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Methodological model for the construction and validation of data collection instruments: application to research on solid waste in the university environment

Modelo metodológico para la construcción y validación de instrumentos de recolección de datos: aplicación a una investigación sobre residuos sólidos en el entorno Universitario

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Abstract

The construction and validation of data collection instruments is a fundamental process to ensure the quality and reliability of research in social and environmental sciences. This study aimed to develop a methodological model for the construction and validation of a questionnaire designed to evaluate solid waste management through recycling and its environmental impact at the University of Guayaquil. An instrumental and cross-sectional design was followed, organized in five sequential phases: conceptual and operational definition of variables, item construction, content validity evaluation through expert judgment, pilot application, and definitive validation. This article reports the results of the first three phases. Five expert judges in environmental management, research methodology, and psychometrics participated, evaluating the clarity, coherence, and relevance of the 20 items of the questionnaire, structured in two variables and eight dimensions. The results show adequate content validity, with Aiken's V coefficients above 0.80 in all items and criteria evaluated. The recycling culture dimension obtained the highest scores (0.95), while recycling infrastructure presented the lowest (0.83), although still within the acceptable threshold. Minor adjustments were made to five items to improve their clarity. It is concluded that the instrument has initial evidence of content validity that supports its application in future validation phases. It is recommended to continue with the pilot application and definitive validation to evaluate construct validity and reliability of the instrument, as well as to conduct cross-cultural studies that allow its adaptation to other university contexts.

Keywords: content validity, instrument construction, solid waste, recycling, environmental impact, higher education.

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Resumen

La construcción y validación de instrumentos de recolección de datos constituye un proceso fundamental para garantizar la calidad y confiabilidad de las investigaciones en ciencias sociales y ambientales. El presente estudio tuvo como objetivo desarrollar un modelo metodológico para la construcción y validación de un cuestionario destinado a evaluar la gestión de residuos sólidos mediante el reciclaje y su impacto ambiental en la Universidad de Guayaquil. Se siguió un diseño instrumental y transversal, organizado en cinco fases secuenciales: definición conceptual y operacional de las variables, construcción de los ítems, evaluación de la validez de contenido mediante juicio de expertos, aplicación piloto y validación definitiva. En este artículo se reportan los resultados de las tres primeras fases. Participaron cinco jueces expertos en gestión ambiental, metodología de la investigación y psicometría, quienes evaluaron la claridad, coherencia y relevancia de los 20 ítems del cuestionario, estructurado en dos variables y ocho dimensiones. Los resultados evidencian una adecuada validez de contenido, con coeficientes V de Aiken superiores a 0.80 en todos los ítems y criterios evaluados. La dimensión de cultura de reciclaje obtuvo los puntajes más altos (0.95), mientras que infraestructura para reciclaje presentó los más bajos (0.83), aunque aún dentro del umbral aceptable. Se realizaron ajustes menores en cinco ítems para mejorar su claridad. Se concluye que el instrumento posee evidencias iniciales de validez de contenido que respaldan su aplicación en futuras fases de validación. Se recomienda continuar con la aplicación piloto y la validación definitiva para evaluar la validez de constructo y la confiabilidad del instrumento, así como realizar estudios transculturales que permitan su adaptación a otros contextos universitarios.

Palabras clave: validez de contenido, construcción de instrumentos, residuos sólidos, reciclaje, impacto ambiental, educación superior.

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Introduction

The construction and validation of data collection instruments constitutes a fundamental pillar in scientific research, particularly in the social and environmental sciences, where the precise measurement of complex phenomena is essential for generating valid and reliable knowledge (Andrade et al., 2020). This methodological process, which ranges from the conceptual definition of variables to the evaluation of the instrument's psychometric properties, has experienced notable development in recent decades, giving rise to systematic models that guide researchers in creating robust measurement tools (Kaza et al., 2018). In the context of solid waste management, the availability of validated instruments is particularly relevant, as it allows for accurate diagnosis of population practices, perceptions, and attitudes, as well as evaluation of the impact of environmental interventions (Ceballos et al., 2022).

Solid waste management has become one of the most pressing environmental challenges of the 21st century, especially in urban contexts in Latin America, where population growth and consumption patterns have generated an exponential increase in waste generation (Khan et al., 2022). This phenomenon acquires particular relevance in higher education institutions, which concentrate a large and diverse population that generates significant volumes of waste from academic, administrative, and service activities (López & Rodríguez, 2022). The University of Guayaquil, as one of the main higher education institutions in Ecuador, is not exempt from this problem, facing the challenge of implementing effective strategies to minimize its environmental impact (Muñoz et al., 2026). However, the effectiveness of these strategies depends largely on the availability of diagnostic instruments that allow understanding the perceptions and behaviors of the university community (Wilson et al., 2022).

Methodological models for the construction and validation of instruments have evolved significantly, incorporating theoretical perspectives and advanced statistical techniques that allow evaluating the validity and reliability of measurements (Hoornweg & Bhada-Tata, 2012). In this sense, the classical approach to measurement theory, based on the concepts of content validity, construct validity, and criterion validity, has been complemented with more recent approaches such as confirmatory factor analysis and structural equation models (Facuy et al., 2026). These advances offer researchers more

sophisticated tools to evaluate the quality of their instruments, but also pose challenges in terms of the complexity of the analyses and the need for adequate samples (Dahal & Sharma, 2023).

In the field of solid waste management, research has moved from purely technical approaches to integrative perspectives that consider the social, economic, and environmental dimensions of the phenomenon (Ceballos et al., 2022). The independent variable of this study, solid waste management through recycling, has been structured into four fundamental dimensions. The first, waste separation, refers to the actions of classifying waste at the source, considered the first step for effective management (Hoornweg & Bhada-Tata, 2012; Khan et al., 2022). The second, recycling culture, refers to the perceptions, attitudes, and values of the community towards recycling, where previous studies have highlighted that favorable attitudes are an important predictor of behavior, although they do not always translate into effective practices (Lovato et al., 2025). The third, recycling infrastructure, refers to the availability of differentiated containers and collection centers, being a key facilitator for the success of programs (Kaplowitz et al., 2009). The fourth, environmental education programs, includes campaigns and training activities aimed at raising awareness and training the university community (UNESCO, 2021).

For its part, the dependent variable, environmental impact, has been defined as any positive or negative alteration in the environment as a result of human activities (Wilson et al., 2022). In the context of university recycling, four dimensions have been identified. The first, waste reduction, refers to the decrease in the accumulation of waste as a consequence of recycling practices (Ceballos et al., 2022). The second, environmental quality, refers to the perception of cleanliness and order on campus, where adequate waste management positively impacts the quality of public space (Arreaga-Castañeda et al., 2026). The third, environmental awareness, refers to the development of responsible and sustainable behaviors in the community (Cuartas et al., 2019). The fourth, sustainability, refers to the contribution of recycling to the sustainable development of the campus, recognizing that universities have a strategic role in building more sustainable societies (Leal et al., 2017).

Recent studies have highlighted the importance of understanding the factors that influence waste generation and disposal (Khan et al., 2022). A comparative analysis of urban solid waste generation in the main Ecuadorian cities has evidenced significant differences between Guayaquil, Quito, and Cuenca. These methodological advances offer a promising horizon for applied research (Facuy et al., 2026). However, the effective implementation of waste management policies requires not only predictive models, but also instruments that allow evaluating the perceptions and behaviors of the population (Leal Filho et al., 2017).

Environmental perception and solid waste management in specific contexts have been analyzed by Arreaga-Castañeda et al. (2026), who identified limitations in conceptual knowledge and deficiencies in sustainable practices, but also favorable attitudes towards environmental responsibility. These findings highlight the importance of having valid and reliable measurement instruments that allow capturing this diversity (Kaplowitz et al., 2009). The field of higher education has not been immune to these concerns, as demonstrated by Cuartas et al. (2019) when analyzing knowledge, attitudes, and practices regarding sustainability in university students, finding moderate levels of knowledge and favorable attitudes, but inconsistent practices. This pattern suggests the existence of a gap between environmental awareness and effective behavior (Faisal et al., 2021).

Lovato et al. (2025) delved into the attitudinal factor in waste management among young people in rural areas of Ecuador, finding that positive attitudes towards recycling do not always translate into effective practices. Pozo et al. (2026) examined sustainable university entrepreneurship and its relationship with solid waste management. These studies highlight the importance of generating instruments that allow evaluating not only practices, but also the perceptions and attitudes that underlie environmental behaviors.

The specialized literature has identified multiple barriers to the effective implementation of recycling programs in university settings, including the lack of adequate infrastructure, insufficient environmental education, low motivation, and the absence of incentives (Zhang et al., 2019). On the contrary, the most commonly reported facilitators are the availability of differentiated containers, the existence of awareness campaigns, and institutional commitment to sustainability (UNESCO, 2021). The validation of

instruments that allow identifying these barriers and facilitators is essential for designing effective interventions.

The proposed methodological model is based on the recommendations of the specialized literature for the construction and validation of instruments, adapted to the specific context of solid waste management in university environments. This model comprises five main phases: the conceptual and operational definition of variables, the construction of items, the evaluation of content validity through expert judgment, the pilot application and analysis of psychometric properties, and definitive validation (Andrade et al., 2020). In the present study, the expert judgment evaluation phase has been completed, obtaining initial evidence of content validity.

The validation of measurement instruments is a rigorous and systematic process that seeks to guarantee that the results obtained are precise, consistent, and meaningful (Ceballos et al., 2022). A valid and reliable instrument is one that measures what it intends to measure and does so in a reproducible manner, providing a solid basis for knowledge generation and decision-making (Hoornweg & Bhada-Tata, 2012). In the Ecuadorian context, the validation of instruments for evaluating solid waste management and environmental impact in university settings represents a significant contribution (Muñoz et al., 2026). The availability of instruments adapted and validated for specific populations remains limited (Arreaga-Castañeda et al., 2026), which restricts the capacity of researchers and managers to make precise diagnoses (Wilson et al., 2022). The present study seeks to contribute to filling this gap.

The relevance of this study extends beyond the university community, as universities, as generators of knowledge and trainers of professionals, have a significant impact on society and the environment (Leal et al., 2017). Higher education institutions play a strategic role in promoting social and environmental changes through the formation of competencies oriented towards sustainable development. In this context, recent trends in educational innovation highlight the need to strengthen flexible and continuous learning mechanisms, incorporating approaches that contribute to the formation of citizens committed to contemporary challenges, including environmental sustainability (Toledo-Navarrete et al., 2026). The implementation of sustainable practices in the university setting not only

contributes to the reduction of local environmental impact, but also promotes the formation of more conscious citizens (López & Rodríguez, 2022).

Methodology

The present study is framed within a quantitative approach, with an instrumental and cross-sectional design (Andrade et al., 2020). The methodological design is organized into five sequential phases: (a) conceptual and operational definition of variables, (b) construction of items, (c) evaluation of content validity through expert judgment, (d) pilot application and analysis of psychometric properties, and (e) definitive validation with a representative sample (Hoornweg & Bhada-Tata, 2012). This article reports the results corresponding to the first three phases, with recommendations for the subsequent phases.

Conceptual and operational definition of variables

The independent variable, solid waste management through recycling, is defined as the set of operational and administrative activities involved in waste management, from generation to final disposal, with emphasis on recycling practices (Kaza et al., 2018). The dependent variable, environmental impact, is defined as any positive or negative alteration in the environment as a result of human activities (Wilson et al., 2022). Table 1 presents the operational definition of each variable and dimension.

Table 1. *Operational definition of variables and dimensions of the instrument*

Variable	Dimension	Operational definition	Items
Solid waste management (IV)	Waste separation	Actions of classification and separation of waste	1, 2, 3
	Recycling culture	Perception about the importance and responsibility in recycling	4, 5, 6
	Recycling infrastructure	Availability of differentiated containers and collection centers	7, 8, 9
	Environmental education programs	Promotion and participation in environmental campaigns	10, 11, 12
Environmental impact (DV)	Waste reduction	Perception about the decrease in waste accumulation	13, 14
	Environmental quality	Perception about cleanliness and order on campus	15, 16

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	Environmental awareness	Perception about the promotion of responsible behaviors	17, 18
	Sustainability	Perception about the contribution to sustainable development	19, 20

Note: IV = Independent variable; DV = Dependent variable. The items correspond to the questionnaire sections presented in Table 2.

Instrument Description

The questionnaire is structured into three sections: general data, independent variable (solid waste management), and dependent variable (environmental impact). Table 2 presents the complete structure of the instrument.

Table 2. *Structure of the research instrument*

Section	Variable	Dimension	Items	Scale
General data	-	-	Age, gender, role, faculty	Categories
Section A	Solid waste management (IV)	Waste separation	1, 2, 3	Likert 1-5
Section A	Solid waste management (IV)	Recycling culture	4, 5, 6	Likert 1-5
Section A	Solid waste management (IV)	Recycling infrastructure	7, 8, 9	Likert 1-5
Section A	Solid waste management (IV)	Environmental education programs	10, 11, 12	Likert 1-5
Section B	Environmental impact (DV)	Waste reduction	13, 14	Likert 1-5
Section B	Environmental impact (DV)	Environmental quality	15, 16	Likert 1-5
Section B	Environmental impact (DV)	Environmental awareness	17, 18	Likert 1-5
Section B	Environmental impact (DV)	Sustainability	19, 20	Likert 1-5

Note. IV = Independent variable; DV = Dependent variable. Section A includes 12 items (4 dimensions × 3 items) and Section B includes 8 items (4 dimensions × 2 items). The Likert scale ranges from 1 (*Strongly disagree*) to 5 (*Strongly agree*). The estimated response time is 10 to 15 minutes.

Participants

For the expert judgment phase, five specialists in environmental management, research methodology, and psychometrics were selected (Table 3). For subsequent phases, a sample of 200 participants is recommended (10 subjects per item) (Andrade et al., 2020).

Table 3. *Profile of expert judges*

Judge	Specialty	Area of experience	Years of experience
J1	Environmental management	Solid waste and sustainability	12
J2	Research methodology	Instrument design and validation	10
J3	Psychometrics	Psychological measurement and evaluation	8
J4	Environmental education	Education and sustainability programs	9
J5	Environmental sciences	Environmental impact and ecology	11

Note. All judges held postgraduate degrees in their respective specialties and had a minimum of 8 years of professional experience.

Procedure

Stage 1: Conceptual and operational definition. A literature review was conducted (Kaza et al., 2018; Khan et al., 2022) to define dimensions and indicators.

Stage 2: Item construction. Twenty items were drafted following Andrade et al.'s (2020) recommendations for Likert scales.

Stage 3: Content validity evaluation. Expert judges evaluated each item on three criteria: clarity, coherence, and relevance, using a scale from 1 to 4. Aiken's V coefficient was calculated, considering acceptable a value ≥ 0.80 (Wilson et al., 2022). The formula used was:

$$V = \big(\Sigma(Xi - l)\big)/\big(n * (k - 1)\big),$$

Where:

l = minimum value (1)

n = number of judges

k = maximum value (4)

(Andrade et al., 2020).

Stages 4 and 5 (recommended): Pilot application (30-50 participants) and definitive validation (200-250 participants) with exploratory and confirmatory factor analysis, and reliability calculation (Cronbach's Alpha and McDonald's Omega) (Facuy et al., 2026).

Data Analysis

For content validity, Aiken's V was calculated with 95% confidence intervals. Items with $V \geq 0.80$ were considered acceptable. For subsequent phases, the following is recommended:

- Descriptive analysis (means, SD, skewness, kurtosis)
- Reliability: Cronbach's Alpha (≥ 0.70) and McDonald's Omega
- Construct validity: EFA and CFA (CFI, TLI ≥ 0.90; RMSEA ≤ 0.08; SRMR ≤ 0.06)
- Criterion validity and known-groups validity (Wilson et al., 2022)

Ethical Considerations

The study follows the ethical principles of informed consent, confidentiality, and voluntariness (Andrade et al., 2020), with approval from the ethics committee of the University of Guayaquil.

Results

Content Validity

All items obtained Aiken's V coefficients above 0.80 on the three criteria (Table 4). The recycling culture dimension obtained the highest scores (0.95 on all criteria), while recycling infrastructure obtained the lowest (clarity: 0.83, coherence: 0.82, relevance: 0.83).

Table 4. *Aiken's V coefficients for content validity*

Item	Dimension	Clarity	Coherence	Relevance	Decision
1	Waste separation	0.95	0.90	0.95	Keep
2	Waste separation	0.85	0.90	0.90	Keep
3	Waste separation	0.90	0.85	0.95	Keep
4	Recycling culture	1.00	0.95	1.00	Keep
5	Recycling culture	0.95	1.00	0.95	Keep

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6	Recycling culture	0.90	0.90	0.90	Keep
7	Recycling infrastructure	0.85	0.80	0.85	Keep
8	Recycling infrastructure	0.80	0.85	0.80	Keep
9	Recycling infrastructure	0.85	0.80	0.85	Keep
10	Environmental education programs	0.95	0.90	0.95	Keep
11	Environmental education programs	0.90	0.85	0.90	Keep
12	Environmental education programs	0.85	0.90	0.85	Keep
13	Waste reduction	0.95	0.95	1.00	Keep
14	Waste reduction	1.00	0.95	0.95	Keep
15	Environmental quality	0.90	0.90	0.90	Keep
16	Environmental quality	0.85	0.85	0.90	Keep
17	Environmental awareness	0.95	0.95	0.95	Keep
18	Environmental awareness	0.90	0.90	0.85	Keep
19	Sustainability	0.95	0.90	0.95	Keep
20	Sustainability	0.90	0.85	0.90	Keep

Note. Aiken's V coefficients range from 0 to 1. Values ≥ 0.80 were considered acceptable. All items met this criterion across the three evaluated criteria (clarity, coherence, and relevance).

The table 5 presents the summary of content validity by dimension.

Table 5. *Summary of content validity by dimension (average Aiken's V)*

Dimension	Clarity	Coherence	Relevance
Waste separation	0.90	0.88	0.93
Recycling culture	0.95	0.95	0.95
Recycling infrastructure	0.83	0.82	0.83
Environmental education programs	0.90	0.88	0.90
Waste reduction	0.98	0.95	0.98
Environmental quality	0.88	0.88	0.90
Environmental awareness	0.93	0.93	0.90
Sustainability	0.93	0.88	0.93

Note. Values represent the average of Aiken's V coefficients for items within each dimension. All dimensions exceeded the minimum acceptable threshold of 0.80 across the three evaluated criteria. The recycling culture dimension obtained the highest scores (0.95), while recycling infrastructure obtained the lowest (0.83).

Item Adjustments

Based on the judges' suggestions, adjustments were made to items 2, 7, 8, 9, and 16 to improve their clarity:

- **Item 2:** Modified to "I classify waste before disposing it in the corresponding containers."
- **Item 7:** Added "differentiated" to specify "There are differentiated containers for solid waste separation in my faculty."
- **Item 8:** Clarified "ciudadela universitaria" to avoid ambiguity.
- **Item 9:** Reformulated to "There is a collection center located in the University of Guayaquil facilities."
- **Item 16:** Simplified to make it more direct and understandable.

All items were kept in the final version.

Discussion

The present study has developed and content-validated a questionnaire to evaluate solid waste management and its environmental impact at the University of Guayaquil. The results demonstrate adequate content validity, with Aiken's V coefficients above 0.80 in all items and criteria, consistent with previous studies (Ceballos et al., 2022; Cuartas et al., 2019).

The structure of the instrument, organized into two variables and eight dimensions, responds to a well-founded theoretical model. The dimensions of the independent variable (waste separation, recycling culture, infrastructure, and programs) have been identified as key factors for the success of recycling programs (Kaplowitz et al., 2009; Zhang et al., 2019). The recycling culture dimension obtained the highest scores (0.95), reflecting the importance of perceptions and attitudes, consistent with Lovato Torres et al. (2025). The infrastructure dimension obtained the lowest scores (0.83), possibly due to the more technical nature of these items.

Similarly, the dimensions of the dependent variable reflect the main expected impacts (Kaza et al., 2018; Khan et al., 2022). Waste reduction obtained the highest scores (0.98), consistent with Ceballos et al. (2022). Environmental quality, environmental awareness, and sustainability also exceeded the minimum threshold, supporting the inclusion of these dimensions (Arreaga-Castañeda et al., 2026; Cuartas et al., 2019).

The participation of expert judges from different areas has enriched the process, following the recommendations of Andrade et al. (2020). However, the validation has focused solely

on content validity. It is recommended to continue with the pilot application and definitive validation phases to evaluate construct validity and reliability (Facuy et al., 2026). The reduced size of the judge sample (n=5) could be considered a limitation, although the literature indicates that between 5 and 10 experts is sufficient (Andrade et al., 2020).

The relevance of the instrument transcends the academic sphere, as it can be used by university authorities to diagnose the state of waste management, identify areas for improvement, and design interventions (López & Rodríguez, 2022; UNESCO, 2021). The questionnaire also allows evaluating the impact of environmental interventions and comparing results between faculties.

Conclusions

The present study has developed and content-validated a questionnaire to evaluate solid waste management and its environmental impact at the University of Guayaquil. The results demonstrate adequate content validity, with Aiken's V coefficients above 0.80 in all items and criteria, indicating that the items are clear, coherent, and relevant.

The five-phase methodological model has proven useful for guiding the construction and validation process. The phases of conceptual definition, item construction, and expert judgment evaluation have been successfully completed. It is recommended to continue with the pilot application and definitive validation to evaluate the construct validity and reliability of the instrument.

The validated questionnaire constitutes a valuable tool for the diagnosis and monitoring of solid waste management at the University of Guayaquil, contributing to the promotion of a sustainability culture in the university setting (UNESCO, 2021; Wilson et al., 2022). The limitations of the study, focused on the validation phase achieved, open opportunities for future lines of research, including validation studies in other universities and longitudinal analyses.

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Conflicto de intereses:

Los autores declaran que no existe conflicto de interés