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Relationships among Knowledge, Attitudes, and Actions in Climate Change Awareness among Senior High School Students in Central Java

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Abstract

This quantitative study analyses the relationship among knowledge, attitudes, and actions regarding climate change awareness among high school students in Central Java, driven by real environmental threats such as persistent flash floods and low climate literacy. Data were gathered via a five-point Likert-scale questionnaire measuring cognitive, affective, and conative aspects across seven schools representing urban, mountainous, agricultural, and coastal geographies. Of the 432 respondents, 396 valid data points were screened and analyzed using Confirmatory Factor Analysis (CFA). The results reveal positive and significant correlations across all dimensions. The strongest correlation exists between attitudes and actions (0.899), followed by knowledge and attitudes (0.849). Crucially, the study identifies a "knowledge-action GAP," evidenced by the lowest correlation between knowledge and action (0.618). This demonstrates that theoretical knowledge does not automatically translate into real-world behaviour without changes in attitude and emotional commitment. Therefore, environmental education must strengthen affective elements and practical exercises to bridge this gap. Future research should expand the geographic scope and incorporate observational methods to enable more precise behavioural measurement.

1. INTRODUCTION

Climate change has evolved into a global civilizational crisis threatening ecosystem stability and human survival, placing secondary environmental education at the forefront of equipping youth with comprehensive climate awareness (Baga et al., 2024; Tahmidaten & Krismanto, 2019). As an archipelago nation, Indonesia is highly vulnerable to extreme weather anomalies (Dietz et al., 2020; Fawzy et al., 2020). In Central Java, these impacts manifest as critical coastal flash floods driven by rising sea levels and landslides in mountainous regions (Joesidawati et al., 2017; Khairullah et al., 2024). This localized vulnerability demands robust adaptation and mitigation capabilities in the younger generation, built on a solid educational foundation (Manikin & Adi Prabowo, 2021; Tahmidaten & Krismanto, 2019).

Theoretically, the ideal trajectory from comprehension to behaviour can be explained through Ajzen's (2020) Theory of Planned Behaviour (TPB), which posits that actions are driven by intentions shaped by personal attitudes and understanding. In Indonesia, this framework aligns with environmental literacy concepts, in which mastery of knowledge and affective care sequentially cultivate cognitive skills and daily ecological behaviours (Rofiqi, 2024). Integrating climate issues into education effectively drives students' intrinsic motivation to engage in mitigation (Sentosa et al., 2024). Ideally, forming a harmonious, linear sequence across knowledge, attitudes, and actions. In reality, however, current environmental education is constrained by the "Knowledge–Action Gap," where high theoretical understanding fails to translate into concrete action (Yang et al., 2025). This misalignment persists because traditional pedagogies frequently overlook students' spontaneous emotions and self-regulatory capacities (Colombo et al., 2023), while passive, memorization-based learning modalities fail to ensure eco-friendly behavioural change (Klement et al., 2025).

To bridge this gap, research indicates that theoretical insights must first foster climate concern and self-efficacy (Kolenatý et al., 2022), a process that is significantly enhanced by active learning frameworks that engage students in social activities and practical carbon-reduction interventions (Mooney et al., 2022). Nevertheless, prior evaluations often isolate cognitive knowledge or merely correlate general attitudinal variables (Akaygun & Adadan, 2021; Suryaningrum et al., 2025), leaving the interactive dimensions of climate awareness largely unexamined. Regional inconsistencies further highlight this empirical gap: 98% of students in South Sumatra understood climate impacts but demonstrated low action (Deshiana et al., 2022). High school students in the Philippines showed high impact awareness, but low mitigation awareness (Desabayla & Gueta, 2023); and 80% of Malang college students were aware of climate issues via social media, yet only 20% acted responsibly (Handoyo et al., 2021). These descriptive, partial snapshots leave a fundamental question unanswered: which indicators constitute the primary weak points hindering the conversion of knowledge into action?

This study addresses these critical limitations by examining whether knowledge directly predicts environmental actions among high school students in Central Java. The novelty lies in using Confirmatory Factor Analysis (CFA) to simultaneously evaluate the dimensions of knowledge, attitudes, and actions and to test construct validity, statistically determining whether these dimensions are distinct or interrelated (Brown, 2015). Compared with simple descriptive analyses, CFA provides greater statistical precision for identifying the weakest indicators shaping students' climate awareness (Byrne, 2016). Ultimately, these findings are expected to refine conventional, over-cognitive environmental education models and serve as an empirical foundation for designing practical chemistry learning strategies and proactive environmental programs.

2. METHOD

This descriptive quantitative study evaluates the structural dimensions of climate change awareness among high school students in Central Java Province, across urban, coastal, and agricultural areas (Baga et al., 2024). Purposive sampling was employed to select target schools based on geographic representation to minimise location bias, utilising inclusion criteria that required active students in grades 10 to 12 to have completed chemistry material on climate change to ensure an equivalent knowledge base. Initial data from 432 respondents were collected digitally via Google Forms and processed using Microsoft Excel and IBM SPSS to conduct validity and reliability tests

(Prananto et al., 2022). To ensure data quality, multivariate outliers were detected using the Mahalanobis Distance method, which identified and eliminated 36 biased respondent data points, leaving a final sample of 396 valid respondents for the primary data analysis stage (Tukatman, 2023).

Data collection utilized a climate awareness questionnaire designed on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), adapted from three key reference articles. The knowledge dimension was adapted from instruments by Sulistyawati et al. (2018) and Djauharoh & Shofiyah (2024); the attitude dimension was also drawn from Djauharoh & Shofiyah (2024), while the action dimension was adopted from Venghaus et al. (2022). Statement items were modified to align with the local context of Central Java and the Indonesian curriculum, specifically in terms of chemistry implementation. For structural transparency, the final item distribution and sample statements for each dimension are presented in Table 1.

Table 1. Final Questionnaire Instrument Grid

Latent Variables	Dimensions	Number of Items	Example Item Question
Climate Change Awareness	Knowledge	6	Burning garbage does not cause air pollution.
	Attitude	6	I do not need to care too much about climate change because I do not feel its impact directly.
	Action	7	I did not leave snack trash in the classroom desk drawer.

This study strictly complied with research ethics standards by obtaining official school permissions, guaranteeing absolute anonymity and confidentiality for all participants, and thoroughly de-identifying data for publication. Confirmatory Factor Analysis (CFA) was conducted using AMOS to simultaneously assess construct validity and reliability, ensuring that the measured indicators accurately represented each latent dimension (Brown, 2015; Byrne, 2016). The analytical stages commenced with a normality test to fulfil parametric statistical assumptions (Kline, 2016; Mohamed Elarbi Boumidouna, 2024). This was followed by a Goodness-of-Fit model evaluation using critical indices including CMIN/DF, GFI, AGFI, and RMSEA to verify that the proposed model aligned with the empirical data (Sulistyawati et al., 2018).

Factor loadings were assessed to determine the strength of the relationships between indicators and the dimensions of knowledge, attitude, and behaviour (Venghaus et al., 2022). Based on established methodological standards, the instrument demonstrated adequacy with factor loadings > 0.50, Average Variance Extracted (AVE) > 0.50, and Composite Reliability (CR) > 0.70; however, an AVE below 0.50 was considered convergent valid if the CR exceeded 0.60 (Jr et al., 2019). Discriminant validity was formally evaluated using the Fornell-Larcker criterion, comparing the square root of each construct's AVE against inter-construct correlation coefficients (Jr et al., 2019). Finally, relationships among latent dimensions were analyzed to investigate whether the Knowledge-Action GAP is the primary finding (Thomson & Stanberry, 2022).

3. RESULTS AND DISCUSSION

Prior to the main analysis, the researchers conducted a rigorous data screening process on the initial 432 respondents to ensure data integrity in the quantitative study. This step was crucial to exclude responses that appeared biased, inconsistent, or anomalous. Based on an outlier test using the Mahalanobis distance criterion in AMOS, 36 respondents were identified with $p < 0.001$. After the outliers were removed, the final sample size deemed valid and suitable for analysis was 396 respondents. Regional profiles then grouped these figures to ensure that the processed data could represent students' conditions across regions. The diversity of the respondents' backgrounds in this study included students from seven schools representing different geographical characteristics of Central Java, ranging from urban and agricultural to mountainous and coastal. The largest number of respondents came from SMA N 2 Semarang (34.8%), MAN 1 Kota Semarang (26.5%), and SMA N 1 Gemolong (24.5%). The sample, which included various types of schools (public, madrasah, and private), enriched the diversity of respondents' answers in shaping robust dimensions of knowledge, attitudes, and actions related to climate change. The variety of responses from respondents across different geographic backgrounds provides a strong foundation for testing the construct validity of the research model. The structure of the relationships between the latent variables and their dimensions is visualized in Figures 1 and 2.

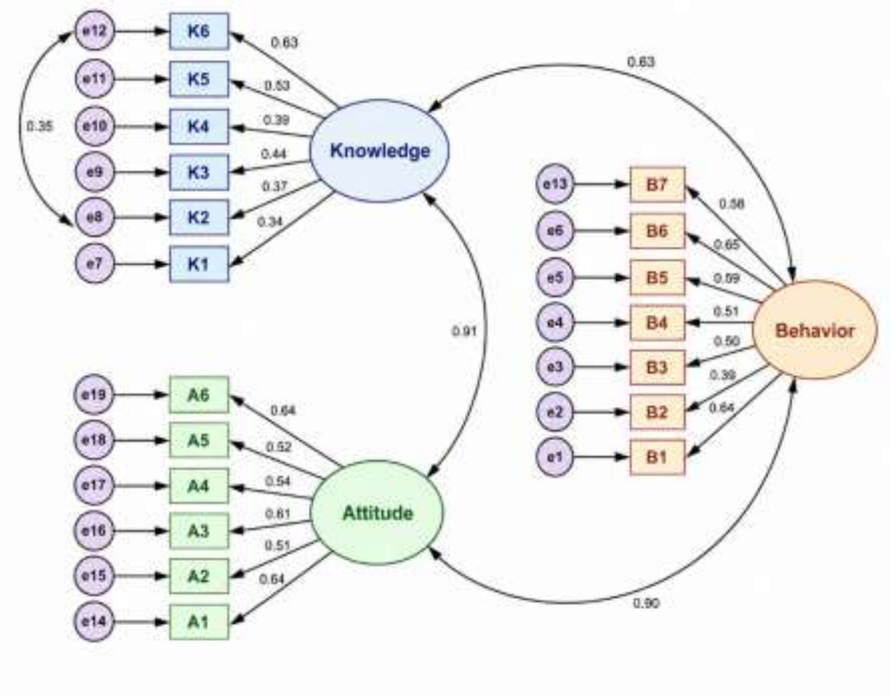

Figure 1. CFA Model

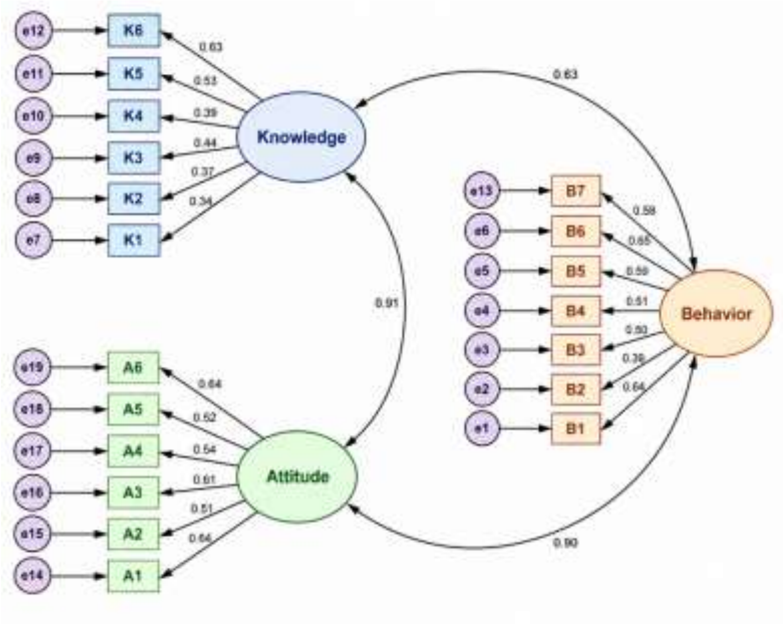

Figure 2. Model CFA

modification), the standardized factor loadings indicate the unique contribution of each questionnaire item. However, several indicators were below the standard threshold of 0.50 (P2 = 0.46 and P3 = 0.42) and even below 0.40 (P1 = 0.37; P4 = 0.38; and T2 = 0.39). Although the elimination of weak indicators is often recommended to improve convergent validity, this study adopted a conservative approach by retaining all of these indicators to preserve construct validity (minimum indicator adequacy) and content validity. In the knowledge dimension, if indicators P1, P2, P3, and P4 are eliminated, the construct risks model identification fails because it would be measured by too few indicators (at a minimum, one dimension should be measured by three indicators) (Brown, 2015;

Byrne, 2016). Furthermore, the items in the Knowledge and Action dimensions contain theoretical substance that is fundamental to the comprehensive representation of the research variables. Therefore, to address low factor loadings and optimize model fit without removing any indicators, a model modification procedure based on Modification Indices (MI) was performed. The modification was performed by correlating the residuals (error terms) between the error variables e8 (indicator P2) and e12 (indicator P6), which had relatively high modification index (MI) values. This was done by drawing a two-way arrow with a covariance value of -0.35.

Theoretically and psychometrically, this specification of inter-error correlation is permissible if there is a logical basis, such as similarity in sentence structure or in respondents' understanding of adjacent test items (Byrne, 2016). In this context, the correlation arises from the phrasing of Item P2 ("The use of fossil fuels is the primary driver of climate change") and Item P6 ("The roles of students and schools are insignificant, as the task of addressing climate change is solely the responsibility of the government and large industries..."), which share systemic contextual similarities at the macro level (industry and global phenomena). This led to overlapping perceptions or interpretive biases among respondents when they filled out the questionnaire. The intervention step using Specification Search proved effective in keeping the model fit index stable. However, it resulted in only minor, largely constant changes in the loading factor values for the other indicators. A comparison of the model fit index values before and after the modification is presented in Table 2.

Table 2. Standardized Regression Weights

Indicators	Latent Variables	Estimate	
		Modification	initial
T1	Action	0.638	0.639
T2	Action	0.389	0.389
T3	Action	0.499	0.500
T4	Action	0.514	0.514
T5	Action	0.585	0.586
T6	Tindakan	0.651	0.650
T7	Tindakan	0.578	0.578
P1	Knowledge	0.367	0.344
P2	Knowledge	0.463	0.375
P3	Knowledge	0.423	0.443
P4	Knowledge	0.379	0.387
P5	Knowledge	0.537	0.528
P6	Knowledge	0.681	0.630
S1	Attitude	0.634	0.638
S2	Attitude	0.511	0.509
S3	Attitude	0.612	0.612
S4	Attitude	0.540	0.537
S5	Attitude	0.511	0.517
S6	Attitude	0.647	0.644

Table 1 demonstrates that model modification through error correlation between P2 and P6 triggered mathematical adjustments across indicators: P1 and P2 rose to 0.367 and 0.463, while P3 (0.423) and P4 (0.379) decreased slightly, and T2 remained constant at 0.389. This phenomenon highlights the high sensitivity and volatility of the knowledge and action dimensions to model re-specification due to variance overlap among survey items. Conversely, the attitude dimension exhibited exceptional structural stability, with all factor loadings (S1–S6) remaining virtually unchanged and consistently exceeding the 0.50 threshold. This confirms that the affective construct is highly robust and statistically independent.

Within the dimensions, indicator P6 (knowledge of emission impacts) yielded the highest loading factor (0.681), indicating that understanding air pollution and greenhouse gases is a core pillar of student cognition. In contrast, lower-valued indicators reveal critical gaps in climate literacy. In line with Yogica et al., (2018), mastering basic concepts is a prerequisite but not a guarantee of behavioral change. In the attitude dimension, indicator S6 (personal commitment) emerged as the strongest element (0.647), indicating a potent internal desire among students to contribute to environmental improvement, which serves as vital social capital for educational programs (Tahmidaten & Krismanto, 2019). The action dimension also improved, particularly in indicator T6 (waste management), showing student engagement in early mitigation measures.

Despite these positive attitudes, the overall action scores clearly reflect the knowledge-action gap. Consistent with the Theory of Planned Behavior (TPB), behavior is driven not just by intention but also by perceived behavioral control; thus, while students possess high cognitive knowledge (average 4.18), their tangible actions depend heavily on the perceived ease or difficulty of execution, which is restricted by resources, time, skills, and supporting school facilities (Ajzen, 2020). To empirically validate these latent interactions, Confirmatory Factor Analysis (CFA) via structural equation modelling was conducted, confirming model fit (Goodness of Fit) using data from 396 validated respondents to ensure a valid representation of the studied variables.

Table 3. The Goodness Model of Match Result

Fit Indices	Model Results		Threshold Values (Cut-off Value)	Conclusion
	After	Before		
Chi-Square (X2)	363.231	391.129	Expected Small	Marginal Fit
Probability (P)	0.000	0.000	≥ 0.05	Marginal Fit
CMIN/DF	2.454	2.625	≤ 3.00 or ≤ 2.00	Good Fit
GFI	0.897	0.891	≥ 0.90	Marginal Fit
AGFI	0.867	0.860	≥ 0.90	Marginal Fit
CFI	0.877	0.862	≥ 0.90	Marginal Fit
RMSEA	0.061	0.064	≤ 0.08	Good Fit
TLI	0.858	0.841	≥ 0.95	Marginal Fit

Based on Table 3, the results of the model modification show a significant improvement in fit. The Chi-Square value decreased to 363.231, accompanied by the CMIN/DF index (2.454 ≤ 3.00) and RMSEA (0.061 ≤ 0.08), which consistently confirm a "good fit" status. Although other fit indices, such as CFI (0.877), TLI (0.858), GFI (0.897), and AGFI (0.867), remain in the "Marginal Fit" category, the upward trend in these values demonstrates that the final model is becoming increasingly valid. These marginal fit values, which are very close to the 0.90 threshold, remain reliable for explaining the dimensions of high school students' climate change awareness, given the complexity of social behaviour research data, which is dynamic and rarely perfectly normally distributed (Byrne, 2016).

Before testing the hypotheses, the discriminant validity was evaluated using the Fornell-Larcker criteria. According to these criteria, the square root of the Average Variance Extracted (AVE) on the diagonal must be greater than the inter-construct correlation coefficients below it.

Table 4. Discriminant Validity Matrix (Kriteria Fornell-Larcker)

Dimension	Knowledge	Attitude	Action
Knowledge	0.487		
Attitude	0.849	0.579	
Action	0.618	0.899	0.557

Based on Table 4, the square roots of the AVEs for the dimensions of knowledge (0.487), attitude (0.579), and action (0.557) were lower than the interdimensional correlation values (such as the attitude-knowledge correlation of 0.849 and the action-attitude correlation of 0.899). This finding indicates a strong conceptual overlap in respondents' perceptions across the dimensions of climate change awareness. This condition reflects high multicollinearity, in which students' cognitive (knowledge), affective (attitude), and conative (action) dimensions regarding climate issues are closely intertwined and difficult to distinguish empirically. Although there are limitations regarding discriminant validity, this model was still advanced to the structural (hypothesis) testing stage to examine the direction of influence among latent variables simultaneously, while considering the dynamics of the relationships between these constructs.

After the model was found to meet the requirements for statistical adequacy and construct validity, the next step was to interpret the relationships among the latent variables tested. The analysis results indicate that there are interesting dynamics within the structure of students' awareness, as shown in the table below.

Table 5. Results of Intervariable Relationship Estimation (Hypothesis Test)

Relationship Statement	Correlation	Critical Ration (CR)	P-Value	Conclusion
The Relationship between Knowledge and Attitudes	0.849	5.540	***	Accepted
The Relationship Between Attitude and Action	0.899	8.127	***	Accepted
The Relationship Between Knowledge and Action	0.618	5.110	***	Accepted

Table 5 highlights the core finding of this study: the knowledge-action gap among high school students. While the three dimensions of climate change awareness are significantly interconnected, the correlation between attitude and action is exceptionally strong (0.899), followed by the correlation between knowledge and attitude (0.849). In contrast, the correlation between knowledge and action is noticeably lower (0.618), indicating that academic mastery effectively fosters cognitive comprehension and emotional empathy (attitudes) but frequently fails to drive constructive actions or tangible mitigation practices (Venghaus et al., 2022). Grounded in the theory of planned behaviour, this gap occurs because behaviour is shaped not only by intent but also by perceived behavioural control; students often feel powerless to act due to a lack of structural support systems, such as green school policies or waste sorting facilities (Dietz et al., 2020; Purnomo et al., 2026).

In the context of chemistry education, these statistics critically expose the limitations of conventional learning models that treat environmental chemistry as purely theoretical. Students struggle to connect laboratory-level green chemistry concepts with real-world climate mitigation. Compared to Sulistyawati et al. (2018), this study provides robust statistical evidence that the action dimension is the most difficult structural element to develop in adolescents. Interestingly, geographical variations emerge: students in coastal areas exhibit higher affective sensitivity due to direct, lived exposure to climate impacts such as flash floods (Baga et al., 2024). Nevertheless, the knowledge-action gap remains a pervasive challenge across all school backgrounds in Central Java.

Ultimately, these empirical insights refute the traditional assumption that expanding environmental literacy will automatically lead to pro-environmental behaviours. Increasing cognitive knowledge alone is insufficient to address complex ecological crises. To bridge this persistent gap between what is known and what is practised, the educational curriculum requires radical instructional shifts toward experiential, project-based learning frameworks that actively compel and enable students to translate their classroom knowledge into concrete, real-world climate actions (Thomson & Stanberry, 2022)

4. CONCLUSION

This research successfully addresses the hypotheses and expectations formulated in the preliminary section, and the data analysis in the results and discussion section consistently aligns with the research's initial purpose. Through Confirmatory Factor Analysis (CFA), it is empirically demonstrated that the dimensions of knowledge, attitudes, and actions are the elements that shape climate change awareness among high school students in Central Java. The main finding was the Knowledge-Action GAP, which shows that adequate cognitive understanding does not automatically translate into effective mitigation measures. This confirms alignment between the urgency presented in the introduction and the asymmetric findings observed in the construct analysis results.

The implications of these findings suggest that environmental education policy can no longer be solely oriented towards the transfer of factual knowledge. A reorientation of the curriculum is needed, emphasising the strengthening of affective and psychomotor aspects to reduce the gap between theory and action. Teachers and education policy developers need to integrate experiential learning methods, such as a chemistry practicum that has a direct impact on the environment, to improve students' self-efficacy in action.

The results of this study can inform the development of more specific educational intervention models based on students' geographical characteristics. For further studies, longitudinal research is recommended to examine the consistency of students' actions over time and to expand the set of variables by including external factors such as social norms and the availability of supporting infrastructure in schools. The prospects for implementing this research are very broad, ranging from the development of more contextual chemistry teaching modules to serving as a reference for local governments in designing more targeted climate campaign programs to change generative behaviour among adolescents.

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