA	LA	EPA	IPPA
Political action (PA)	.612	.882	—				
Consumer/economic action (CEA)	.553	.848	.051	—			
Legal action (LA)	.646	.872	.629	.028	—		
Ecomanagement/physical action (EPA)	.423	.761	.050	.058	.057	—	
Individual/public persuasion action (IPPA)	.631	.890	.092	.021	.040	.303	—

3.3. Convergent and discriminant validity

The scale's convergent and discriminant validity results are presented in table 3. The findings generally support the convergent validity of the scale, with CR values exceeding the recommended threshold of 0.70 (Hair *et al* 2018). Most AVE values were also above 0.50. However, the AVE value for the EPA dimension was slightly below the recommended threshold (AVE = .423). Nevertheless, the dimension was retained because its CR value exceeded 0.70 and the factor loadings were theoretically meaningful and statistically acceptable. As noted by Fornell and Larcker (1981), convergent validity of a construct may still be considered adequate when AVE is below 0.50 but CR exceeds 0.60. In addition, discriminant validity was assessed using the HTMT criterion. As shown in table 3, HTMT values ranged from 0.021 to 0.639, all below the recommended threshold of 0.850 (Kline 2015), indicating acceptable discriminant validity among the dimensions.

Furthermore, internal reliability (i.e. Cronbach's a and McDonald's ω) and CR were measured. REBES demonstrated acceptable reliability, with CR values ranging from 0.761 to 0.890, Cronbach's a

value from 0.710 to 0.856, and McDonald's ω value from 0.719 to 0.872 (Hair *et al* 2018). Consequently, the five-dimensional structure of REBES, which aims to evaluate the responsible recycling behaviors of university students, was revealed.

A complete list of all items in Turkish and English is provided in table SM3 (supplementary material). The Turkish version of the scale was translated into English in collaboration with a translator highly proficient in both English and Turkish.

4. Discussion

4.1. Multidimensional structure and interpretation of REBES

In this study, an instrument was developed to assess the responsible recycling behaviors of university students within the framework of Hinkin's (1998) methodological framework. The analyses revealed that our measurement items adequately captured the function of this five-action model, reflecting recycling behavior from different perspectives. The results provide evidence of a reliable and theoretically grounded five-factor structure, supported by internal consistency and convergent and discriminant validity indicators. This instrument (REBES) consists of five dimensions and 24 items, with responses recorded on a five-point Likert scale.

Beyond its psychometric adequacy, the identified five-factor structure offers important insights into the nature of responsible recycling behavior. Specifically, the results suggest that recycling should not be conceptualized as a single or routine behavior but rather as a multidimensional construct encompassing behavioral, social, economic, and institutional forms of engagement. This interpretation aligns with ERB frameworks and extends them by demonstrating how these dimensions manifest specifically within the context of recycling. In this respect, the REBES framework provides a more nuanced understanding of recycling behavior, highlighting that individuals engage not only through direct actions (e.g. waste separation) but also through consumption choices, social influence, and civic or institutional participation. The following sections elaborate on each dimension to interpret its roles within this multidimensional structure.

The strong factor loadings and reliability coefficients associated with EPA suggest that this dimension constitutes the behavioral core of responsible recycling. This finding is consistent with prior research emphasizing that recycling is often conceptualized primarily as a set of routine, task-oriented actions (Barr *et al* 2005, Miafodzyeva and Brandt 2013). From a theoretical perspective, EPA aligns closely with the TPB (Ajzen 1991), particularly the role of perceived behavioral control and habit formation. The results also resonate with the Habit Disruption Model (Verplanken and Aarts 1999), indicating that responsible recycling is not merely a one-time decision but a repeated and context-dependent behavior. The prominence of this factor may reflect the fact that physical recycling practices are relatively more accessible and visible compared to more abstract forms of environmental engagement; this suggests that individuals are more likely to internalize and report behaviors that are routine, observable, and structurally supported. Importantly, by distinguishing EPA as a standalone dimension, the REBES captures nuances often overlooked in broader pro-environmental behavior scales, such as consistency, accuracy, and personal accountability in recycling practices.

The emergence of CEA as a distinct factor underscores the economic dimension of recycling behavior, which has been highlighted in ERB typologies but is often underrepresented in recycling-specific instruments. This finding is theoretically consistent with VBN theory (Stern *et al* 1999), as consumer choices are frequently guided by underlying environmental values and moral norms. Moreover, CEA resonates with Blake's (1999) value–action gap, illustrating that responsible recycling extends beyond waste disposal to upstream consumption decisions. The identification of CEA as a separate factor suggests that recycling behavior is not confined to end-of-life waste management but is cognitively linked to pre-consumption decision-making processes, indicating a broader behavioral integration across the consumption cycle. The inclusion of this dimension strengthens the REBES by capturing recycling-related behaviors that operate within market and consumption systems, thus aligning with contemporary sustainability and circular economy frameworks.

The validation of IPPA highlights the social diffusion aspect of responsible recycling, emphasizing that recycling behavior is not solely an individual act but also a socially embedded practice. This dimension is well supported by social learning theory (Bandura and Walters 1977), which emphasizes observational learning and social reinforcement, as well as by subjective norms within TPB (Ajzen 1991). The results also align with findings that peer influence, family norms, and social expectations significantly shape recycling behaviors, particularly among university students (Wu *et al* 2021, Chao *et al* 2023). The

emergence of IPPA as a distinct factor suggests that individuals do not merely engage in recycling behaviors but also act as agents of behavioral transmission, indicating that responsible recycling can propagate through interpersonal networks and social influence mechanisms. By incorporating IPPA, the REBES acknowledges the role of informal education and social advocacy in promoting responsible recycling, reinforcing the behavioral-change goals emphasized in the Tbilisi Declaration.

The emergence of PA as a distinct dimension suggests that responsible recycling behavior may extend to engagement with institutional and policy-related processes. Although often less frequently practiced than individual recycling behaviors, PA emerged as a valid and reliable dimension, indicating that responsible recycling encompasses civic engagement and systemic change efforts. This finding supports earlier ERB models that position political participation as a higher-order form of environmental responsibility (Ramsey *et al* 1981, Hsu 1997). Theoretically, PA aligns with Environmental Citizenship and NAM perspectives, wherein individuals act on personal norms and a sense of responsibility toward societal well-being (Schwartz 1977). The identification of PA suggests that, for a subset of individuals, recycling behavior extends beyond personal or household practices to include engagement with institutional processes, reflecting a transition from individual action to collective and policy-oriented responsibility. The inclusion of PA in the REBES extends recycling research beyond household-level behavior and underscores the importance of collective action in achieving sustainable waste management systems.

The identification of LA further extends responsible recycling behavior to formal and institutional mechanisms. Although this dimension often receives limited empirical attention, its presence as a distinct factor confirms that responsible recycling behavior may also manifest through institutional and rights-based pathways. The validation of LA aligns with advanced ERB frameworks that recognize legal engagement as an essential component of environmental responsibility (Erdogan *et al* 2012). From a policy perspective, this dimension highlights the role of informed and active citizens in shaping regulatory environments conducive to sustainable recycling practices. The emergence of LA further indicates that responsible recycling behavior may be influenced by individuals' awareness of legal frameworks and their willingness to engage with formal accountability mechanisms, highlighting a more advanced level of environmental engagement. Including LA in the REBES contributes to a more comprehensive understanding of recycling behavior as a multi-level construct spanning personal, social, economic, and institutional domains.

The five-factor structure of the REBES provides strong empirical support for the multidimensional conceptualization of responsible recycling behavior. Unlike existing instruments that treat recycling as a single behavioral indicator or a subcomponent of general environmental behavior, the REBES captures the breadth, depth, and complexity of recycling-related actions. Methodologically, the rigorous scale development process, incorporating mixed methods, large samples, EFA–CFA validation, and comprehensive reliability and validity analyses, strengthens the robustness and generalizability of the findings. Theoretically, the REBES bridges classical ERB frameworks with contemporary pro-environmental behavior theories, offering a refined tool that reflects both individual agency and structural engagement. By operationalizing recycling across behavioral, social, economic, political, and legal dimensions, the scale responds directly to calls for more behaviorally specific and context-sensitive measurement tools in EE and psychology.

4.2. Conceptual and methodological contributions of REBES

The five-factor structure of the REBES provides strong empirical support for conceptualizing responsible recycling behavior as a multidimensional construct. Existing instruments in EE research have typically approached recycling and ERB from either a general behavioral or an attitudinal perspective, with important limitations. For instance, the Children's Responsible Environmental Behavior Scale (CREBS) operationalizes ERB across several action categories, including eco-management, persuasion, PA, and consumer behavior (Erdogan *et al* 2012). However, CREBS was developed for younger populations and does not explicitly conceptualize recycling as a distinct and context-specific behavioral domain. Moreover, its broader focus on general environmental actions limits its sensitivity to the specific practices and decision processes involved in responsible recycling.

Similarly, the Recycling Attitude Scale provides a structured assessment of students' attitudes toward recycling but does not directly measure behavioral engagement (Ugulu 2015a). This reflects a broader limitation in the literature, where recycling is frequently examined through attitudinal proxies despite consistent evidence that attitudes alone are insufficient predictors of behavior. As a result, existing instruments tend to capture either what individuals think about recycling or whether they report engaging in isolated actions, but not the full spectrum of how responsible recycling behavior is enacted across different contexts.

REBES addresses this critical gap by shifting the analytical focus from attitudes or isolated actions to a theoretically grounded, behavior-centered framework. Drawing explicitly on ERB theory, the scale differentiates between eco-management, CEA, persuasion, PA, and LA, thereby capturing multiple levels of engagement within a single instrument. This multidimensional structure reveals that responsible recycling is not a singular behavior but a system of interrelated practices spanning routine actions, consumption choices, social influence, and institutional participation. Importantly, REBES extends prior ERB-based instruments (e.g. Erdogan *et al* 2012) by adapting their conceptual foundations to the specific domain of recycling, while also overcoming the limitations of attitude-based measures (e.g. Ugulu 2015a, 2015b, 2021a, 2021b) by directly operationalizing observable and context-dependent behaviors. In doing so, the scale provides a more precise and ecologically valid representation of recycling behavior, particularly in complex real-world settings where behavioral, social, and structural factors interact.

Methodologically, REBES further advances the literature by integrating qualitative item generation, expert-based content validation, and sequential EFA–CFA procedures within a unified development framework. Compared to earlier instruments, which tend to emphasize either conceptual breadth or psychometric rigor, REBES combines both, resulting in a scale that is simultaneously theory-driven, empirically robust, and context-sensitive.

5. Implications

5.1. Theoretical implications

The development and validation of the REBES offer several important theoretical contributions to the literature on ERB and pro-environmental psychology. First, the five-factor structure of the REBES empirically supports the long-standing proposition that environmental behavior is inherently multidimensional, extending beyond simple, routine actions to include social, economic, political, and legal forms of engagement. By operationalizing recycling behavior across eco-management, CEA, individual/public persuasion, PA, and LA, the scale provides a refined and domain-specific application of classical ERB frameworks (Hungerford and Peyton 1977, Ramsey *et al* 1981).

Second, the REBES helps improve our understanding of theory by connecting general models of promoting environmental behaviors (e.g. TPB, VBN theory, and NAM) to the specific behaviors involved in recycling. Although most of the existing research has treated 'recycling' as a single behavioral outcome, the REBES shows that there are many qualitatively distinct types of responsible behavior when it comes to recycling, all of which can be motivated by different structures and norms. This evidence supports the critique of linear behavior models as well as contemporary views concerning complexity in behavior, the importance of habits, and the limitations associated with various contexts (Kollmuss and Agyeman 2002).

Third, incorporating political and LAs into recycling research helps to expand the theoretical understanding of recycling by demonstrating how an individual's actions fit into the larger context of governance and regulation. They also reflect a move away from an exclusively individualistic view of our responsibility towards the environment towards a model that recognizes our collective responsibility as environmental citizens. In this way, the REBES expands the application of ERB theory into areas typically overlooked by recycling researchers and provides a more complete theoretical framework for future modelling and testing of hypotheses.

Finally, the psychometric robustness of the REBES, specifically, its strong evidence of convergent and discriminant validity, provides a solid basis for future research across cultures and over time, and through experimental means. Thus, the REBES allows researchers to study the differences between predictors (and outcomes) of the various recycling dimensions, thus fostering the development of theories with greater detail regarding what drives and results from environmentally responsible recycling behavior.

5.2. Practical implications

From a practical standpoint, the REBES can provide many meaningful applications in the areas of EE, Environmental Policy Development, and sustainable practices, especially in the context of Higher Education Institutions. The REBES' multidimensional structure enables Educators to assess both students' strengths and weaknesses across various types of recycling behavior. In addition to using the REBES to assess the education of students with respect to waste sorting, Educators can also incorporate strategies that foster increased awareness of consumer behaviors, social/civic advocacy, and active participation in recycling initiatives. These types of intervention strategies closely align with the behaviors encouraged by EE as described in the Tbilisi Declaration.

Furthermore, for Policy Makers and University Administration, the REBES may serve as a diagnostic tool for evaluating campus sustainability programs and recycling-related initiatives within university settings. By identifying what dimensions of responsible recycling behavior are lacking and underdeveloped within an institution, Policy Makers and University Administrators may be able to create targeted interventions tailored to their specific campus needs. Examples of targeted interventions would include improving the recycling infrastructure to help foster eco-management behaviors or creating platforms for promoting political and legal engagement in recycling and the environment. Such targeted interventions may be more effective than generalized recycling campaigns in addressing specific behavioral dimensions.

In addition, the REBES may help assess the effects of circular economy and zero waste initiatives implemented in higher education contexts. Monitoring changes across the five dimensions of the scale may provide insights into whether sustainability-related interventions are associated with more consistent and long-term patterns of responsible recycling behavior. This may be particularly useful in cases where reported recycling participation does not fully reflect actual behavioral engagement.

Finally, the REBES may provide useful preliminary data for understanding recycling-related behavioral patterns and barriers among university students. However, these implications should be interpreted within the scope of the present study, which was conducted with university students from two provinces of Turkey and relied on self-report data. Therefore, the applicability of the scale to broader community populations, different age groups, or diverse educational and cultural settings requires further validation through future research.

6. Conclusion

This study developed and initially validated the REBES, a theoretically grounded instrument designed to assess responsible recycling behavior among university students. The findings support a five-factor structure, ecomanagement, CEA, persuasion, PA, and LA, based on a 24-item scale. Results from exploratory and confirmatory factor analyses, together with reliability and validity indicators, provide evidence for the internal consistency and construct validity of the instrument within the study sample.

Beyond its psychometric properties, the findings reinforce the view that responsible recycling behavior is multidimensional, encompassing not only routine waste management practices but also broader forms of engagement, including consumption-related decisions, social influence processes, and civic-oriented actions. In this respect, REBES provides a more differentiated and behavior-focused assessment framework, extending beyond approaches that rely on single indicators or attitudinal measures. Accordingly, the main contribution of this study lies in offering a theory-driven and multidimensional instrument that enables a more comprehensive assessment of responsible recycling behavior within the context of higher education.

Despite the methodological rigor of this study, some limitations must be considered. The sample was limited to university students in two provinces of Turkey; this may restrict the generalizability of the findings to other populations and cultural contexts. Furthermore, reliance on self-report data may have led to social desirability bias, potentially inflating reported levels of responsible recycling behavior. The cross-sectional design further limits conclusions regarding behavioral change over time. Future research should validate REBES across diverse age groups and cultural settings, incorporate longitudinal and mixed-methods designs, and integrate self-report measures with objective indicators of recycling behavior. Moreover, examining the different psychological, social, and contextual determinants of the five REBES dimensions will contribute to a deeper understanding of responsible recycling behavior and support the development of more targeted and effective EE and policy interventions.

Data availability statement

The data cannot be made publicly available upon publication because they are not available in a format that is sufficiently accessible or reusable by other researchers. The data that support the findings of this study are available upon reasonable request from the authors.

The five open-ended items: Supplementary data 1 available at https://doi.org/10.1088/2515-7620/ae7256/data1.

University students' responses: Supplementary data 2 available at https://doi.org/10.1088/2515-7620/ae7256/data2.

Final scale: Supplementary data 3 available at https://doi.org/10.1088/2515-7620/ae7256/data3.

Conflict of interest

The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Ethical statement

This study was conducted in accordance with established ethical guidelines for research involving human participants, including the principles of the Declaration of Helsinki. Ethical approval was obtained from the Usak University Social and Human Sciences Scientific Research and Publication Ethics Committee (Decision No: 2024-81, dated 04.04.2024). All participants were university students aged between 19 and 24 years and were therefore legally adults. Accordingly, informed consent was obtained directly from the participants, and no parental or guardian consent was required. Participation was voluntary, and participants were informed of their right to withdraw at any stage without any consequences. Confidentiality and anonymity were ensured throughout the study, and all data were used solely for research purposes.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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