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Assessing Sustainability Consciousness in Teacher Education Through Instrument Validation among Indonesian Pre-Service Teachers

Annas Solihin
State University of Surabaya
Suryanti Suryanti
suryanti@unesa.ac.id
State University of Surabaya
Neni Mariana
State University of Surabaya
Wiryanto Wiryanto
State University of Surabaya
Ganes Gunansyah
State University of Surabaya
Rooselyna Ekawati
State University of Surabaya

Research Article

Keywords: Sustainability consciousness, Teacher education, Psychometric validation, Pre-service teachers, SDG 4 Quality Education, Education for Sustainable Development, Environmental behavior, Indonesia, Instrument development, Sustainability assessment

Posted Date: February 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-8671307/v1

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Additional Declarations: No competing interests reported.

Abstract

Sustainability consciousness represents a critical competency for elementary teachers who must prepare learners to address complex environmental and social challenges. However, validated instruments for assessing sustainability consciousness among pre-service teachers in non-Western contexts remain limited. This study reports psychometric validation of a sustainability consciousness assessment instrument administered to 112 Indonesian pre-service elementary teachers. The instrument measures three dimensions: knowingness (sustainability knowledge, 0–40 points), attitude (environmental and social values, 0–40 points), and behavior (pro-sustainability practices, 0–40 points), yielding total sustainability consciousness scores (0-120 points). Psychometric analyses revealed strong internal consistency (Cronbach's α = 0.89 overall; knowingness α = 0.85, attitude α = 0.82, behavior α = 0.80), adequate construct validity through confirmatory factor analysis (CFI = 0.93, TLI = 0.91, RMSEA = 0.06), and appropriate test-retest reliability ($r = 0.84$, $p < 0.001$). Descriptive analyses indicated mean scores of 28.75 (SD = 3.52) for knowingness, 20.93 (SD = 3.76) for attitude, and 16.79 (SD = 3.82) for behavior, revealing systematic gaps between knowledge and action. The descending pattern (knowingness > attitude > behavior) suggests knowledge-action disconnection requiring pedagogical attention. Categorical distribution showed 28.57% with low, 46.43% with moderate, and 25% with high sustainability consciousness. These findings validate a culturally appropriate assessment tool for teacher education contexts while illuminating specific developmental needs in transforming sustainability knowledge into committed attitudes and consistent behaviors among future educators.

Introduction

The United Nations Sustainable Development Goals (SDGs), particularly SDG 4 on Quality Education, emphasize education's transformative role in achieving global sustainability [1]. Education for Sustainable Development (ESD) has emerged as a critical framework for preparing learners to address interconnected environmental, social, and economic challenges threatening planetary and human wellbeing [2, 3]. Within this context, sustainability consciousness—defined as integrated awareness of sustainability issues, commitment to sustainable values, and engagement in pro-sustainability behaviors—represents a fundamental competency for educators who shape future generations' capacities to create sustainable societies [4, 5].

Elementary teachers occupy particularly strategic positions in developing sustainability consciousness among young learners during formative developmental periods when foundational values, attitudes, and behavioral patterns emerge [6]. Pre-service teachers' own sustainability consciousness significantly influences their pedagogical approaches, curricular emphases, and capacity to model sustainable lifestyles [7, 8]. However, research reveals concerning patterns: while many pre-service teachers possess adequate sustainability knowledge, they often demonstrate limited commitment to sustainability values and inconsistent engagement in pro-environmental behaviors [9, 10]. This knowledge-action gap undermines ESD effectiveness and necessitates comprehensive assessment of sustainability consciousness across its multiple dimensions.

Robust assessment requires psychometrically validated instruments demonstrating reliability (measurement consistency), validity (measuring intended constructs), and cultural appropriateness (functioning effectively across diverse contexts) [11]. While sustainability consciousness assessment instruments exist, most were developed and validated in Western European or North American contexts, potentially limiting their applicability in non-Western settings characterized by distinct cultural values, environmental priorities, and socio-economic conditions [12, 13]. Cultural psychology research suggests that sustainability consciousness may manifest differently across individualist and collectivist cultures, with implications for instrument design, item interpretation, and dimensional structure [14, 15].

Indonesian contexts present particular challenges and opportunities for sustainability consciousness research. As the world's fourth most populous nation experiencing rapid urbanization, deforestation, and climate vulnerability, Indonesia faces acute sustainability challenges requiring educational responses [16]. Simultaneously, Indonesian cultural traditions emphasizing harmony with nature, communal responsibility, and intergenerational obligation provide cultural resources potentially supporting sustainability consciousness development [17]. However, empirical investigation of sustainability consciousness among Indonesian pre-service teachers remains notably limited, impeding evidence-based teacher education reform aligned with ESD imperatives.

This study addresses these gaps through comprehensive psychometric validation of a sustainability consciousness assessment instrument administered to Indonesian pre-service elementary teachers. The research aims to: (1) evaluate instrument reliability and validity through rigorous psychometric analyses, (2) characterize sustainability consciousness profiles across knowledge, attitude, and behavior dimensions, (3) identify specific developmental patterns and challenges requiring pedagogical attention, and (4) provide validated assessment tools for teacher education research and practice. By contributing culturally grounded empirical evidence from an underrepresented context, this investigation advances international understanding of sustainability consciousness while supporting ESD capacity-building in Indonesian teacher preparation programs.

Methods

Study Design and Participants

This quantitative psychometric validation study employed a cross-sectional research design with 112 pre-service elementary teachers (N = 112) enrolled in undergraduate teacher education programs at Indonesian institutions during the 2024 academic year. Participants represented diverse cohorts across program years (Year 2: 38%, Year 3: 42%, Year 4: 20%), providing developmental breadth in the sample. The gender distribution comprised 68% female and 32% male participants, reflecting typical elementary teacher education demographics in Indonesian contexts. Ages ranged from 19 to 23 years (M = 20.8, SD = 1.2).

Inclusion criteria required: (1) active enrollment in accredited elementary teacher education programs, (2) completion of at least one environmental or social studies coursework, and (3) voluntary informed consent. Exclusion criteria eliminated participants with incomplete assessment data or recent participation in sustainability-focused interventions that might confound baseline measurements. The final sample (n = 112) represented 94.1% of initially recruited participants, with 7 exclusions due to incomplete data. Power analysis indicated this sample size provides adequate statistical power (0.80) for detecting medium-sized psychometric effects ($r \geq 0.30$) at $\alpha = 0.05$.

Sustainability Consciousness Assessment Instrument

The sustainability consciousness instrument adapts and extends frameworks from Gericke et al. [18] and Olsson and Gericke [19], modified for Indonesian teacher education contexts through expert consultation and pilot testing. The instrument operationalizes sustainability consciousness through three theoretically grounded dimensions:

Knowingness (0–40 points)

Assesses factual knowledge of sustainability principles, environmental challenges, social equity issues, and interconnections among ecological, social, and economic systems. Items address climate change, biodiversity loss, resource depletion, poverty, and sustainable development pathways. Higher scores indicate comprehensive sustainability literacy.

Attitude (0–40 points)

Evaluates affective commitment to sustainability values, including environmental stewardship, social justice, intergenerational responsibility, and ethical consumption. Likert-scale items measure agreement with sustainability-aligned value statements and concern regarding environmental degradation and social inequity. Higher scores reflect stronger pro-sustainability attitudes.

Behavior (0–40 points): Measures self-reported engagement in pro-sustainability behaviors across multiple domains: resource conservation (energy, water), waste reduction and recycling, sustainable transportation, ethical consumption, environmental advocacy, and social action. Frequency scales assess consistency of sustainability-aligned practices. Higher scores indicate habitual pro-sustainability behavior.

Total sustainability consciousness scores range from 0 to 120 points, representing comprehensive assessment across knowledge, affective, and behavioral dimensions. The instrument comprises 36 items (12 per dimension), requiring approximately 30–40 minutes completion time. Linguistic validation included forward translation (English to Indonesian), back-translation, expert review by bilingual sustainability education specialists, and pilot testing (n = 30) to ensure semantic equivalence and cultural appropriateness.

Data Collection Procedures

Data collection employed standardized administration protocols to ensure measurement consistency and minimize response bias. Participants completed assessments individually during designated class periods in quiet, distraction-free environments. Research assistants provided uniform instructions emphasizing: (1) honest, reflective responses rather than socially desirable answers, (2) absence of correct or incorrect responses for attitude and behavior items, and (3) confidentiality of individual data. Participants received assurance that responses would not influence academic evaluations.

For test-retest reliability assessment, a subset of participants (n = 40, 35.7% of the sample) completed the instrument twice with a two-week interval—a timeframe sufficient to prevent response memory effects while minimizing genuine change in sustainability consciousness. This subset demonstrated comparable demographic characteristics to the full sample, supporting representativeness of reliability estimates.

Psychometric Analysis Procedures

Comprehensive psychometric evaluation proceeded through multiple analytical stages:

Reliability Analysis

Internal consistency was assessed using Cronbach's alpha (α) for each dimension and overall scale, with $\alpha \geq 0.70$ considered acceptable and $\alpha \geq 0.80$ good [20]. Test-retest reliability employed Pearson correlations between Time 1 and Time 2 scores, with $r \geq 0.70$ indicating adequate temporal stability [21].

Validity Analysis: Construct validity was evaluated through Confirmatory Factor Analysis (CFA) testing the hypothesized three-factor structure (knowingness, attitude, behavior). Model fit was assessed using multiple indices: Comparative Fit Index (CFI ≥ 0.90), Tucker-Lewis Index (TLI ≥ 0.90), Root Mean Square Error of Approximation (RMSEA ≤ 0.08), and Standardized Root Mean Square Residual (SRMR ≤ 0.08) [22]. Convergent validity examined correlations among dimensions, expecting moderate positive associations reflecting related but distinct constructs.

Descriptive and Distributional Analyses: Means, standard deviations, ranges, skewness, and kurtosis were computed for each dimension and total scores. Categorical classifications employed theoretically informed thresholds: Low sustainability consciousness (49–60 points), Moderate (61–79 points), and High (80–90 points), facilitating meaningful interpretation while acknowledging developmental continuity.

All statistical analyses employed SPSS 27.0 and Mplus 8.6. Missing data were minimal (< 2%) and handled through listwise deletion given negligible impact on parameter estimates. Significance levels were set at $p < 0.05$, with Bonferroni corrections applied where multiple comparisons were conducted.

Ethical Considerations

This study received ethical approval from the institutional review board at State University of Surabaya (Protocol: EDU-2024-088). All participants provided written informed consent after receiving detailed information regarding study purposes, procedures, voluntary participation, and data confidentiality. Participants could withdraw without consequences. Data were de-identified immediately following collection, with only aggregate results reported. Individual assessment results were not shared with program faculty to prevent potential academic consequences. Clinical trial number: not applicable.

Results

Psychometric Properties: Reliability

Internal consistency analyses demonstrated strong reliability across all dimensions (Table 1). Cronbach's alpha for the overall sustainability consciousness scale reached 0.89, exceeding the 0.80 threshold for good reliability. Dimensional analyses revealed knowingness α = 0.85, attitude α = 0.82, and behavior α = 0.80, all indicating adequate to good internal consistency. Item-total correlations ranged from 0.42 to 0.78, with all items demonstrating sufficient contribution to their respective dimensions. Alpha-if-item-deleted analyses indicated no substantial reliability improvements from item removal, supporting retention of all items.

Test-retest reliability assessment with the subset (n = 40) yielded strong temporal stability: overall sustainability consciousness r = 0.84 (p < 0.001), knowingness r = 0.82 (p < 0.001), attitude r = 0.79 (p < 0.001), and behavior r = 0.77 (p < 0.001). The two-week interval demonstrated measurement consistency while allowing sufficient time to minimize memory effects. These findings indicate the instrument produces reliable, stable measurements suitable for research and assessment purposes.

Table 1
Reliability Analyses of Sustainability Consciousness Instrument (N = 112)

Dimension	Cronbach's α	Test-Retest r	Mean Inter-Item Correlation	Alpha if Item Deleted Range
Knowingness	0.85	0.82***	0.43	0.82–0.84
Attitude	0.82	0.79***	0.39	0.79–0.81
Behavior	0.80	0.77***	0.36	0.77–0.79
Total Scale	0.89	0.84***	0.41	0.87–0.88

*Note: ***p < 0.001. Test-retest reliability based on n = 40 subset with 2-week interval.*

Psychometric Properties: Construct Validity

Confirmatory Factor Analysis supported the hypothesized three-factor structure (Table 2). Model fit indices demonstrated adequate to good fit: CFI = 0.93, TLI = 0.91, RMSEA = 0.062 (90% CI [0.048, 0.076]), and SRMR = 0.054. These values meet conventional thresholds for acceptable model fit, supporting the conceptual distinction among knowingness, attitude, and behavior dimensions. Standardized factor loadings ranged from 0.58 to 0.84 (all $p < 0.001$), indicating substantial relationships between items and their respective latent factors.

Convergent validity was evidenced through moderate positive correlations among dimensions (Table 2): knowingness-attitude $r = 0.52$ ($p < 0.001$), knowingness-behavior $r = 0.44$ ($p < 0.001$), and attitude-behavior $r = 0.61$ ($p < 0.001$). These correlations demonstrate meaningful relationships while remaining sufficiently distinct to support dimensional differentiation. The stronger attitude-behavior correlation aligns with theoretical expectations that affective commitment more directly influences behavioral engagement than does knowledge alone [23].

Table 2
Construct Validity Evidence (N = 112)

Validity Indicator	Value	Interpretation
CFA Model Fit Indices		
CFI	0.93	Good fit (≥ 0.90)
TLI	0.91	Good fit (≥ 0.90)
RMSEA [90% CI]	0.062 [0.048–0.076]	Acceptable fit (≤ 0.08)
SRMR	0.054	Good fit (≤ 0.08)
Inter-Dimensional Correlations		
Knowingness - Attitude	0.52***	Moderate positive
Knowingness - Behavior	0.44***	Moderate positive
Attitude - Behavior	0.61***	Strong positive

*Note: ***p < 0.001. CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root Mean Square Error of Approximation; SRMR = Standardized Root Mean Square Residual.*

Descriptive Profiles of Sustainability Consciousness

Descriptive statistical analyses revealed systematic patterns across sustainability consciousness dimensions (Table 3). Mean scores demonstrated a descending gradient: knowingness ($M = 28.75$, $SD = 3.52$), attitude ($M = 20.93$, $SD = 3.76$), and behavior ($M = 16.79$, $SD = 3.82$). This progressive decline suggests pre-service teachers possess adequate sustainability knowledge but demonstrate weaker affective commitment and substantially lower behavioral engagement—a pattern indicating significant knowledge-action disconnection.

Overall sustainability consciousness scores (M = 66.46, SD = 11.02, Range: 49–90) positioned the sample predominantly within the moderate range, with considerable individual variation. Skewness (0.24) and kurtosis (-0.31) values approached zero, indicating approximately normal distribution. The relatively large standard deviation (11.02 points) reflects substantial heterogeneity in sustainability consciousness development, underscoring needs for differentiated pedagogical approaches.

Table 3
Descriptive Statistics of Sustainability Consciousness Dimensions (N = 112)

Dimension	M	SD	Min	Max	Range	Skewness	Kurtosis
Knowingness	28.75	3.52	23	36	13	-0.12	-0.18
Attitude	20.93	3.76	15	29	14	0.09	-0.22
Behavior	16.79	3.82	11	25	14	0.28	-0.35
Total ESC	66.46	11.02	49	90	41	0.24	-0.31

Note: ESC = Ethno-Sustainability Consciousness (Total Score). Maximum possible scores: Knowingness = 40, Attitude = 40, Behavior = 40, Total = 120.

Categorical Distribution and Dimensional Performance

Categorical classification (Table 4) revealed that 32 participants (28.57%) demonstrated Low sustainability consciousness, 52 (46.43%) exhibited Moderate levels, and 28 (25.00%) displayed High sustainability consciousness. The modal concentration in the moderate category suggests most pre-service teachers possess foundational competencies requiring systematic enhancement rather than fundamental development. However, the substantial proportion demonstrating low sustainability consciousness (nearly one-third) highlights significant developmental needs inadequately addressed by current programs.

Dimensional profiling illuminated specific patterns and challenges (Table 4). Within knowingness, 60.71% demonstrated high knowledge levels (≥ 30 points), while only 10.71% showed low knowledge. This suggests teacher education programs effectively develop sustainability literacy through coursework. In contrast, attitude patterns revealed greater challenge: only 25% demonstrated strongly positive attitudes (≥ 24 points), while 33.93% showed weak attitudinal commitment (< 18 points). Most concerningly, behavior analyses indicated only 17.86% engaged in consistently pro-sustainability practices (≥ 20 points), while 39.29% demonstrated minimal behavioral engagement (< 14 points).

Table 4
Categorical Distribution and Dimensional Performance Patterns (N = 112)

Category / Dimension	Score Range	Frequency (n)	Percentage (%)	Interpretation
Overall Classification				
Low ESC	49–60	32	28.57	Basic sustainability consciousness
Moderate ESC	61–79	52	46.43	Developing sustainability consciousness
High ESC	80–90	28	25.00	Advanced sustainability consciousness
Knowingness Performance				
High (≥ 30)	30–36	68	60.71	Comprehensive knowledge
Moderate (24–29)	24–29	32	28.57	Adequate knowledge
Low (< 24)	11–23	12	10.71	Limited knowledge
Attitude Performance				
High (≥ 24)	24–29	28	25.00	Strong pro-sustainability values
Moderate (18–23)	18–23	46	41.07	Neutral/developing attitudes
Low (< 18)	11–17	38	33.93	Weak sustainability commitment
Behavior Performance				
High (≥ 20)	20–25	20	17.86	Consistent pro-sustainability action
Moderate (14–19)	14–19	48	42.86	Occasional engagement
Low (< 14)	11–13	44	39.29	Minimal behavioral engagement

Note: ESC = Ethno-Sustainability Consciousness. Percentages based on N = 112.

Knowledge-Action Gap Analysis

The systematic descending pattern across dimensions—knowingness (71.9% of maximum) > attitude (52.3% of maximum) > behavior (42.0% of maximum)—reveals substantial knowledge-action disconnection. While participants demonstrated reasonably strong sustainability knowledge, this did not

translate proportionally into committed attitudes or consistent behaviors. The 29.9 percentage point gap between knowledge and behavior performance suggests that possessing sustainability literacy does not automatically generate pro-sustainability action. This finding aligns with extensive research documenting attitude-behavior gaps in environmental psychology [24, 25] and highlights the necessity for pedagogical approaches explicitly targeting affective transformation and behavioral change alongside knowledge development.

Figure 1 presents the frequency distribution of total sustainability consciousness scores across the sample. The histogram illustrates score distribution from 49 to 90 points with 5-point intervals, revealing approximately normal distribution centered around the mean (M = 66.46). Visual representation through color-coded regions (red for Low, yellow for Moderate, green for High) facilitates immediate identification of categorical concentrations, demonstrating modal clustering in the moderate range with smaller proportions at distribution extremes.

The approximately normal distribution supports parametric statistical approaches for future research while indicating adequate sampling of the sustainability consciousness spectrum. The predominance of moderate scores suggests potential for growth through targeted interventions rather than requiring fundamental consciousness development from baseline levels.

Figure 2 provides comparative visualization of mean performance across the three sustainability consciousness dimensions, explicitly illustrating the knowledge-action gap. The grouped bar chart format enables direct comparison on a consistent 0–40 scale, visually representing the systematic descending pattern: knowingness substantially exceeds attitude, which in turn exceeds behavior. Error bars (± 1 SD) demonstrate comparable variability across dimensions, indicating that heterogeneity exists consistently rather than being concentrated in particular aspects of sustainability consciousness.

Figure 2 visually confirms the knowledge-action gap pattern requiring pedagogical intervention. The larger knowingness-attitude gap (7.82 points, 19.6% of scale) compared to attitude-behavior gap (4.14 points, 10.4% of scale) suggests particular challenges in transforming sustainability knowledge into affective commitment. However, both gaps indicate that teacher education programs must move beyond knowledge transmission toward approaches fostering deep values transformation and behavioral habituation.

Discussion

This study provides comprehensive psychometric validation of a sustainability consciousness assessment instrument while illuminating critical developmental patterns among Indonesian pre-service elementary teachers. The findings contribute both methodological advances through validated measurement tools and substantive insights regarding sustainability consciousness profiles, knowledge-action disconnection, and implications for teacher education aligned with Education for Sustainable Development imperatives.

Psychometric Validation: Reliability and Validity Evidence

The instrument demonstrated strong psychometric properties across multiple reliability and validity indicators. Cronbach's alpha values (overall α = 0.89; dimensional α = 0.80–0.85) substantially exceeded conventional thresholds, indicating the instrument produces consistent, reliable measurements [20]. These reliability estimates compare favorably with established sustainability consciousness instruments developed in Western contexts [18, 19], supporting cross-cultural applicability of the dimensional framework while employing culturally adapted items.

Test-retest reliability (r = 0.77–0.84) demonstrated adequate temporal stability over the two-week interval. This finding indicates the instrument measures relatively stable characteristics rather than transient states, appropriate for assessing sustainability consciousness as an enduring disposition [21]. The moderate-to-strong test-retest correlations balance measurement consistency with allowance for genuine developmental change, supporting utility for longitudinal assessment of teacher education interventions.

Confirmatory Factor Analysis provided compelling construct validity evidence through good model fit indices (CFI = 0.93, TLI = 0.91, RMSEA = 0.062). These findings support the theoretical three-factor structure distinguishing knowingness, attitude, and behavior as related but distinct dimensions [22]. The moderate inter-dimensional correlations (r = 0.44–0.61) indicate meaningful relationships while maintaining sufficient independence to justify separate assessment. Importantly, the stronger attitude-behavior correlation (r = 0.61) aligns with theoretical predictions from the Theory of Planned Behavior [26] and environmental psychology research [24] suggesting affective commitment more directly predicts behavioral engagement than does knowledge alone.

Knowledge-Action Gap: Theoretical and Practical Implications

The systematic descending pattern across dimensions—knowingness (71.9% of maximum) substantially exceeding attitude (52.3%) and behavior (42.0%)—reveals significant knowledge-action disconnection requiring pedagogical intervention. This pattern resonates with extensive research documenting attitude-behavior gaps in environmental psychology [24, 25] and sustainability education [9, 10]. Chen et al. [4] similarly reported that Chinese students demonstrated strong sustainability literacy but weaker behavioral engagement, suggesting knowledge-action gaps may be widespread across diverse educational contexts.

Multiple theoretical frameworks illuminate this disconnection. The Value-Belief-Norm theory [27] posits that environmental knowledge activates personal values, which generate pro-environmental beliefs, ultimately producing normative obligations to act. Gaps can occur at each transition point, with knowledge failing to activate values (knowingness-attitude gap) or values failing to generate behavioral commitments (attitude-behavior gap). Our findings suggest both transitions present challenges, with particularly large deficits in translating knowledge into affective commitment.

Ovais [5] demonstrates that locus of control—beliefs regarding personal agency and efficacy—significantly moderates relationships between sustainability knowledge and behavior. Pre-service teachers with strong sustainability knowledge but weak behavioral engagement may feel powerless to effect meaningful change, viewing sustainability challenges as beyond individual influence. This suggests teacher education must cultivate not only knowledge and values but also self-efficacy and empowerment—the conviction that personal actions matter and collective efforts can transform systems [28].

Dimensional Patterns and Developmental Needs

The finding that 60.71% demonstrated high knowingness but only 25% showed strongly positive attitudes and merely 17.86% engaged in consistent pro-sustainability behaviors illuminates specific developmental trajectories. Teacher education programs appear effective at knowledge transmission through coursework addressing environmental science, social issues, and sustainable development principles. However, they prove less successful at fostering deep affective transformation and behavioral habituation.

Al-Nuaimi and Al-Ghamdi [29] report similar patterns among higher education students in Qatar, with strong sustainability knowledge coexisting with limited behavioral engagement. They attribute this gap partially to social norms and infrastructure constraints that impede sustainable behaviors even among motivated individuals. In Indonesian contexts, factors such as limited recycling infrastructure, transportation dependencies, and consumer culture may similarly constrain behavioral expression of sustainability commitments despite strong knowledge and values.

Ariza et al. [30] emphasize the importance of sustainability consciousness for effective environmental citizenship and educational practice. The substantial proportion of pre-service teachers demonstrating low behavioral engagement (39.29%) raises concerns regarding their capacity to model sustainable lifestyles for students. Teachers who do not embody sustainability principles in their personal lives may struggle to authentically engage students in ESD or inspire behavioral change through example [31].

Cultural Considerations and Contextual Adaptation

Validation within Indonesian contexts provides culturally grounded assessment tools while contributing to international understanding of sustainability consciousness across diverse settings. Indonesian cultural frameworks emphasizing communal harmony, respect for nature, and intergenerational responsibility [17] may shape how sustainability consciousness manifests, potentially emphasizing collective action and traditional ecological knowledge over individual lifestyle changes prominent in Western environmental discourse.

Albareda-Tiana et al. [32] advocate for holistic approaches integrating sustainability and research competencies in pre-service teacher training, emphasizing the importance of culturally responsive pedagogies. Indonesian teacher education might productively draw on local wisdom traditions (kearifan lokal) that embody sustainability principles—such as gotong royong (mutual cooperation),

keseimbangan (balance), and harmoni dengan alam (harmony with nature)—to cultivate sustainability consciousness grounded in cultural strengths rather than imposing Western environmental frameworks [33].

Malandrakis [34] demonstrates that sustainability education pedagogies emphasizing social dimensions and urban environmental issues effectively develop Greek pre-service teachers' sustainability consciousness. This suggests that culturally relevant, locally contextualized approaches addressing pressing regional challenges—such as Jakarta's air pollution, deforestation in Kalimantan, or coastal erosion in Java—may prove more effective than abstract global sustainability discourse in fostering deep consciousness transformation.

Implications for Teacher Education Reform

These findings carry significant implications for redesigning elementary teacher education programs to systematically cultivate sustainability consciousness. First, curricula must move beyond knowledge transmission toward transformative learning experiences engaging affective and behavioral dimensions [35]. García-González et al. [36] emphasize the importance of perceptions and experiential learning in developing sustainability consciousness among pre-service teachers, suggesting pedagogies such as place-based education, sustainability audits, community engagement projects, and reflective practice that connect abstract knowledge to personal values and lived experiences.

Second, teacher education should explicitly address knowledge-action gaps through metacognitive reflection, values clarification exercises, and action research projects requiring sustained behavioral engagement [37]. Strategies might include sustainability challenges (e.g., plastic-free month, zero-waste week) with structured reflection on barriers and facilitators, helping pre-service teachers develop practical strategies for translating values into action despite systemic constraints.

Third, assessment frameworks should evaluate sustainability consciousness development across all three dimensions rather than focusing exclusively on knowledge outcomes. The validated instrument provided here enables pre- and post-program assessment, supporting evidence-based evaluation of intervention effectiveness. Regular assessment can also support formative feedback, helping pre-service teachers recognize growth areas and set personalized development goals [38].

Fourth, institutional environments must support sustainability consciousness through modeling sustainable practices in campus operations, providing infrastructure enabling pro-environmental behaviors (recycling facilities, sustainable food options, green spaces), and creating cultures valuing sustainability commitments [39]. Teacher education institutions practicing institutional sustainability send powerful implicit messages about the importance of translating values into action [40].

Connections to Broader SDG Implementation

This research contributes to SDG 4 (Quality Education) implementation by providing validated tools for assessing teacher competencies aligned with Target 4.7: ensuring learners acquire knowledge and skills

needed to promote sustainable development [1]. Pre-service teachers with strong sustainability consciousness are better positioned to integrate ESD across curricula, model sustainable behaviors, and cultivate students' capacities for critical thinking about sustainability challenges [2].

Moreover, sustainability consciousness development among educators supports interconnected SDGs addressing environmental sustainability (SDGs 13–15), social equity (SDGs 1, 5, 10), and sustainable consumption (SDG 12). Teachers embodying sustainability consciousness can help students understand these interconnections and develop capacities for systems thinking essential for addressing complex sustainability challenges [41].

Limitations and Future Research Directions

Several limitations warrant acknowledgment. First, reliance on self-report data may inflate sustainability consciousness estimates through social desirability bias or limited self-awareness. Future research should triangulate self-reports with behavioral observations, ecological momentary assessment of daily behaviors, or analysis of actual resource consumption patterns [42]. Second, the cross-sectional design precludes examination of sustainability consciousness developmental trajectories. Longitudinal investigations tracking changes from program entry through graduation and into teaching practice would illuminate developmental patterns and intervention effectiveness.

Third, while the instrument demonstrated strong psychometric properties in Indonesian contexts, cross-cultural validation across diverse national and cultural settings would strengthen generalizability claims. Measurement invariance testing could assess whether the instrument functions equivalently across cultural groups, supporting meaningful cross-cultural comparisons [43]. Fourth, the current study did not examine potential moderators of knowledge-action relationships, such as self-efficacy, locus of control, social norms, or structural barriers. Future research investigating these mechanisms could inform more targeted interventions.

Future research should also investigate intervention effectiveness through randomized controlled trials or quasi-experimental designs testing specific pedagogical approaches for developing sustainability consciousness. Design-based research developing and iteratively refining culturally responsive ESD curricula could advance practical knowledge while contributing theoretical understanding. Additionally, qualitative investigations exploring pre-service teachers' conceptualizations of sustainability, perceived barriers to behavioral engagement, and experiences with sustainability-supporting or -constraining educational practices would enrich quantitative findings.

Conclusions

This study validates a psychometrically sound sustainability consciousness assessment instrument for Indonesian pre-service elementary teachers while revealing significant knowledge-action gaps requiring pedagogical intervention. Strong reliability ($\alpha = 0.80–0.89$) and construct validity (CFI = 0.93, TLI = 0.91) support the instrument's utility for research and assessment purposes. The systematic descending

pattern across dimensions—knowingness substantially exceeding attitude and behavior—illuminates specific developmental needs in transforming sustainability literacy into affective commitment and consistent pro-sustainability action.

These findings underscore the imperative for transforming teacher education from knowledge-centered approaches toward holistic programs systematically cultivating sustainability consciousness across cognitive, affective, and behavioral dimensions. Such transformation requires curriculum innovations emphasizing transformative learning, explicit attention to knowledge-action gaps, comprehensive assessment frameworks, and institutional modeling of sustainability principles. By developing robust sustainability consciousness, teacher education can prepare educators capable of fostering students' capacities to address complex sustainability challenges and contribute to achieving the Sustainable Development Goals.

The validated instrument and empirical insights provided here offer tools and evidence supporting this transformation in Indonesian contexts while contributing to international scholarship on sustainability consciousness and Education for Sustainable Development. As elementary teachers shape future generations during formative periods, investing in their sustainability consciousness development represents strategic leverage for creating sustainable, equitable, resilient societies aligned with the 2030 Agenda for Sustainable Development.

Declarations

Competing Interests

The authors declare no competing interests.

Ethics Approval and Consent to Participate

This study was approved by the institutional review board at State University of Surabaya (Protocol: EDU-2024-088). The study was conducted in accordance with the Declaration of Helsinki and the guidelines of the State University of Surabaya institutional review board. All participants provided written informed consent.

Consent to Publish

Not applicable.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contribution

AS: Conceptualization, Methodology, Data Collection, Formal Analysis, Writing - Original Draft. S: Supervision, Writing - Review & Editing, Project Administration. NM: Validation, Psychometric Analysis, Writing - Review & Editing. W: Writing - Review & Editing. GG: Conceptualization, Writing - Review & Editing. RE: Methodology, Statistical Analysis, Writing - Review & Editing. All authors read and approved the final manuscript.

Acknowledgements

The authors acknowledge the pre-service teachers who participated in this study and the institutional support provided by State University of Surabaya.

Data Availability

All data generated and analyzed during this study are openly available in the Figshare repository: https://doi.org/10.6084/m9.figshare.31125307. The repository includes raw data, descriptive statistics, categorical distributions, and psychometric properties. The validated sustainability consciousness instrument is provided as supplementary material [44].

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Figures

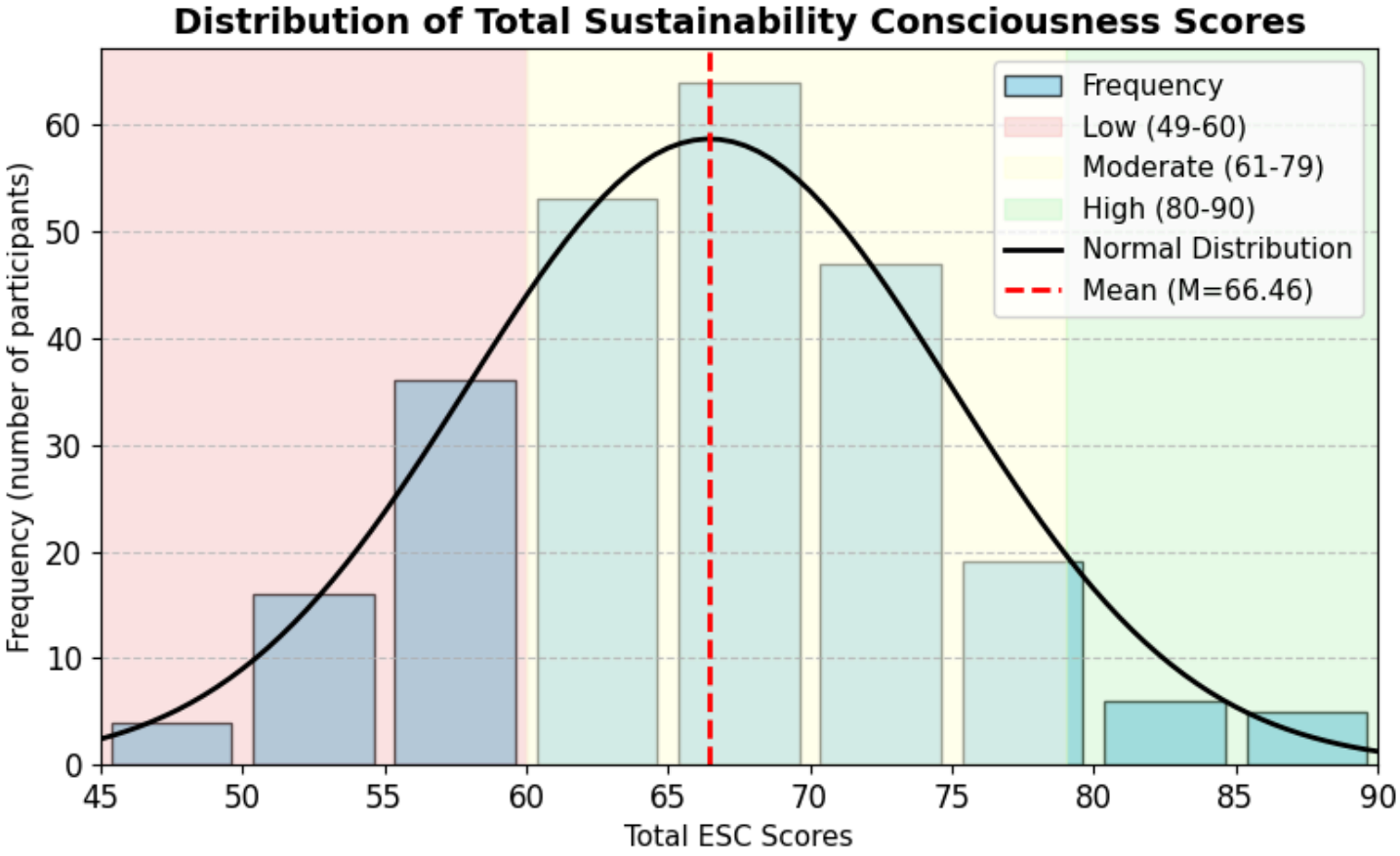


Figure 1

Distribution of Total Sustainability Consciousness Scores

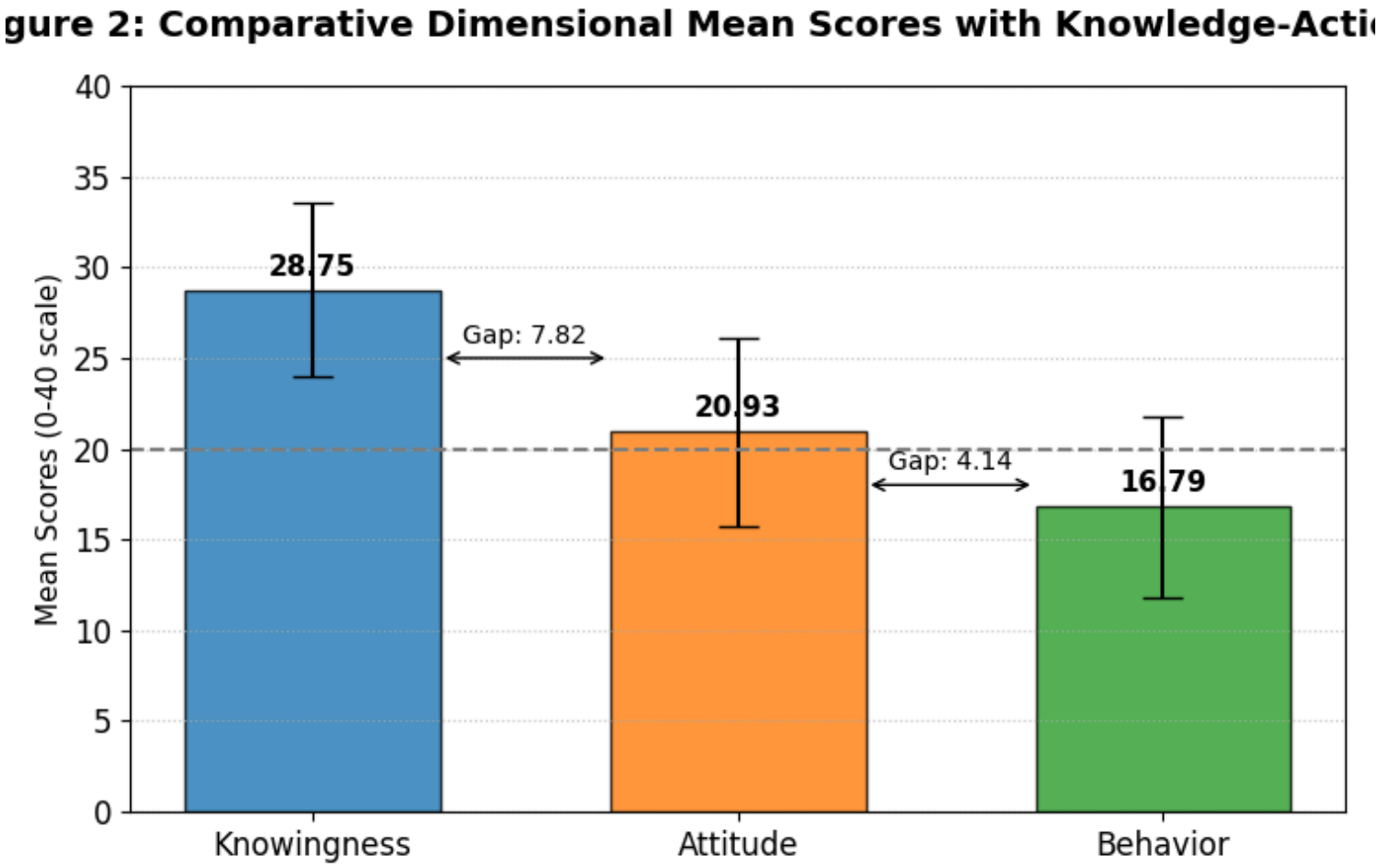


Figure 2

Comparative Dimensional Mean Scores with Knowledge-Action Gap

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 1.ESCRawData.xlsx
- 2.ESCDescriptiveStatistics.xlsx
- 3.ESCCategoricalDistribution.xlsx
- 4.ESCPsychometricProperties.xlsx